Alaska Oyster Growers Manual 4th Edition

A resource for new and experienced farmers including recommended culture techniques, explanations of various culture systems, business planning assistance, and a guide to obtaining permits and leases

Alaskan Shellfish Growers Association and Alaska Sea Grant Marine Advisory Program, University of Alaska Fairbanks
November 2012

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http://seagrant.uaf.edu/bookstore/pubs/AN-19.html
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This manual is dedicated to Art King for his tireless efforts to help shellfish farming in Alaska grow. King (left) helps ASGA president Rodger Painter (center) and Ray RaLonde, of the Alaska Sea Grant Marine Advisory Program, shuck purple-hinged rock scallops for a research project.

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Chapter 1. Introduction

Rodger Painter

Most people are drawn to oyster farming in Alaska for the lifestyle. While there's nothing wrong with the desire to make a living by growing a high quality food amidst some of the world's most spectacular scenery, if you don't view your farm as a business from the beginning you are more likely to grow more regrets than world class oysters.

Frankly, starting any new small business in rural Alaska is not the best strategy for generating a healthy return on investment, and entering a still unproven industry adds additional uncertainty. So, why should anyone even consider it?

While there are many challenges, growing oysters is one of the few promising small business opportunities in most rural coastal communities from Dixon Entrance to Cook Inlet. Mechanization, improved husbandry, and the introduction of more efficient culture systems are helping farmers increase production and improve product quality. The image of the Alaska oyster in the marketplace is very positive and market demand far outstripped production at the end of 2010.

The real draw of oyster farming and shellfish aquaculture, for me, has been the ability to create a sustainable, environmentally friendly business in rural Alaska—something that may benefit my grandchildren or community for decades or even centuries. I grew up in a Kenai Peninsula fishing village that no longer has a processing plant and is now home to many fewer fishermen than during my pre-statehood childhood. Very few of my extended family in Ninilchik own limited entry permits. Shellfish aquaculture has the potential to diversify and strengthen the economic base of communities like Ninilchik throughout coastal Alaska.

Planning a new farm or shifting to a new culture method is challenging. As a farmer, you must make critical decisions when you know the least about the realities of the new enterprise or culture method.

Farming oysters is more similar to growing apples than it is to commercial fishing or subsistence harvesting of marine resources. Shellfish and apple growers must invest considerable front-end capital and labor for many years before any significant revenues are generated from harvests. In addition, any mistakes made during the early years of farming affects you for years down the road.

Doing your homework is vital.

This fourth edition of the *Alaska Oyster Grower's Manual* is designed to help you with that homework. The result of a collaborative effort between the Alaskan Shellfish Growers Association (ASGA) and the Alaska Sea Grant Marine Advisory Program (MAP), the manual covers all phases of developing and operating oyster culture systems, as well as the business of growing oysters.

The manual provides detailed information on growing oysters in both lantern nets and trays, methods that have been utilized in Alaska for decades. While less information is available on bag and beach culture of oysters because of limited experience among local growers, these methods are presented because they appear to hold great potential in some areas.

ASGA surveyed all active growers to gather information used in the manual, particularly in development of recommended husbandry methods. ASGA also interviewed individual growers, gathered recommendations at its 2010 annual meeting, and had the manual reviewed by members of the industry.

The manual represents the pooling of a half-century of combined experience in Alaska aquaculture of its two primary authors, Ray RaLonde, MAP's aquaculture specialist, and me, Rodger Painter. RaLonde has been involved in shellfish aquaculture projects in Alaska too numerous to list over the past three decades as University of Alaska Fairbanks MAP faculty, professor at Sheldon Jackson College in Sitka, and teacher on Annette Island. I've been a shellfish grower and aquaculture researcher/consultant, and have managed numerous projects for ASGA as president or vice president for the past 20 years.

The first edition of the *Alaska Oyster Grower's Manual* was published by MAP in the early 1980s and the third edition in 1987. The first version of the *Alaska Oyster Grower's Manual* pulled together in one place virtually all the information available at that time on farming oysters in Alaska. While the dictionary-size document was helpful, a new farmer would not have been able to negotiate the permitting process or write a business plan based on what he or she read in the manual. The document was also of little help to an experienced farmer considering shifting to a new culture method or wanting to investigate new defouling methods.

Ray RaLonde and I have long discussed the need for creating a new resource document for new and experienced oyster farmers. For me, the manual is the culmination of a decade-long quest to ensure that no one else makes the same mistakes I did during my two decades as an oyster farmer in Alaska.

Funding for the project was provided by the U.S. Department of Agriculture Rural Development program in the form of a Rural Business Enterprise Grant.

Basic Biology of the Pacific Oyster

Chapter 2. Biology of the Pacific Oyster in Alaska: Classification and Anatomy

Raymond RaLonde

Introduction

The Pacific oyster, *Crassostrea gigas*, is not native to the Pacific coast. It was imported from Japan to Puget Sound, Washington, in the early 1900s as a substitute for the declining populations of the Olympia oyster, *Ostrea lurida*, which was devastated by pollution and habitat destruction. Initial seed plantings proved successful, and excellent growth and natural reproduction enabled sustained harvests and revitalization of the fishery, which reached 1.5 million gallons of oyster meats by 1946 (Conte et al. 1997). Further seed planting expanded the fishery to Willapa Bay on the Washington coast, which historically produced approximately two-thirds of the total state harvest. Since 1957, the Washington commercial fishery of native oysters has been replaced by aquaculture.

In conjunction with restoration of Washington oyster population, Alaska began importing Pacific oysters in 1909. Pacific oyster seed was planted on intertidal beaches from Ketchikan, in the most southern part of the state, to Kachemak Bay, 700 miles to the northeast. Production peaked at 550 gallons of shucked meat in 1943 with the industry surviving only in the southern most regions. The demands through unwieldy regulations and difficulties with the remoteness of the farms eventually led to the industry's demise in 1967 (Yancey 1966).

Alaska oyster aquaculture restarted in the late 1970s using raft culture and seed imported from shellfish hatcheries in Washington state to produce live oysters for the live half-shell market (RaLonde 1992). This new oyster farming initiative started from a dozen farmers, continued to grow, and in 2010 the industry consisted of 45 farms spread from Annette Island near the Canada border in southeastern Alaska, to Kachemak Bay (RaLonde et al. 2008).

The shellfish aquaculture industry continues to grow and expand the number of species under cultivation. In this new expansion period the oyster is the only non-native species authorized for farming, even though Alaska Department of Fish and Game regulations ban the importation of non-native species for aquaculture. Grandfathered in, the Pacific oyster can be farmed along the entire shoreline of the Gulf of Alaska. In addition, Pacific oysters exhibit minimal risk because, due to cold temperatures, they cannot reproduce and establish breeding populations in Alaska.

Classification

Oysters are bivalves, meaning they have two shells joined at a hinge. The shell surface texture is rough, caused by extensive fluting of overlapping shell layers. Approximately 100 oyster species distributed worldwide are classified within the animal kingdom as follows:

- Phylum: Mollusca
  - Class: Bivalvia
    - Order: Ostreoida
      - Family: Ostreidae
        - Genus: *Ostrea*
        - Genus: *Saccostrea*
        - Genus: *Crassostrea*

Commercially important oysters narrow down to about six species in these three genera.

Ostrea sp.—flat oysters

- *Ostrea edulis*: The European flat oyster is native from the British Isles to the Mediterranean Sea and introduced to the east coast of the United States in the 1940-50s, providing an aquaculture industry to the northeastern states.
- *Ostrea lurida*: The Olympia oyster is native to the west coast of the United States from central California to Canada. There is no commercial harvest due to low populations and the species is under strict conservation management. A small aquaculture production contributes to the fresh shellfish market.

Saccostrea sp.

- *Saccostrea glomerata:* the Sydney rock oyster is native to Southeast Asia, Australia, and New Zealand, providing approximately 5% of the income of the seafood industry of Australia.

Crassostrea sp.

- *C. virginica* : The eastern oyster is native to the mid-coast of the eastern United States and the Gulf of Mexico. As a native subtidal species, it is both commercially harvested and farmed. Until the past decade, the eastern oyster was the dominant oyster species in the American seafood market (Galtsoff 1964). Chronic disease, habitat damage, and pollution caused substantial population declines of the Eastern oyster. The Pacific oyster, grown on the west coast of North American, later assumed the lead in U.S. production.
- *C. gigas*: Native to Japanese waters, the Pacific oyster is now grown in western North America, Europe, Russia, Australia, and Africa and continues to expand worldwide. Considerable debate surrounds proposals to import the Pacific oyster to the eastern United States to contribute oysters to the stricken seafood industry caused by the decline of the eastern oyster (Quayle 1988).
- *C. sikamea*: Imported from the Ariake Sea region of southern Japan, the Kumamoto oyster is a close relative to the Pacific oyster, often interbreeding with it and producing fertile progeny. Widespread hybridization, resulting in a *gigas*/*sikamea* oyster, has almost completely eliminated pure stock of Kumamoto oysters on the west coast of North

America and only small, isolated populations exist in Japan (Hedgcock et al. 1999, Gaffney and Allen 1993). Due to its low latitude equatorial range, and adaptation to warm water conditions, the Kumamoto oyster is an unlikely candidate for farming in Alaska.

Anatomy of the Pacific Oyster

The first important process to aid your study of oyster anatomy is to correctly orient the oyster specimen. The oyster should be positioned cup down with the hinge to the right. The hinge part of the oyster is the anterior and the opposite end is the posterior, while the upper shell is the dorsal surface and the bottom shell is the ventral surface (Figure 1).

The **mantle** is composed of an edge, a thickened dark tissue that surrounds the interior of the body mass, and a thin sheet that covers the entire body. The mantle membrane often tears and shrinks when the oyster is shucked. The thickened edge of the mantle forms a seal along the margin of the shellfish that helps to control the flow of water inside the oyster. The mantle edge is primarily responsible for growing the shell. The mantle membrane also produces the mother of pearl that covers the inside of the shell.

Digestive system: The **mouth** is located at the anterior end to which two leaf-like **labial palps** are attached. It connects to the stomach via a short esophagus. The labial palps assist in the sorting of particles, choosing higher quality food items and rejecting unwanted particulates. The **stomach,** visible in the photograph, is often completely surrounded by the **digestive gland**. Cutting into the digestive gland reveals a darkened mass of tubules where microalgae are digested; the digestive gland often assumes the color of the food that is eaten. Inside the stomach is the **crystalline style**, a clear, worm-like structure that is, in fact, often misidentified as a worm. The crystalline style contributes enzymes to digest food, and when it is not actively digesting it is small and difficult to see. Connected to the digestive gland is a tubular intestine, which is coiled through the visceral mass. The intestine absorbs digested nutrients and expels waste out the anus.

The **adductor muscle,** located at dorsal/central position, is composed of two tissue types, the smooth and striated muscles. The striated muscle is dark (located beneath the arrowhead in the photograph) while the smooth muscle is pale or white. The striated muscle closes the shell to any point of closure determined by the oyster while the white muscle, also termed the catch muscle, holds the oyster shells tightly together.

Heart: When shucking the oyster, carefully cut the adductor muscle close to the flat upper shell. Remove the membrane mantle and move the tissue away from the ventral side of the adductor muscle. You should be able to see the tubular shaped heart that changes length with beating. Oysters have microscopic blood cells, termed hemocytes, which circulate throughout the body.

The **gonad** is a completely white tissue mass, unlike the digestive gland, and is located at an anterior/dorsal position. It is most prominent during the summer months, after it has been warm enough for gametes, eggs and sperm, to develop. The sex of an oyster can only be determined by microscopic examination of maturing gametes.

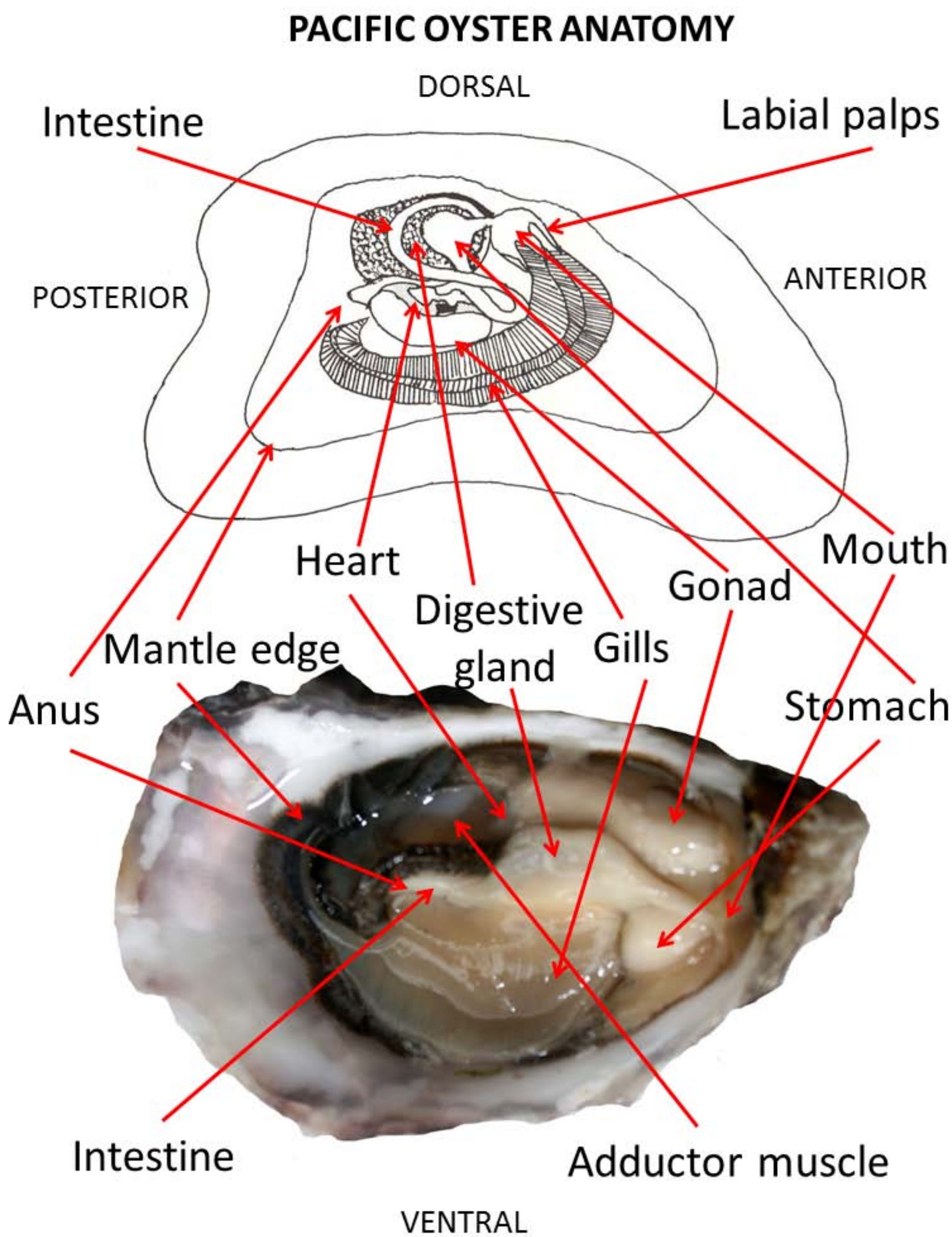


Figure 1. Anatomy of the Pacific oyster.

The Shell

The Pacific oyster is commonly called the "cupped oyster" because of the deeply cupped upper or right shell that cements it to the substrate (the surface that it grows on) (Figure 2). Shell shape and hardness are highly variable and are influenced by environmental conditions, farming growout techniques, and substrate composition where the oyster grows. On muddy substrate, oysters tend to be flattened and become shoe-shaped while a hard substrate deepens the cup, forms an oval shell, and tends to be harder and more brittle in higher salinities (Quayle 1988). Overcrowded oysters often develop irregular shell shapes and a shallow cup. Frequent handling, 2-3 times during each May to October growing season, results in a thicker uniform shell shape and deeper cup with more meat weight.

Figure 2. Cupped shell of the Pacific oyster. The hinge is on the left.

Pacific oysters naturally grow in the intertidal zone where they are out of the water for several hours each day. When oysters are periodically exposed to air in the warmer waters of the intertidal zone, the buffeting action of waves produces thicker shells than when developed in suspended culture.

Shell Structure

The oyster shell is a three-layered exoskeleton. The periostracum is an organic outer layer of the shell that has undergone "tanning" to form a thin structurally hardened brittle covering of the shell. The periostracum is evident only in small oysters and totally lacking in adults. The external shell visible in adult oysters is the prismatic layer, formed from layers of calcium carbonate that compose the majority of the shell mass. The calcium carbonate crystals are formed within an organic material matrix. The internal surface is the nacreous layer, called mother of pearl (Figure 3). Soft calcite deposits often form irregularities on top of the nacreous layer. These soft deposits contain little calcium and can form internal shell bumps or chambers, called chambering. The chambering process may be an adaptive response of oysters to reduce internal open volume in response to drastic changes in salinity, injury, or dramatic reductions in body mass (Quayle 1988).

Figure 3. Internal shell surface. Notice white calcium deposits, the development of chambering, and thin new shell growth. A remnant of the brown conchiolin hinge is on the right.

The two shells join at the pointed anterior end by a tough flexible hinge made of a protein matrix called conchiolin. The hinge joins the two shells and keeps the shells sprung open, acting in opposition to the adductor muscle. A large centrally located adductor muscle acts to close the shells. When an oyster dies, the complete loss of adductor muscle function causes the shell to gap open, called a gaper. This is a clear indication for consumers to identify dead or weakened oysters prior to purchase.

The Mantle

Removal of the flat top shell exposes the soft body tissues. The dominant body part exposed is the mantle, which forms the shell and repairs damage to the shell. The mantle is a two-lobed structure covering the internal surface of both shells, fused together at a single point near the hinge. Each mantle lobe is composed of two major anatomical structures: the mantle edge and the general surface covering. The mantle edge is a dark thickened tissue surrounding the internal edge of the shell, attached to a thin membrane that covers the inner shell surface (Figure 4).

Figure 4. Internal tissue of the oyster, showing the dark edge of the mantle.

In cross section, the mantle edge has three folds: the outer, middle, and inner lobes. The outer lobe, attached to the shell, functions to form the shell, contributing to oyster length and width. The inner lobe forms the outer shell periostracum layer in young oysters. The large highly muscular mantle edge also functions to provide a seal that retains internal fluids while the oyster is out of the water. The middle lobe has a sensory function, detecting the chemical properties of water passing over it (Quayle 1988). The entire mantle surface secretes layers that add to the shell, increasing shell thickness and size.

The Mantle's Role in Shell Construction and Repair

The live half-shell market has grown along the west coast of North America and the attention to quality is paramount for Alaskan farmers. Shell shape and quality is a predominant feature in assessing quality. As mentioned earlier, the oyster shell is quite variable in shape, highly influenced by environmental conditions and farm practices. Oyster buyers and consumers prefer hard shells that do not fragment when shucked, a deeply cupped shell that contains more meat, and moist meat that does not drain during shipment due to poorly sealed shell edges.

Oysters grown in the cold waters of Alaska form shells that are less dense than oysters grown in warmer waters. Close examination shows that the crystalline structure of the prismatic layers is irregular, causing the layers to be more porous and thus lighter and more fragile (Galtsoff 1967). Other features such as reversed hinges, chipped unhealed shell margins, and shallow shell cup demonstrate to consumers that the farmer has not conducted practices that enhance shell quality, and consequently meat quantity.

Forming the shell is a complex process, and an understanding of the shell synthesis (production) and repair provides rationale for site selection, adopting farm operational practices, and developing quality standards that are based on science. The foundation to understanding shell formation lies with the function of the mantle from which the shell is constructed. Comprehensive descriptions can be found in Sakeyddub and Wilbur 1983, Watabe 1983, Sikes and Wheeler 1986, and Johnstone et al. 2008.

Two membrane sheets, the inner and outer epithelium, blanket the inner shell surface. Each layer is only one cell thick and is easily torn when the oyster is shucked. Both the epithelium and the edge of the mantle form the shell, but their mechanisms are different.

The mantle epithelium primarily contributes to the nacreous layer (mother of pearl) covering the inside of the shells. It adds very little to the shell thickness. When shell damage occurs toward the middle of the shell, the epithelium slowly repairs the damage by first covering the area with an organic matrix, and then lays down calcium carbonate layers (Sakeyddub and Wilbur 1983). The patched area is structurally different from the undamaged portion of the shell. Since the epithelium has limited capacity to repair severe damage and repair time is relatively slow, any badly damaged shellfish will likely die.

Figure 5. Oyster shell shapes: rabbit-eared on left and oval on right.

The thickened margin of the mantle is a particularly active site of shell formation, contributing shell to enlarge the oyster and increase shell thickness. The posterior part of the mantle margin, the part of the shell opposite the hinge, most actively contributes to growth that increases shell length. Disproportional shell growth that favors the posterior edge can cause oysters to be long and thin, termed "shoe-shaped" or "rabbit-eared" oysters. Flat elongated shellfish are common when grown undisturbed in subtidal areas or in soft substrate (Figure 5). Shell growth along the narrow side of the oyster shell is slower.

The margins of the mantle are effective in repairing the damaged edges of the shell, and when mantle margins are active in edge repair, the cup of the top shell deepens (Watabe 1983). The process of shell edge chipping, subsequent repair, and cup deepening occur in oyster farming through regular handling and tumbling, which chips away new shell edge growth. The deeper cup holds a higher meat content. Regular handling also prevents rabbit-eared oysters by widening the shell.

The mantle function warrants a word of caution with respect to oyster handling practices on the farm. It can be a problem if handlers assume that, "If a little is good, more is better." Such a handling strategy can do more harm than good. Consider that:

1. Intensive handling and tumbling is labor intensive and time consuming.
2. Frequent handling may not allow adequate healing time between handlings. Remember that tumbling is also stressful to the oyster. Research shows that rough handling suppresses the oyster's immune response capability and requires at least four days for full recovery (Lacoste et al. 2009). Repeated handling that does not allow for healing and return of immune function can lead to lengthening the stress recovery period (Lacoste et al. 2002).
3. Too much handing can create rabbit-eared oysters if the new growth at the posterior edge of the shell is not sufficiently removed.

In addition, farmers should be concerned that shell formation is not disrupted by rough handling. The thickened edge of the mantle is lightly attached to the inside of the oyster shell, allowing the epidermal/perimeter mantle components attached to the shell to form a sealed chamber called the pallial chamber. The function of the pallial chamber is to concentrate and contain calcium carbonate in a supersaturated solution, as seawater enters the body cavity and is filtered through the thin mantle epithelium surface and into the pallial chamber (Figure 6). Shell formation can happen only when the concentration of calcium carbonate in the pallial chamber is greater than the surrounding seawater. If rough handling damages the mantle a "leak" of the pallial chamber occurs, and the concentrated calcium carbonate solution empties. This loss of fluid slows or stops new shell formation and repair.

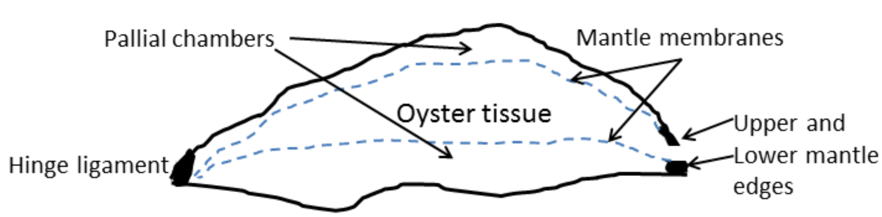


Figure 6. Side view of oyster with mantle edges and membrane enclosing two pallial chambers.

A damaged mantle is repairable, but this complex process takes time. In addition, some incompatible ions, magnesium, or organic particles entering the pallial chamber inhibit calcium carbonate crystal formation (Watabe 1983).

You can evaluate the integrity of the pallial chamber by tasting an oyster. When the pallial chamber of an oyster fresh out of the water is punctured, the internal fluid tastes very salty because of the concentrated calcium carbonate salt solution. Oysters held in dry storage for a while are less salty because the pallial chamber has emptied into the oyster body cavity, diluting the salts.

A number of environmental factors dramatically reduce shell growth and repair. These include seasonal cooling of water temperature, a decline in salinity and nutrients, and an increase in turbidity (Quayle 1988, Johnstone et al. 2008). These environmental factors have greater impact on the shell repair process than on normal shellfish growth. The take-home message to farmers is to schedule intense handling or tumbling well before the onset of winter and during a time of minimal freshwater influence.

Shell Surface Texture and Color

The texture of the oyster shell surface is rough and often has partially overlapping plates that lay down like shingles. This form of plating is called fluting (Figure 7). The fluting phenomenon is caused by irregular growth activation of the mantle due to changes in environmental conditions (Sikes and Wheeler 1986).

Figure 7. Oyster with fluted shell. The beautiful color of this shell is largely determined by genetics, not environment.

Due to the significant organic matrix in oyster shells and the vulnerability to fluting, oysters grown intertidally in Alaska can be subject to extreme shell damage caused by the winter freezing and thawing process, similar to fractured pipes in household plumbing. Oysters that are repeatedly frozen and thawed have the appearance of being normal, but shells pulverize and can even be crushed in the hand. Before attempting intertidal growout of oysters, carefully check the climate history of the farm site area.

Surface shellfish colors of the Pacific oyster are variable, ranging from black, to various colored mottling, to pure white. Recent research indicates that shell color has a strong genetic component. The genetic pattern is an additive genetic variance. This means that breeding a dark shelled oyster with one that is light colored produces offspring with intermediate coloration contributed from both parents. The light colored gene appears to be dominant (Evans et al. 2009).

Gills

Removal of the mantle exposes the gills, primarily responsible for capturing oxygen that will be distributed to body tissues. Gills are greenish to brown, and their surface is composed of fused lamellae that appear as lines across the gill surface (Figure 8). There are eight gills, four on each side of the body. The four gills are fused along the base and attached to the mantle edge. Across the lamellae are finger-like plicae that have openings, collectively termed ostea, where oxygen is extracted from the water.

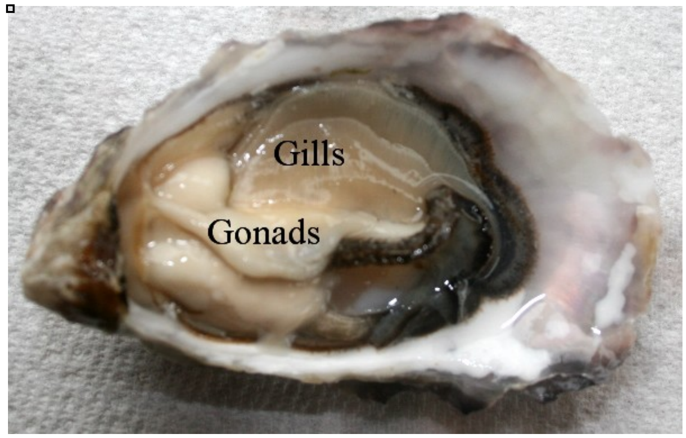


Figure 8. Four sheets of gills are shown. There are four more under the body. Also evident is a sizable white gonad.

Covering the surface of the gills are many cilia (fine hair-like structures that bend and beat in unison). The cilia move water over the gills, transporting food and cleaning the gill surface of unwanted particles. Unlike a clam, the Pacific oyster does not have incurrent and excurrent siphons through which water enters and exits the shell. In the oyster, water enters the shell through an opening on the ventral side of the shell (the side with gills), circulates in a counterclockwise motion, and exits along the posterior end of the shell where another set of cilia move food particles toward the mouth (Quayle 1988). At the entrance to the mouth, labial palps perform additional sorting, moving larger particulates away from the mouth and disposing of them on the surface of the mantle covering. Smaller particulates, including microalgae, are sifted out and directed to the mouth to be digested. Post digestion waste is called feces, and rejected particles are known as pseudofeces (false feces) because the ejection occurs prior to digestion.

Digestive System

Structure and Function

The digestive system, which is closely associated with the gills, is composed of the mouth, a short esophagus, stomach, digestive gland, intestine, and anus. Food travels through the esophagus to a highly grooved stomach. Attached to the stomach is a mass of minute tubular structures called digestive diverticula (pouches), together called the digestive gland (Figure 9). The digestive

Figure 9. Tucked within the gonad mass is the dark digestive gland. These gonads are particularly runny.

diverticula digest food particles. The digestive gland changes color based on the color of the food being eaten.

When food first reaches the stomach, the particles contact a unique structure called the crystalline style (Figure 10). Having the appearance of a semitransparent worm, and often confused with one, the crystalline style excretes digestive enzymes, enhancing the digestive process (Quayle 1988). When the oyster is actively feeding, the crystalline style is enlarged and actively processing food, but when the oyster is not feeding (e.g., out of the water at low tide, during dry storage, and shipping) the crystalline style nearly disappears. Evidence of the crystalline style is and indicator of freshness. Sorting through particles continues through the digestive system; larger unwanted particles are shunted directly to the intestine rather than the digestive diverticula and ultimately ejected as feces.

Figure 10. Tube-shaped crystalline style.

The intestine solidifies the wastes into a string shape; waste excretes out the anus and is expelled through the posterior excurrent opening. Wastes are not expelled from the body in an organized manner, but collect in the shell until they are then expelled with water movement created by opening and closing (clapping) of the shell.

The open water circulation system of an oyster lacks controlling elements such as tubes and valves, enabling oysters to live in relatively turbid environments because the water flow system is not subject to clogging at portals of entry and exit.

Circulatory System

The circulatory system delivers oxygen and nutrients to tissues and carries away metabolic waste products. The circulatory system of mollusks is quite simple, composed of a heart located near the adductor muscle and a very complex and diverse delivery system. The heart can be seen pulsating in a freshly opened oyster. The blood of oysters, or hemolymph, is a clear fluid that flows through veins and arteries, which control the blood flow system to a modest degree, but there are no smaller vessels or capillaries. Two axillary pumps, which are expanded arteries, help to smooth the delivery of blood. Primitive kidneys filter the hemolymph (Quayle 1988).

Hemolymph is composed of fluid carrying proteins that fight infections by collecting and binding bacteria and eventually destroying them. Hormones are transported through the hemolymph to tissues, where they enable the oyster to adapt to environmental changes. Also contained within the hemolymph are circulating cells termed hemocytes. Their function is immune response by consuming and digesting foreign particles that include bacteria and parasites (Lacoste et al. 2002). Hemocytes also mediate shell growth and repair (Mount et al. 2004). The study of the role of hemocytes in shellfish is a relatively new field of investigation and much still needs to be learned.

Nervous System

Oysters have three nerve cell aggregations, rather than a central nervous system. Nerves from cerebro-pleural ganglia pass through the mouth, stomach, and tissues near the hinge. The visceral ganglia connect to the adductor muscle and posterior area opposite the hinge. The function of the abdominal sense organ remains unknown (Quayle 1988). Although apparently primitive, the nervous system is responsive to environmental stimuli. This results in coordinated hormone responses, enabling oysters to adapt to environmental stress.

The environment of an oyster is extremely variable and requires nearly constant adjustments to a new status of normalcy, called homeostasis. A major hormone group involved with homeostatic function is catecholamine in the form of noradrenaline and dopamine, which are supplied to the appropriate organs by the hemolymph in times of stress (Lacoste et al. 2009).

The main environmental stressors to an oyster are shaking and changes in temperature and salinity. When a stress event occurs, circulating catachalomine levels rise, and as the stress is relieved the levels decrease. The time duration to achieve normalcy varies. It takes an oyster approximately 4 hours to fully recover from the stress of 15 minutes of shaking. Adapting to a temperature increase from 15 to 28ºC or a drop in salinity from 34 to 24 parts per thousand takes about 96 hours. Repeated stressing requires a much longer time to adjust (Lacoste et al. 2002).

Muscular System

A muscle that needs special consideration is the adductor muscle that closes the oyster shells to protect the body and latch the shell in position, preventing opening. In a relaxed state, an oyster's shells are wide open and held in position by a tough ligament. The natural tendency is for the shells to be held open by the hinge ligament, and only the contraction of the striated (opaque) portion of the adductor muscle can close the shell. A dead oyster, which does not have a functioning adductor muscle, is identified by shells that are permanently gaped open. The striated muscle holds the shell at any position, from wide open to completely shut, requiring a considerable amount of energy to perform the closing task. Also included in the task of the striated adductor is clapping the shells

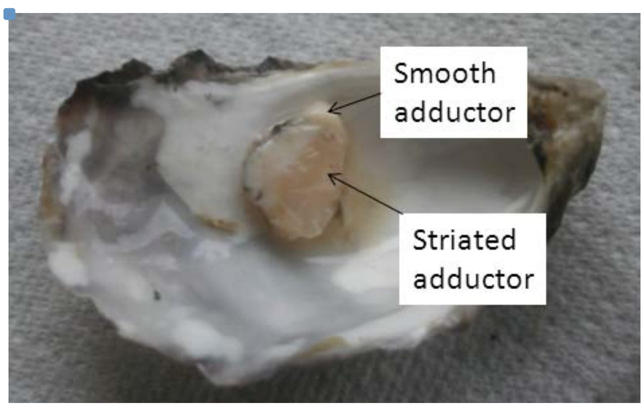


Figure 11. Smooth and striated adductor muscle.

to clean out the interior from excess particle accumulation. The striated muscle does not sustain closed shells, but moves the shells closer together (Hopkins 1936, Millman 1964).

Keeping the shell shut is a function of the smooth (white) muscle (Figure 11). The smooth muscle is termed the catch muscle and latches the position of the shells in a position as determined by the striated muscle. The striated muscle can fatigue, but the catch muscle does not (Millman 1964).

The physiological nature of the two muscles leads to a controversial topic of hardening oysters prior to shipping. Hardening is performed by placing the oysters at about a plus 5 tidal height for three weeks. This presumably strengthens the adductor muscle by forcing it to open and close the shell every time the tide flows in and out, enabling the oyster to remain shut during shipping and out-of-water storage. Such a practice may strengthen the striated muscle, but the white muscle latches the shells in a closed position. So, what happens during hardening? Is some other mechanism developed through the hardening process that keeps the shellfish shut?

The Pacific oyster is a complex living organism that has sophisticated physiological functions to respond to its environment. As an oyster farmer, you are part of the oyster's new environment and your participation is essential to produce a quality product for the seafood consumer.

Bibliography

Conte, F.S., S.C. Harbell, and R.L. RaLonde. 1997. Oyster culture: Fundamentals and technology of the west coast industry. Western Regional Aquaculture Center, publication no. 94-101.

Evans, S., M.D. Camara, and C.J. Langdon. 2009. Heritability of shell pigmentation in the Pacific oyster, *Crassostrea gigas*. Aquaculture 286:211-216. http://dx.doi.org/10.1016/j.aquaculture.2008.09.022

Gaffney, P.M., and S.K. Allen Jr. 1993. Hybridization among *Crassostrea* species: A review. Aquaculture 116(1):1-13. http://dx.doi.org/10.1016/0044-8486(93)90217-M

Galtsoff, P.S. 1967. The American oyster, *Crassostrea virginica* (Gmelin). U.S. Fish and Wildlife Service Bulletin 64. 430 pp.

Hedgecock, D., G. Li, and M.A. Banks. 1999. Occurrence of the Kumamoto oyster *Crassostrea sikamea* in the Ariake Sea, Japan. Marine Biology 133(1):65-68. http://dx.doi.org/10.1007/s002270050443

Hopkins, A.E. 1936. Activity of the adductor muscle in oysters. Physiol. Zool. 9(4):498-507.

Johnstone, M.B., S. Ellis, and A. Mount. 2008. Visualization of shell matrix proteins in hemocytes and tissues of the eastern oyster, *Crassostrea virginica*. J. Exp. Zool. 310B:227-239. http://dx.doi.org/10.1002/jez.b.21206

Lacoste, A., S.K. Malham, A. Cueff, and S.A. Poulet. 2009. Stress-induced catecholamine changes in the hemolymph of the oyster *Crassostrea gigas*. Gen. Comp. Endocr. 122(2):181-188. http://dx.doi.org/10.1006/gcen.2001.7629

Lacoste, A., S.K. Malham, F. Gélébart, A. Cueff, and S.A. Poulet. 2002. Stress-induced immune changes in the oyster *Crassostrea gigas*. Dev. Comp. Immunol. 1:109.

Millman, B.M. 1964. Contraction in the opaque part of the adductor muscle of the oyster (*Crassostrea angulata*). J. Physiol. 173:238-262.

Mount, A.S., A.P. Wheeler, R.P. Paradkar, and D. Snider. 2004. Hemocyte-mediated shell mineralization in the eastern oyster. Science 304(5668):297-300. http://dx.doi.org/10.1126/science.1090506

Quayle, D.B. 1988. Pacific oyster culture in British Columbia. Can. Bull. Fish. Aquat. Sci. 218. 241 pp.

RaLonde, R. 1992. Growing shellfish in Alaska. Alaska's Marine Resources 7(4). Alaska Sea Grant, University of Alaska Fairbanks.

RaLonde, R.L., A.C.M. Oliveira, B. Himelbloom, C. Crapo, C. Vorholt, and Q. Fong. 2008. Pacific oyster (*Crassostrea gigas*) mariculture in Alaska. World Aquaculture Magazine 39(2).

Sakeyddub, A.S.M., and K.M. Wilbur. 1983. Shell formation. In: K. Wilbur (ed.), The Mollusca Part 4, Physiology Part 1. Academic Press New York, pp. 235-287.

Sikes, C.S., and A.P. Wheeler. 1986. The organic matrix from oyster shell as a regulator of calcification in vivo. Biol. Bull. 170:494-505. http://dx.doi.org/10.2307/1541857

Watabe, N. 1983. Shell repair. In: K. Wilbur (ed.), The Mollusca Part 4, Physiology Part 1. Academic Press, New York, pp. 289-316.

Yancey, R.M. 1966. Review of oyster culture in Alaska, 1910-1961. Proceedings of the National Shellfisheries Association 56.

Chapter 3. Biology of the Pacific Oyster in Alaska: Feeding and Nutrition

Raymond RaLonde

Feeding Mechanisms

Oysters obtain nutrition from direct consumption of live phytoplankton and particulate organic matter (POM). While this statement implies a broad, diverse diet, oysters exhibit various levels of particle selection based on food particle size, the amount of particles, and nutritional quality (Pauley et al. 1988) (Figure 1)

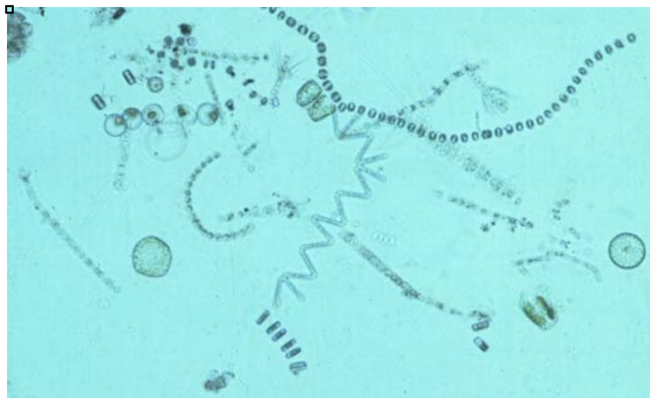


Figure 1. Spring plankton bloom in Sitka Sound showing a mixture of diatoms. Plankton variety makes an excellent meal for oysters.

Oysters, like all bivalves, have a particle sorting process performed by the ctenidia, fine hair-like structures that cover the surface of the gill. Ctenidia sort the particles by size with only about 15% of small particles (<5 µm (micrometer; 5/1000 of a mm) retained. As the cell size of the phytoplankton increases, the retention level reaches 100% at about 9 µm cell size (Ward et al 1998). Oysters also have cell size sorting capabilities that reject large celled phytoplankton of particular species. For example the eastern oyster, *Crassostrea virginica*, retains *Pseudo-nitzschia* phytoplankton cells 24-28 µm in size, but rejects cell sizes between 82-90 µm of the sample species (Mafra et al. 2009). Ctenidia filter out large nonliving particulates and silt from turbid water, which are then expelled as pseudofeces by a process of shell clapping to clear unwanted sediment and particulates collected inside the shell.

This cleaning capacity is presumed to be an adaptation to growing in more turbid water conditions and improves the quality of the food eventually consumed (Quayle 1988).

Phytoplankton as a Food Source

Marine photosynthetic phytoplankton, single-cells and cell chains, is the predominant source of nutrients for oysters. It is primarily composed of two groups: diatoms and dinoflagellates (Figure 2).

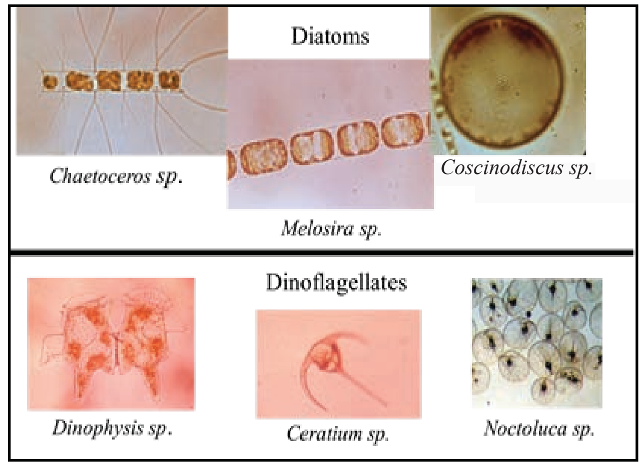


Figure 2. Examples of phytoplankton in Alaska waters. Note: *Coscinodiscus* and *Noctoluca* are the largest and are less efficiently captured by oysters as food.

Most abundant during spring and fall, phytoplankton blooms develop rapidly with sustained cell division increasing the number of phytoplankton. The bloom intensity eventually levels off and declines until cell numbers "crash" to low levels. Crashing is caused primarily by two mechanisms: depletion of nutrients that support the bloom and foraging on the cells by microscopic invertebrates.

In Alaska, diatoms dominate spring and early fall phytoplankton blooms while dinoflagellates peak during the summer. Diatoms are a nutritious food source for oysters and experienced shellfish farmers attest to significant growth spurts during spring and early fall.

Blooms can demonstrate explosive growth in phytoplankton cell numbers. A single species may dominate the bloom for a short time, only to crash and be replaced by another species (Table 1).

Table 1. Dynamics of a spring diatom bloom in Sitka Sound, Alaska. Phytoplankton cell counts per 2 ml. Notice the explosive blooms and declines in April.

Genus	*27-Feb*	3-Mar	6-Mar	10-Mar	13-Mar	17-Mar	20-Mar	24-Mar
Biddulphia	*420*	945	1,358	292	408	933	3,273	712
Coscinodiscus	*7*	16	2	12	13	10	12	14
Thalassiosira	*2*	222	12	3	0	14	33	18
Chaetoceros	*0*	9	4	0	4	0	0	0

	27-Mar	1-Apr	3-Apr	7-Apr	10-Apr	14-Apr	18-Apr	21-Apr
Biddulphia	*5,789*	968	784	0	2,623	467	93	856
Coscinodiscus	*9*	4	4	21	740	196	13,739	7
Thalassiosira	*169*	356	248	12,890	33,808	7,528	2,856	2,556
Chaetoceros	*5*	0	0	53,056	812,787	176,625	410,370	47,001

Particle Size and Turbidity

Phytoplankton are in three major size categories: microplankton, nanoplankton, and picoplankton (Table 2). Most nutrients are contributed to oysters by nanoplankton and microplankton; picoplankton are not retained by their filtering system (Ward et al. 1998, Dupuy et al. 2000). The nutrient quality of the phytoplankton is essential to the health, growth, and reproductive success of oysters. The labial palps select for food nutritional qualities, retaining high quality nutrient particles.

Table 2. Phytoplankton food categories, cell sizes, and groups.

Category	Cell size (microns)	Groups
Microplankton	20-200	Larger diatoms, most phytoplankton, ciliates
Nanoplankton	2-20	Small diatoms, flagellates, dinoflagellates, green algae, golden brown algae
Picoplankton	0.2-2	Bacteria, blue-green algae

High turbidity reduces the efficiency of particle retention because the oyster must expend the effort to sort and expel unwanted particles, and highly nutritious food may not be fully utilized. High turbidity causes rejection of small particles, less than 12 µm, which may compose a substantial portion of the oyster diet (Pastoureaud et al. 1996, Beninger et al. 2008). Oysters are adapted for short periods of high turbidity, having developed the sorting system to handle the high load. But longer duration turbidity can lead to poor growth.

Low turbidity conditions enable oysters to capture and retain small particles that can be highly nutritious. I conducted the first oyster nursery project in Alaska at Little Jakolof Bay in Kachemak Bay. The site appeared to be extremely unproductive with no evidence of a major phytoplankton bloom for the entire summer. The water was very clear—the bottom of the bay, at 30 feet, was visible for almost the entire summer. Yet the oyster seed grew at a good rate, increasing in length from 2 mm to 24 mm in 60 days. There was obviously highly nutritious phytoplankton of small particle size feeding the oyster seed (RaLonde 1994).

Individual bacteria are very small picoplankton and not efficiently captured; however, bacteria may occur in the water attached to organic particles. When bacteria-coated particles are an appropriate size for retention by the oyster, the attached bacteria increase the nutrient value of the food.

Clearance Rate

Oysters regulate the amount they eat and the times of feeding. The feeding rate is termed the clearance rate. A peculiar term, clearance rate refers to the time taken for an oyster to “clear” a volume of water of a known quantity of algae cells. Clearance rate is often measured as liters of water per gram of oyster tissue per day. Water temperature, oyster size, availability of food, quality of food, turbidity, and general health of the oyster can affect clearance rate (Quayle 1988, Ward et al. 1998)

Cool water temperatures reduce the metabolic activity of oysters, decreasing the clearance rate. Larger oysters consume more food and have a higher clearance rate. As food abundance increases, the clearance rate increases to a point, flattens out at some level, and then declines as the plankton bloom grows (Ward et al. 1998). In the presence of excess food, the reduction in clearance rate appears to be an adaptation necessary for the oyster to efficiently process food by preventing excess particles from clogging ingestion and hindering digestion. Excess turbidity also reduces the clearance rate. The take-home message is that more food does not necessarily mean more feeding and subsequent growth. There is only so much food and particulate matter that an oyster can effectively handle.

Feed Timing

Since suspended culture oysters are submerged all the time while being grown, the general assumption is that they are feeding all the time. This is not the case. Oysters grown in their natural intertidal habitat feed when the tide is in, and assimilate the food when they are out of water. They are periodic feeders and the adaptation for this feeding in an intertidal regime carries over to their life as submerged farmed shellfish. In suspended culture, however, they do not time feeding events according to the tidal cycle, but do so at irregular periods.

Nutritional Needs for Oysters

Major nutritional requirements of oysters are in three categories: carbohydrates, protein, and lipids. Carbohydrates originate from photosynthesis in phytoplankton and are composed of crude fiber and various sugars. Of the total carbohydrates, crude fiber dominates, followed by glucose. Crude fiber can vary from 10% to nearly 30% of the total biomass in phytoplankton, and is more prominent in larger phytoplankton as it provides structural support for the larger cells. Crude fiber is less digestible than glucose and decreases the food value of the phytoplankton.

Carbohydrates

Photosynthetic algae in sufficient abundance supply the glycogen needs of oysters. When processed by shellfish, glucose is stored as glycogen. Glycogen, a natural animal sugar, is an essential source of energy that is particularly important in development and maturation of eggs and sperm (Conte et al. 1997).

Proteins

Fulfilling the protein requirement of oysters is not usually a problem with adequate food available from all types of algae consumed. Proteins contain amino acids, many of which are essential nutritional requirements. Essential amino acids must be obtained from food eaten by the oyster, while other nonessential amino acids can be synthesized by the oyster. Oyster growth increases on a diet high in protein, but a strong link between lack of function and growth of oysters due to amino acid deficiency in algae is not well documented (Conte et al. 1997).

Lipids

Lipids are also a food requirement. The oyster must get essential fatty acids from lipids in various algae in order to survive, grow, and reproduce. Lipids are in three major groups: phospholipids, fatty acids, and sterols.

Phospholipids are a major structural component of cell membranes. Of particular importance are the cell membranes of circulating hemocyte cells in shellfish hemolymph (blood). Hemocytes have an immune response function and repair tissue damage. In early spring glycogen provides the energy to synthesize phospholipids, which in turn are the energy source to develop and mature eggs and sperm. There is no evidence of phospholipid deficiency in phytoplankton food (Conte et al. 1997).

Fatty acids provide essential energy for metabolism in shellfish. Alaska oysters contain 14 fatty acids. Polyunsaturated fatty acids (PUFA) are essential fatty acids, which can be obtained only from phytoplankton; PUFA have the highest concentration at about 50.4% of the total fatty acid composition in oysters (Oliveira et al. 2006). PUFA incorporate into cell membranes of oyster tissues to improve "fluidity" or functionality of the cell membrane in cold climates. Of the food resources available to oysters, diatoms contain the largest amount of PUFA (Akman and Tocher 1968).

Nutritional Value of Phytoplankton

The nutritional values of phytoplankton are difficult to measure since the absolute values at any given time can vary. Some factors that determine nutritional value are:

- *Species*: Some species inherently have greater nutritional value than others. For example, there are higher PUFA concentrations in diatoms than in dinoflagellates (Leblond and Chapman 2000).

- *Cell size*: Small cell algae are often more nutritious than large cell algae, i.e., small *Isochrysis* vs. large *Coscinodiscus* (Zhukova and Aizdaicher 1994).

- *Stage of the plankton bloom*: Phytoplankton is most nutritious during the exponential growth phase (Ackman et al. 1963). Plankton blooms start with a small number of cells, and then explode in abundance. The dramatic increase in cell number generated by a bloom is called the exponential growth phase. The bloom eventually decreases growth and levels off, caused by a deficiency in nitrogen and necessary minor elements and grazing by zooplankton. This phase is termed the stationary phase. The bloom continues to decrease and crash, often followed by another species dominating and going through the same process.

- *Environmental factors*: Light, salinity, water temperature, and nutrients all support and affect bloom intensity. If they are less than ideal, the phytoplankton may be less nutritious.

Cell Size
While small cell algae are often more nutritious than large cell algae, cell size does not always indicate the nutritional value. For example, *Isochrysis galbana* at 4.30 µm in size has the same nutritional value as *Skeletonema costatum* with a cell size of 9.94 µm.

Environment
When held in the same environment, different species of phytoplankton can have vastly different nutritional values as shown in Table 3.

Table 3. Proximal analysis of phytoplankton algal cells in Alaska as a percent of dry weight. (Source: Parsons et al. 1961)

Species	Protein	Carbohydrate	Fat (lipid)
Chaetoceros sp.	35	6.6	6.9
Skeletonema costatum	37	20.8	4.7
Coscinodiscus sp.	17	4.1	1.8

In addition to poor nutritional quality of *Coscinodiscus*, this species has a very large cell size and grows very slowly, making it a particularly poor food source. A general rule in evaluating a site for oyster farming is to seek phytoplankton variety—not the abundance of a particular species (Parsons et al. 1961).

Essential Lipids
Of particular importance for oyster nutrition are the quality and quantity of essential fatty acids in phytoplankton (Figure 3). As mentioned earlier, specific fatty acids are essential, in particular the polyunsaturated fatty acids eicosapentaenoic (EPA) and docosahexaenoic (DHA).

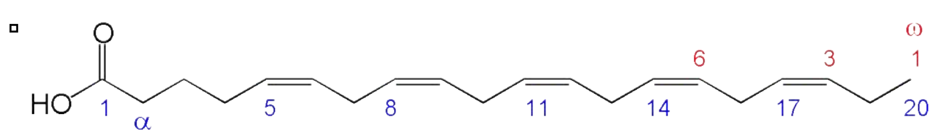


Figure 3. Fatty acid structure for DHA.

Diatoms provide EPA and dinoflagellates provide DHA fatty acids, and the species vary in EPA and DHA amounts (Table 4). The diatoms in Table 4 contain concentrations of PUFA fatty acids essential for oyster growth and conditioning.

Table 4. Percent PUFA concentrations in selected phytoplankton.

Species	EPA	DHA
Diatoms		
Skeletonema costatus	15.4	2.3
Chaetoceros constrictus	18.8	0.6
Biddulphia sinensis	15.4	Trace
Dinoflagellates		
Gymnodinium sp.	Trace	4.0
Protocentrum triestinum	8.4	4.4

Source: Parsons et al. 1961, Leblond and Chapman 2000.

Steroids are another essential lipid that oysters are incapable of synthesizing. The primary sterol in oysters is cholesterol, which is responsible for formation of cell membranes including developing eggs (Knauer et al. 1998). As a precursor for hormone formation, sterols also control reproduction in invertebrates. To facilitate the reproductive process, oysters acquire sterols stored in other tissues such at the adductor muscle when necessary (Danton et al. 1999).

Conclusion

Environmental conditions profoundly influence the food quantity and quality that establish the nutritional status of oysters. Understanding basic nutritional requirements may help explain interannual differences in growth and unexpected mortalities, particularly over the winter. Ultimately, the nutritional condition of the oyster determines the quality of the meat purchased by the consumer.

Bibliography

Ackman, R.G., and C.S. Tocher. 1968. Marine phytoplankton fatty acids. J. Fish. Res. Board Can. 25(8):1603-1620. http://dx.doi.org/10.1139/f68-145

Ackman, R.G., P.M. Jangaard, R.J. Hoyle, and H. Brockerhoff. 1963. Origin of marine fatty acids. I. Analyses of the fatty acids produced by the diatom *Skeletonema costatum*. J. Fish. Res. Board Can. 21(4):747-756. http://dx.doi.org/10.1139/f64-067

Beninger, P.G., A. Valdizan, P. Decottignies, and B. Cognie. 2008. Impact of seston characteristics on qualitative particle selection sites and efficiencies in the pseudolamellibranch bivalve *Crassostrea gigas*. J. Exp. Mar. Biol. Ecol. 360(1):9-14. http://dx.doi.org/10.1016/j.jembe.2008.03.003

Conte, F.S., S.C. Harbell, and R.L. RaLonde. 1997. Oyster culture: Fundamentals and technology of the west coast industry. Western Regional Aquaculture Center, publication no. 94-101.

Danton, E., B. Véron, and M. Mathieu. 1999. Influence of diet level on sterols of diploid and triploid oysters *Crassostrea gigas* (Thunberg). J. Exp. Mar. Biol. Ecol. 233(2):259-267. http://dx.doi.org/10.1016/S0022-0981(98)00132-4

Dupuy, C., A. Vaquer. T. Lam-Höai, C. Rougier, N. Mazouni, J. Lautier, Y. Collos, and S. Le Gall. 2000. Feeding rate of the oyster *Crassostrea gigas* in a natural planktonic community of the Mediterranean Thau Lagoon. Mar. Ecol. Prog. Ser. 205:171-184. http://dx.doi.org/10.3354/meps205171

Knauer, J., R.G. Kerr, D. Lindley, and P.C. Southgate. 1998. Sterol metabolism of Pacific oyster (*Crassostrea gigas*) spat. Comp. Biochem. Physiol. 119B(1):81-84.

Leblond, J.D., and P.J. Chapman. 2000. Lipid class distribution of highly unsaturated long chain fatty acids in marine dinoflagellates. J. Phycol. 36(6):1103-1108. http://dx.doi.org/10.1046/j.1529-8817.2000.00018.x

Mafra Jr., L.L., V.M. Bricelj, C. Ouellette, C. Léger, and S.S. Bates. 2009. Mechanisms contributing to low domoic acid uptake by oysters feeding on *Pseudo-nitzschia* cells. I. Filtration and pseudofeces production. Aquat. Biol. 6:213-226. http://dx.doi.org/10.3354/ab00122

Oliveira, A.C.M., B. Himelbloom, C.A. Crapo, C. Vorholt, Q. Fong, and R. RaLonde. 2006. Quality of Alaskan maricultured oysters (*Crassostrea gigas*): A one-year survey. J. Food Sci. 7(9):C532-C543. http://dx.doi.org/10.1111/j.1750-3841.2006.00186.x

Parsons, T.R., K. Stephens, and J.D.H. Strickland. 1961. On the chemical composition of eleven species of marine phytoplankton. J. Fish. Res. Board Can. 18(6):101-116.

Pastoureaud, A., M. Heral, J. Prou, D. Razet, and P. Russu. 1996. Particle selection in the oyster *Crassostrea gigas* (Thunberg) studied by pigment HPLC analysis under natural food conditions. Oceanologica Acta 19(1):79-88.

Pauley, G.B., B. Van Der Raay, and D. Troutt. 1988. Pacific oyster. Biological Report 82(11.85). 29 pp. U.S. Fish and Wildlife Service.

Quayle, D.B. 1988. Pacific oyster culture in British Columbia. Can. Bull. Fish. Aquat. Sci. 218. 241 pp.

RaLonde, R.L. 1994. Oyster spat nursery system feasibility study for Kachemak Bay, Alaska Project of the Kenai Peninsula Borough Economic Development District Symposium.

Ward, J.E., J.S. Levinton, S.E. Shumway, and T. Cucci. 1998. Particle sorting in bivalves: In vivo determination of the pallial organs of selection. Mar. Biol. 131(2):283-292. http://dx.doi.org/10.1007/s002270050321

Zhukova, N.V., and N.A. Aizdaicher.1994. Fatty-acid composition of 15 species of marine microalgae. Phytochemistry 39(2):351-356. http://dx.doi.org/10.1016/0031-9422(94)00913-E

Chapter 4. Biology of the Pacific Oyster in Alaska: Life History and Growth

Raymond RaLonde

Life History

Life Cycle of the Pacific Oyster

Pacific oysters are protandric hermaphrodites, meaning that an individual can be a male or female. In year 1 before the age of sexual maturity, Pacific oysters are male. The subsequent sexual status can change based on the genetic character of the individual and environmental conditions. Sexual status is most affected by feeding and growth; males are formed during poor growth while females develop during an abundance of food and subsequent growth (Conte et al. 1997). Within their natural range, oysters reproduce during the summer when the water temperature is warmer, and spawning is often induced by a heat shock event when warmed beaches exposed to intensive solar heat during low tides suddenly transfer heat to the water during the incoming tide (Quayle 1988).

Eggs fertilize quickly in the water, followed by trochophore, veliger, and pediveliger larval stages (Figure 1). The time of development from fertilized egg to seed is usually over 30 days in Alaska, and is influenced by water temperature, food availability, and the quality of the substrate as sensed by the pediveliger foot. Cooler water temperatures and a reduced food supply can lengthen the time required for larvae to develop. The larva can also re-suspend in the water and flow in the current drift for an extended period if the setting habitat is not favorable. Extended larval drift will significantly reduce the survivability of the larvae. When appropriate substrate is determined by chemical receptors in the foot of the pediveliger, a cementing compound is secreted and the larva attaches the left shell to the substrate. After setting the larvae undergo profound anatomical changes that eventually form the structures of an adult. The fully transformed oyster is a spat. If a spat is removed from its substrate, it cannot re-cement and remains a single oyster for life and can be sold live for a premium price on the seafood market.

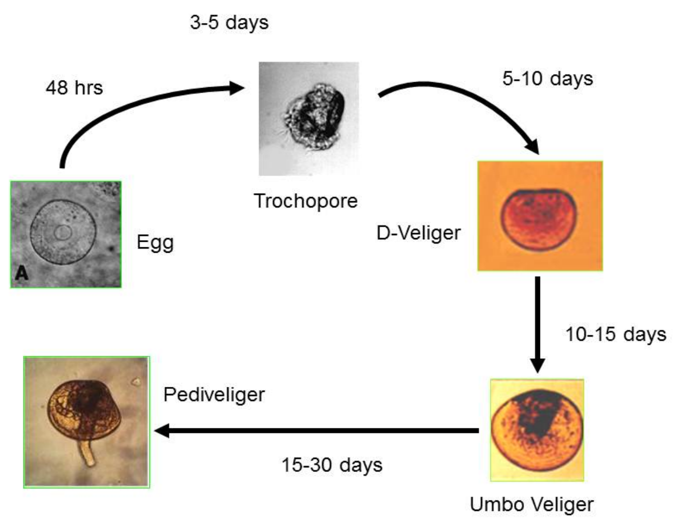


Figure 1. Larval life cycle of the Pacific oyster.

Figure 2. In the spawny oyster on the left, the white milky mass is mature gamete.

In the state of Washington oysters begin sexual maturation in early spring with reproduction occurring in mid July. The larval stage ends in mid to late August, enabling the spat to grow through the fall and undergo conditioning to survive the winter. Unfortunately for the consumer, mature 2-year-old oysters develop eggs and sperm. During later stages of gamete development, the taste and quality of the oyster decreases significantly. What was a sweet, glycogen-rich, clean oyster, is now a bitter milky mass of eggs or sperm with limited marketability (Figure 2).

In Alaska, cold-water temperatures inhibit sexual maturation, and spawning and successful reproduction have not been confirmed. Even in northern latitudes where oysters cannot reproduce successfully, the process of sexual maturation caused by a combination of warmer water temperatures and an abundant food supply can lead to spawning condition and the onset of the poor quality features. Termed "spawny," sexually developing oysters are not marketable. Even more disconcerting is the prospect that spawniness is not easily resolved since, unlike Washington, Alaska oysters do not spawn and purge themselves of gametes. For the Alaska farmer, the best prospect for dealing with spawniness is prevention by selling small 1-year-old oysters as petites or selecting a farm site where water temperatures are cold enough to suppress sexual maturation.

Predicting Sexual Maturation

Mann (1979) established a handy method to estimate the potential onset of sexual maturation and to measure the progress of gamete development. His method uses accumulated daily water temperatures, termed daily thermal units, to estimate a farm site's potential for producing a spawny oyster. The formula for calculating thermal unit accumulation is:

$$D = \sum(t_d - t_o)$$

> D is the total accumulated daily temperature units needed for spawning. (For Pacific oysters D is 592.)
> $\sum$ is a summation sign indicating the addition of all the $(t_d - t_o)$
> t_d = temperature for the day
> t_o = temperature where gonadal develop is suppressed. (For Pacific oysters t_o is 10.55ºC.)

The equation requires that daily water temperatures be recorded at the water depth where the oysters are being grown, then putting the data through the thermal unit calculation function. Water temperature days below 10.55ºC are not counted in the calculation. Below is an example of the process using 7 days of data (Table 1).

Table 1. Example of *D* value calculation for a 7 day period.

Date	Temperature	Temperature minus 10.55ºC
April 1	12.0	1.45
April 2	11.0	0.45
April 3	10.5	–0.05 (eliminate)
April 4	11.0	0.45
April 5	13.0	2.45
April 6	12.0	1.45
April 7	11.5	0.95
D value		7.20

In the calculation of *D* in Table 1, ignoring April 3 where the water temperature was below 10.55ºC, the *D* value for the single week is 7.20. The process of adding daily temperatures should start in early spring when water temperatures approach 10.55ºC and continue through fall.

Table 2 shows *D* values for some areas of Alaska. The method has proven valuable, even though the exact *D* value that creates spawniness in oysters is unknown, and without feed production data it is not an entirely accurate method to compute the time of spawniness. The values in Table 2 were calculated from temperature data from mid May through September 30, and indicate that oysters did not reach a sexual maturity value of $D = 592$ at any of the locations.

Table 2. *D* values of spawniness in five areas of Alaska.

Location	*D* value	Percent toward maturation
Kachemak Bay	158.4	27
Western Prince William Sound	428.7	72
Northern southeast Alaska	161.9	27
Southern southeast Alaska	224.6	38
Annette Island	350.1	59

Local environmental conditions may also be quite different between farms that are close to one other, and gonadal development at the farms can be quite different.

Sexual maturation and spawning does help to guarantee a sustained supply of oysters via natural reproduction. Even in Washington and southern British Columbia, Canada, successful spawning and juvenile oyster survival has been historically irregular, requiring construction and operation of shellfish hatcheries to sustain a reliable source of oyster seed for farmers.

Gametes are also a great location for storing lipids. Since spawning does not occur in Alaska, resorption of gametes, as observed by farmers over the winter, helps to keep the oyster healthy and ultimately improves oyster quality when the lipids from the gametes are fully utilized.

Biochemical Aspects of Maturation and Spawning

Reaching sexual maturity requires significant energy. In humans, the primary source of energy is lipids (fats), while in oysters the primary energy source is glycogen. Oysters have a relatively low lipid content.

The sexual maturation process for the Pacific oyster begins in summer prior to spawning. During their first year of life oysters accumulate the glycogen needed for maturation and eventual spawning, which first occurs in midsummer of their second year. Glycogen is used in the production of protein-based sperm and lipid-based eggs. In late summer after spawning, glycogen resources are depleted and must be revived during late summer and fall to enable reproduction the next summer. In addition, the tissue mass of the oyster reduces after eggs and sperm are released, leaving the oyster relatively "skinny." Late summer and fall is a period of "fattening." More accurately, oysters do not get fat but become plump with the accumulation of glycogen and body mass, as they recover during the period between spawning and winter.

Glycogen is used sparingly over the winter to develop the gonads for egg and sperm production. When early spring arrives, sexual maturation has already started utilizing after-winter glycogen reserves to jump-start the process. Active feeding commences, which increases glycogen production needed to finish gamete development, eventually leading to spawning.

Savvy oyster consumers understand this cycle of events. They know that early summer is a period of spawniness with oysters filled with white milky maturing gametes. They understand that post spawning oysters are lean and flavor deprived. Savvy oyster consumers know that fall oysters fully recovered from spawning depletion and revived with glycogen are sweet, plump, and in prime condition.

In Alaska, with water temperatures too cold to complete the maturation and reproductive process, the cycle of events is quite different. Instead, oysters proceed through their first year, growing tissue and accumulating protein, lipids, and glycogen. The major problem in Alaska, however, is that oysters do not accumulate as much tissue mass as those in Washington, which average 4.4 times more weight over the same growout period than genetically identical oysters grown in Kachemak Bay. The net result is that higher tissue mass will likely prepare oysters to survive and even thrive over winter, whereas skinny oysters have less energy reserves to withstand the nonfeeding winter conditions. Table 3 shows the oyster overwintering process in Alaska. In the fall, glycogen is at its highest, lipids at their typical low level, and protein content also is high. By spring glycogen is modestly reduced to between 11.1% and 13.6%, lipid content is variable, and protein has reduced substantially by 25.5-30.1%.

Table 3. Season variations of oyster biochemistry by region and season in Alaska, 2003 (% w/w).

Region	Season	Glycogen	Change %	Lipids	Change %	Protein	Change %
SE	Fall	8.82	–12.1	0.66	12.1	10.47	–28.1
SE	Spring	8.06		1.31		7.52	
PWS	Fall	11.89	–11.1	1.97	23.7	8.70	–25.5
PWS	Spring	10.57		2.03		7.36	
K Bay	Fall	8.76	–13.6	1.28	–36.7	7.69	–30.1
K Bay	Spring	7.56		0.81		5.33	

Data source: Oliveira et al. 2006.

SE = southeast Alaska; PWS = Prince William Sound; K Bay = Kachemak Bay.

Alaska oysters appear to provide for their nutritional needs during winter by utilizing their own tissues, particularly protein. In northern latitudes, oysters often emerge from the cold season skinny and undernourished, but by mid June generally recover their condition and are approaching prime quality.

One possible problem can ensue if oysters have a particularly poor summer growth period. Reduced phytoplankton production and colder water may produce oysters in poor condition entering the winter. This is a situation that results in higher than expected overwinter mortalities.

Growth

Types of Growth and Measurement

In Alaska, oyster growth begins in a shellfish hatchery since natural reproduction does not occur. The Alaska oyster industry requires single oyster seed produced by hatcheries deliberately setting oyster larvae on minute grains of ground oyster shells. Once the oyster larva cement to the grain of shell, the attachment is permanent, and the oyster grows its entire life as an independent individual. Individual oysters are termed cultchless and are destined for the half-shell market.

Cultch oysters grow in clusters formed at the hatchery when multiple larvae set on a single, whole oyster shell. Whole oyster shells are placed in tanks and the larvae added to a density of about 200 larvae per shell. The goal is to have a set density of 20 oyster spat (seed) per shell. Cultch oysters are grown on-bottom or hung from lines on poles driven into the intertidal bottom. They are destined for the shucked shellfish market, and sold as meats in half-pint jars. Most often these oysters are cooked prior to consumption.

Cultchless oysters have a more uniform shell and are sold by the dozen while cultch oyster sell by the volume or weight. Cultchless oysters sell individually and are graded by dimensional size. Cultch oysters grow irregular shaped shells and the harvest is measured as yield, which is the weight per number of oysters at the end of a growout period.

Since cultchless oysters are individuals with relatively uniform shell shapes, measurements of shell growth are more accurate. Three types of measurement are used:

- *Allometric growth*: Defined as a difference in the growth rate of the parts of an animal, allometric growth measurements are used for oysters because not all parts of an oyster grow at the same rate. For example, growth in length is allometric because it grows at a rate different from other parts of the oyster. Length measurements are still the most common way of determining oyster size, and indicate readiness for market and allow grading the oysters into small, medium, and large size categories. Length measurements of growth have been a standard method, but often unreliable for indicating meat content.
- *Size and weight estimates*: This measurement method uses the combination of length and weight as an indication of growth and quality, and as an indicator of readiness for the market. For example, a 3 inch oyster weighing 2 ounces is a growth standard used for purchase by an oyster buyer. A farmer estimates meat volume of the oyster by examining the fullness of the meat in the shell at harvest.
- *Index of growth*: With irregular shell growth occurring throughout life, obtaining an accurate length measurement is challenging. To address this issue, indexes of growth have been developed. An index of growth uses two or more different measurements of growth to compute a numerical value as a growth indicator. An index number provides a method to compare year-to-year and site-to-site differences, and is useful as a quality standard.

Using whole weight of an oyster to determine readiness for market is problematic since oyster weight will likely be dominated by the weight of relatively dense calcium carbonate shell and may not provide an accurate measurement of meat content inside the shell. Also, oysters grown in colder climates produce lighter, less dense shells.

Cup Development

The Pacific oyster is also referred to as the cupped oyster because of the capacity for its bottom shell to form a cup. The degree of cupping has a profound effect on the shell length, as measured from the hinge to the opposite edge. Formation of shell shape is influenced by the substrate where it grows and the level of crowding. On soft silt substrate, oyster shells tend to be flat and hard surfaces tend to produce a deeper cup. But other environmental conditions also have an influence. Since water currents flow at various velocities along a beach, the force of the water is a determining factor in what deposits or washes away. For example, along silt substrate beaches the water movement is slow; this causes oysters to settle for extended periods, which results in a flattened shell. Conversely, in a hard rocky area where water movement tosses the oysters, shell edges fray and cause a deepened cup. Tumbling oysters regularly during farm growout has the same effect on developing a deep cup. Oyster shells tend to grow in the path of least resistance, so when they are not worked enough on the farm, they will grow flat and not develop a deep cup.

Through time, densely packed oysters grow into various distorted shapes because their shell growth is shaped by growing along the surfaces of other oysters. The formation of doubles, where two oysters grow attached to each other, may also be caused by dense packing and lack of handling to keep oysters separated. Obtaining a reliable shell length from cultch oysters is not possible.

Growth Models

Understanding the pattern of growth, as depicted in growth models, provides some insight into the changes oysters go through as they age. Figure 3 shows the relationship between individual age and growth that is commonly seen in the animal kingdom, including oysters.

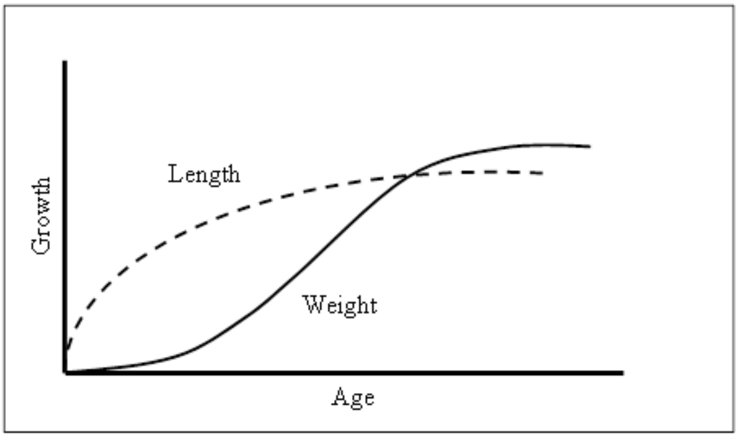


Figure 3. Growth graphs of length and weight with age typical of oysters and other animals.

The graph shows that when an oyster is young, growth in length increases faster than weight. Length accelerates and then levels off as the oyster ages. Weight increase is slower in young oysters, but surpasses the growth rate in length in older oysters. Animals typically increase in length first because of their need to grow quickly to avoid predation by smaller predators and increase their survival rate.

Genetics, environmental conditions, food supply, water quality, latitude, salinity of the water, water currents, and cultivation methods influence oyster growth. Measuring growth in oysters is extremely challenging and is complicated by the fact that growth is so variable. Also, measurements based on shell size can be misleading because shell shapes are profoundly affected by environmental conditions (Brown 1988). The defining elements that determine oyster growth potential in Alaska are listed below.

1. The most southern location for oyster culture in Alaska, at Annette Island, is 10 degrees north of the most northern natural range for Pacific oysters in Japan. Alaska's northern location precludes growing oysters intertidally in much of the state, though southern southeast Alaska appears promising. The quality and duration of sunlight throughout Alaska is different. Growing seasons are shorter, and water temperatures colder. These conditions cause oysters to grow more slowly than, for example, in the state of

Washington. A recent study on the post-harvest quality of Alaska oysters showed that identical genetic strains grown for three years in Thorndyke Bay, Washington, grew to whole weight of 210.5 gm., while in Kachemak Bay, Alaska, the oysters reached 50.4 gm. Based on water temperature estimates, oysters grown in Alaska take longer to reach market size of 3 inch (75 mm) shell length (Figure 4).

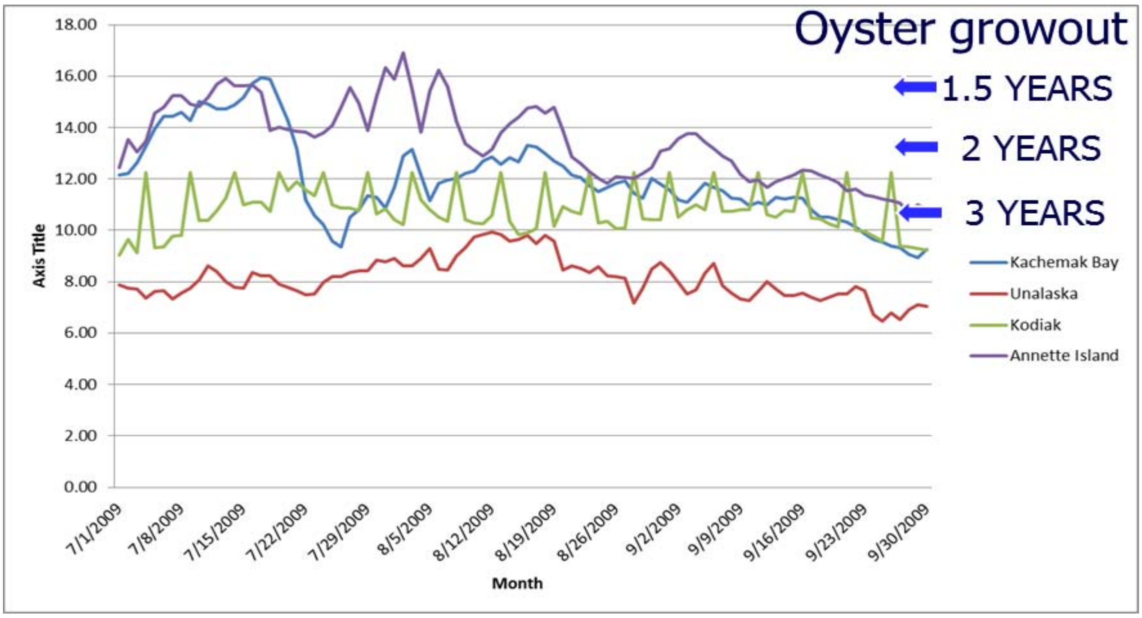


Figure 4. Estimated oyster growout time at four areas in Alaska based on water temperature estimates.

2. Shells of Alaska-grown oysters are thinner and more fragile than those grown at lower latitudes. Two factors likely cause this problem: suspended culture techniques that can result in thin shells if oysters are not handled and tumbled regularly, and cold water temperatures. Shell thickness varies throughout Alaska. Quayle (1988) documents shell growth beginning at 10ºC. Table 4 shows potential shell growth days for four locations in Alaska. Low shell density, caused by low temperature, can make shells more prone to breakage based on the increased pore space between the shell crystals. In a study of oyster quality in 2005, Kachemak Bay oyster shells were 2.5% less dense than oysters grown in Sea Otter Sound, near Wrangell. Although shells may have the potential for breakage, frequent handling can help to overcome the problem and produce a harder shell.

Table 4. Number of shell growth days (above 10ºC) for locations in Alaska.

Location	2004 (warm year)	2009 (cool year)
Ketchikan	156	104
Sitka	149	149
Cordova	100	84
Seldovia	63	67

3. Oyster growth can vary over a very short geographic distance. The first oyster study conducted on Annette Island from 6/13/1979 to 2/16/81 found that oysters in the Salt Chuck site grew 45.3% faster than those grown in Canoe Cove just 4 miles (6.44 km) away. Proper site selection has a profound impact on oyster growth.
4. Hatchery-produced seed often have irregular growth performance. This is likely caused by genetic characteristics of the broodstock used to produce the seed, over which the hatchery has little control, or inadequate food. The ability to genetically identify different oyster strains and control breeding results in more consistent seed quality with minor year-to-year variations in growth performance. As an example, in 1995 I operated the Kachemak Bay oyster nursery as a research program. Oyster seed 3 mm in length were purchased from the Lummi Oyster Hatchery in Washington. For nearly four weeks, the oysters did not grow nearly as fast as expected. The hatchery manager suspected that the seed was a Kumamoto/Pacific oyster cross. Since the Kumamoto oyster grows in warmer water, and its genes are included in the seed, that seed did not grow well. Another seed shipment without Kumamoto genetic influence resulted in an acceptable growth performance.

Oyster Growth Studies in Alaska

The first systematic growth study comparing growth in length of oyster in Alaska with other locations on the North American west coast was published in RaLonde (1992) (Figure 5). Involving oyster farmers operating near Wrangell who were passionate about the potential of farming, the study showed that Alaska grown oysters could compete with producers located at lower latitudes.

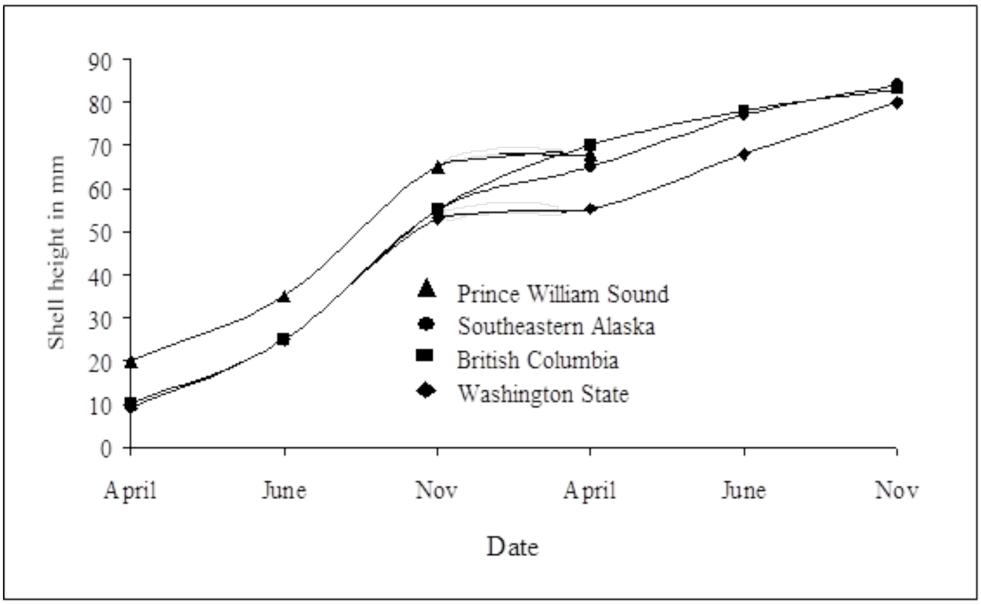


Figure 5. Comparison of oysters grown in Alaska and other west coast locations.

The next major growth study was conducted from 1995 to 1997, in conjunction with nursery culture development. The purpose of the study was to determine if larger seed of higher performance could accelerate growth in oysters. A study compared growth of 3 mm oyster seed grown in trays, to seed grown in a nursery floating upwelling system where large volumes of water is pumped through bins increasing food availability to the seed. Figure 6 shows that, indeed, nursery culture dramatically increased growth to produce large seed for the farmer. Another advantage to nursery culture is that through regular sorting with screens, the non-growing seed were identified early. All oyster seed that sifted through a ¼ inch screen over three weeks did not show any subsequent increase in growth and were culled from the lot and destroyed (RaLonde 1994). Through this method, farmers received only high performance seed. The use of nursery culture to produce large, high-performance seed has now become common practice in Alaska.

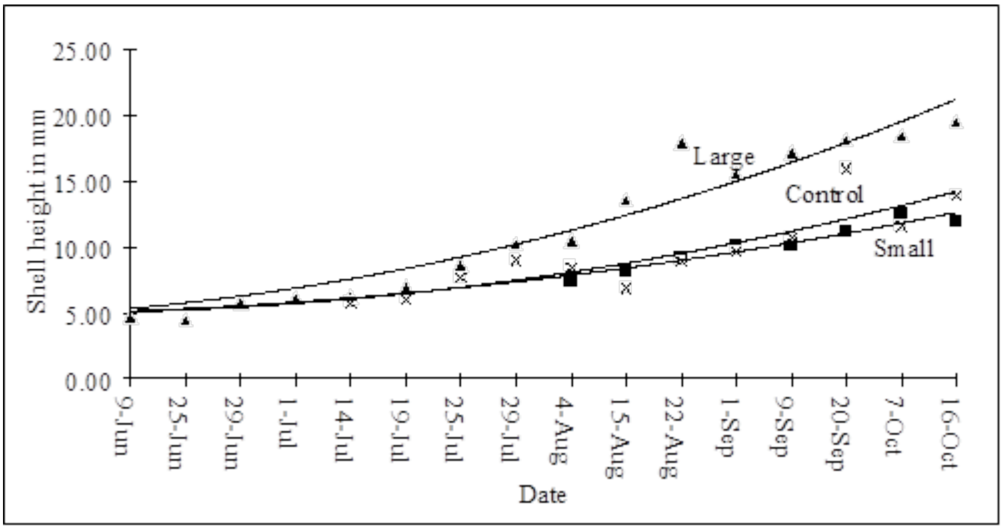


Figure 6. Growth of Pacific oyster spat cultured in the FLUPSY (floating upweller system). Spat were planted when they were 3-5 mm, and then sorted on August 4 at 6.25 mm. Control spat were not sorted.

Growth and Condition Indexing

A condition index (*CI*) uses two or more measurements of individual oysters; the data are put into a mathematical equation and a number is generated that can be used for comparative purposes. The condition index is used to determine growth and condition through time. The use of an index aids in reducing the variability that occurs when measuring only length or weight. For example, in 2006 a study was conducted to assess seasonal growth and condition of oysters grown and harvested from farms at various locations in Alaska. The purpose of the study was to examine oyster condition at the wholesale level by measuring and evaluating quality features (Oliveira et al. 2006). Two condition indexes were performed on the samples.

The *CI*, defined by Imai and Sakai (1961), reflects the economic value of the product and is generally referred to as the economic condition index (CI^E). This index is calculated using the formula below, where a high value represents a large oyster:

$$CI^E = \textit{Shell Thickness} \times [0.5\,(\textit{Shell Length} + \textit{Shell Width})]^{-1}$$

The second condition index was defined by Hand and Nell (1999) and derives from a combination of Lawrence and Scott (1982) and Crosby and Gale (1990) methods used for the calculation of oyster meat condition indices (CI^{HN}). This seems to be the most commonly used *CI* in oyster research. Hand and Nell's index accounts for the presence of fluid in the oyster and shell cavity volume, and is calculated according to the following formulas, where a high value represents a large oyster meat:

CI^{HN} = *Dry Meat Weight* (g) x 1,000/*Cavity Volume* (Crosby and Gale 1990)

Cavity Volume = *Whole Weight* (g) – *Shell Weight* (g) (Lawrence and Scott 1982)

An example of Alaska CI^{HN} data is in Appendix 1 and Appendix 2 of this chapter. Clearly, in the study, eastern Prince William Sound (PWS) excelled in both size and condition while southeast Alaska (SE) and Kachemak Bay (KB) indices were lower and more similar.

The Hand and Nell condition index is useful for research, where laboratory equipment is required, but the method is awkward as a field application. Other methods have been proposed that include multiple shell dimensions and use of cavity volume.

Brake et al. 2003 proposed using oyster measure ratios to determine quality. The ratios are:

Shell Depth (*D*)/*Shell Length* (*L*)
and
Shell Length (*L*)/*Shell Width* (*W*)

In this method, you measure the length, width, and depth of the shell, compute the ratios and compare with acceptable values. A good quality oyster has a combination of *D/L* greater than 0.25 and *L/W* greater than 0.63. Assignment to the good quality measurement is correct 56.4% of the time. A major advantage of the Brake technique is that the oyster does not need to be sacrificed in the process.

Another method proposed by Lawrence and Scott (1982) is the use of cavity volume. As follows:

Cavity Volume = *Whole Weight* (g) – *Shell Weight* (g)

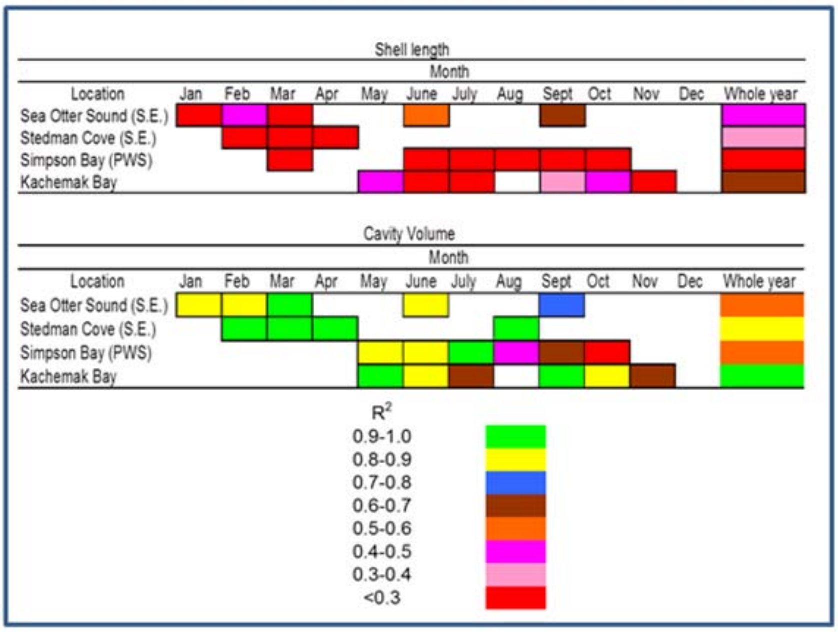
The method is simple. Using a scale capable of measuring to 0.1 grams, weigh the whole oyster, then shuck the meat and weigh the shell. Cavity volume is determined by subtracting the shell weight from the whole weight.

You might wonder why measuring weights computes into a volume. The answer is that a live oyster contains both meat and water inside the shells. The meat weight is about the same as seawater per volume, and the remainder of the shell content is water. So the entire content of the shell weighs essentially the same as seawater, and 1 gram (weight) equals 1 milliliter (volume).

The cavity volume method was used by RaLonde (2010) on Alaska oysters to compare the accuracies of cavity volume and shell length to predict meat content in an oyster. Figure 7 provides a visual evaluation of the results. The R^2 value is a statistical measure of accuracy. The closer the value is to 1, the better the prediction works. The numerous green blocks in the figure indicate that cavity volume is a far better predictor of meat content than shell length for both location and month of the year. An obvious disadvantage of the process is that the oysters must be sacrificed.

Using oyster measurements in three Alaska regions, cavity volume index values were calculated for large, medium, and small oysters (Table 5). Cavity volume also can be used as a quality standard for marketing oysters.

Table 5. Cavity volumes calculated for large, medium, and small oysters in three Alaska regions. (S.E. AK = Southeast Alaska, PWS = Prince William Sound, Kbay = Kachemak Bay)



Cavity Volume by Size Grade

S.E. AK	R^2	Cavity volumes mls Average	95% Confid.	Range
Total	0.81	28.3	27.3 - 29.3	11.0 - 52.6
Medium	0.75	31.4	29.1 - 33.7	15.3 - 52.6
Small	0.82	26.4	24.0 - 28.0	11.0 - 48.1
PWS				
Total	0.74	35.5	33.7 - 37.3	19.1 - 72.4
Large	0.74	42.1	32.8 - 51.5	27.1 - 72.4
Medium	0.73	36.6	34.1 - 39.1	21.1 - 56.1
Small	0.73	33.4	31.3 - 35.6	19.1 - 56.2
Kbay				
Total	0.89	32.5	29.9 - 35.1	10.6 - 59.4
Medium	0.91	37.0	34.1 - 39.9	22.0 - 59.4
Small	0.82	28.3	21.4 - 35.1	10.6 - 49.3

Figure 7. Cavity volume and shell length as predictors of meat content in Alaska oysters. Cavity volume is a far better predictor of meat content for both location and month of the year.

Growout

A section on growth would not be complete without attempting to answer the question: How long does it take to grow an Alaska oyster to market size? To answer this question, an indirect and pragmatic answer is likely the best approach. Because oyster growth is extremely variable, the answer must draw on the experience of farmers and research regarding average oyster growth in different regions. The general principles are:

1. Farmers use seasons of growth as a guide for determining growout time. Since oysters grow more rapidly in spring and fall, each is considered a growing season. In the warmest and most productive areas in Alaska, three growing seasons can bring about 10% of farmed oysters to a market size of 3 inches in length. Two more seasons could bring most of the remainder to market size. In the current cooling regime, oysters grown in cooler, but productive, areas will require 3-5 growing seasons to complete growout, and cold northern areas will require 5-6 growing seasons
2. Temperature has a profound effect on growth. Growth rates in 2009 were slower than in 2004, requiring at least one more growing season to achieve market size in most locations. Expect year-to-year variation in growout time.
3. As mentioned earlier, different seed batches purchased from hatcheries will likely differ in growth performance. The best practice is to determine performance as soon as possible and notify the hatchery.
4. Large seed will shorten the growout time. A 12 mm seed will likely need at least one more growing season to reach market size than a 24 mm seed. Large seed are more expensive, but the savings in labor and allocation of growout gear is worth the expense.
5. Farm maintenance is essential to good oyster growth. Prompt removal of fouling should be the priority of every farmer. Blue mussels (*Mytilis trossulus*) are the worst of the fouling organisms and allowing nets to be badly fouled by mussels can delay harvest by as much as a year. Regular sorting to size is important to allow the small oysters space and food access to grow. Leaving large oysters mixed with small oysters

is not good practice. Sorting creates uniformity and is an economically efficient practice.

6. Consider regular measure of oyster condition to monitor the quality of your product both seasonally and annual.

Making a Better Oyster

On the mind of every farmer is the prospect of producing a high performance oyster particularly adapted for Alaska growing conditions. Is such a prospect possible? The answer is yes.

Alaska has participated in a growout study with the U.S. Department of Agriculture Molluscan Broodstock Program (MBP), located at the Oregon State University Hatfield Marine Science Center since 1999. Working with 56 family lines of oysters, the study used the following procedure: crossbreeding of oyster families, conducting subsequent growout, selection of the top seven performing families, then crossing the new top performers. Repeating the process every 2-3 years has resulted in an overall increase of 30% in yield during a decade of breeding and growout evaluation. In a recent study funded by Alaska Sea Grant, the most recent top seven performance lines were evaluated for use as broodstock for the west coast and Alaska. The resulting information is exciting. Alaska-specific high performance families have been identified that can significantly increase yield in Alaska waters. An interesting result is that the three high performance families for Alaska are different from families identified as top performers for the west coast. Bringing these Alaska top performing broodstock into production needs to be a priority of the industry.

Conclusion

The biology of the Pacific oyster is complex, and the environment they live in is varied. The science describing the oyster is only in its infancy, and application of what we learn from the science can be of great benefit to farmers and the aquaculture industry in Alaska. This chapter is incomplete, as we currently do not know everything about Pacific oyster biology. Continuation of research coupled with the dedication and practical knowledge of shellfish farmers will result in a thriving aquaculture industry in Alaska.

Bibliography

Brake, J., F. Evans, and C. Langdon. 2003. Is beauty in the eye of the beholder? Development of a simple method to describe desirable shell shape for the Pacific oyster industry. J. Shellfish Res. 22:767-771.

Brown, J. 1988. Multivariate analyses of the role of environmental factors in seasonal and site-related growth variation in the Pacific oyster *Crassostrea gigas*. Mar. Ecol. Prog. Ser. 45:225-236. http://dx.doi.org/10.3354/meps045225

Conte, F.S., S.C. Harbell, and R.L. RaLonde. 1997. Oyster culture: Fundamentals and technology of the west coast industry. Western Regional Aquaculture Center publication no. 94-101.

Crosby, M.P., and L.D. Gale. 1990. A review and evaluation of bivalve condition index methodologies with a suggested standard method. J. Shellfish Research 9:233-237.

Hand, R.E., and J.A. Nell. 1999. Studies on triploid oysters in Australia XII. Gonad discolouration and meat condition of diploid and triploid Sydney rock oysters (*Saccostrea commercialis*) in five estuaries in New South Wales, Australia. Aquaculture 17:181-194. http://dx.doi.org/10.1016/S0044-8486(98)00435-9

Imai, T. and S. Sakai. 1961. Study on breeding of Japanese oyster, *Crassostrea gigas*. Tohoku J. Agriculture Research 12:125-171.

Lawrence, D.R., and G.I. Scott. 1982. The determination and use of condition index of oysters. Estuaries 5:23-25. http://dx.doi.org/10.2307/1352213

Mann, R. 1979. Some biochemical and physiological aspects of growth and gametogenesis in *Crassostrea gigas* and *Ostrea edulis* grown at sustained elevated temperatures. J. Mar. Biol. Assoc. UK 59:95-110. http://dx.doi.org/10.1017/S0025315400046208

Oliveira, A.C.M., B. Himelbloom, C.A. Crapo, C. Vorholt, Q. Fong, and R. RaLonde. 2006. Quality of Alaskan maricultured oysters (*Crassostrea gigas*): A one-year survey. J. Food Sci. 71(9):C532-C543. http://dx.doi.org/10.1111/j.1750-3841.2006.00186.x

Quayle, D.B. 1988. Pacific oyster culture in British Columbia. Can. Bull. Fish. Aquat. Sci. 218. 241 pp.

RaLonde, R. 1992. Growing shellfish in Alaska. Alaska's Marine Resources 7(4). Alaska Sea Grant, University of Alaska Fairbanks.

RaLonde, R.L. 1994. Oyster spat nursery system feasibility study for Kachemak Bay, Alaska. Project of the Kenai Peninsula Borough Economic Development District Symposium.

RaLonde, R. 2010. Condition indexing in oysters. Presentation to the Alaska Sea Grant Marine Advisory Program Shellfish Technology Conference. October 15, 2010. Ketchikan, Alaska.

Appendix 1. Weights and condition indices of Alaska oysters (from Oliveira 2006).

Alaska region	Harvest (mo - yr)	Transit (days)	Whole wt (g)	Shell wt (g)	Meat wt (g)	CI^E	CI^{HN}
SE	Aug - 03	9	52.17 (11.31)	38.38 (8.17)	12.64 (4.43)	0.35 (0.11)	118.89 (30.78)
SE	Sep - 03	un	64.06 (10.19)	45.94 (9.95)	16.54 (2.54)	0.39 (0.05)	128.39 (24.00)
SE	Nov - 03	9	67.38 (15.43)	45.68 (9.34)	20.73 (6.79)	0.36 (0.05)	140.14 (25.25)
SE*	Jan - 04	5	76.70 (6.15)	50.77 (1.12)	21.90 (4.55)	0.36 (0.01)	96.88 (18.25)
SE**	Feb - 04	6	67.97 (2.48)	48.67 (3.07)	17.06 (0.73)	0.39 (0.03)	106.37 (19.54)
SE**	Mar - 04	6	70.14 (3.33)	49.65 (2.86)	18.76 (2.09)	0.37 (0.02)	126.84 (12.21)
SE	Apr - 04	11	75.40 (8.57)	53.99 (6.51)	19.82 (4.70)	0.39 (0.08)	115.78 (17.41)
SE	Jun - 04	6	51.51 (7.04)	40.06 (5.37)	10.53 (3.07)	0.36 (0.07)	102.57 (24.24)
KB	Sep - 03	3	98.64 (26.80)	69.95 (21.64)	27.48 (9.99)	0.37 (0.07)	118.56 (23.73)
KB	Oct - 03	9	111.03 (23.06)	76.81 (12.49)	26.38 (7.91)	0.34 (0.06)	123.07 (28.70)
KB	Nov - 03	9	92.78 (16.97)	67.83 (14.19)	22.23 (5.56)	0.39 (0.06)	100.48 (28.34)
KB	Apr - 04	3	55.78 (11.41)	nd	nd	0.35 (0.05)	89.73 (16.17)
KB	May - 04	3	67.69 (16.29)	47.07 (10.79)	17.79 (5.78)	0.38 (0.11)	84.38 (20.94)
KB	Jun - 04	6	47.16 (10.59)	35.76 (7.40)	10.99 (3.65)	0.38 (0.07)	119.70 (31.23)
KB	Jul - 04	2	69.02 (8.81)	49.95 (6.74)	15.98 (4.04)	0.35 (0.06)	91.38 (17.12)
PWS	Sep - 03	5	73.50 (9.57)	53.53 (7.90)	18.75 (2.56)	0.35 (0.08)	91.94 (20.22)
PWS*	Oct - 03	8	94.44 (17.80)	68.19 (10.40)	24.37 (6.39)	0.41 (0.01)	134.26 (5.05)
PWS	Nov - 03	4	88.72 (14.19)	63.61 (10.43)	23.10 (4.94)	0.37 (0.04)	148.10 (21.84)
PWS	May - 04	11	76.48 (11.05)	57.10 (8.54)	19.09 (3.96)	0.38 (0.07)	134.91 (25.20)
PWS	Jun - 04	4	97.58 (33.29)	72.99 (28.30)	22.11 (6.58)	0.41 (0.10)	124.72 (42.00)
PWS	Jul - 04	4	90.43 (10.56)	63.92 (7.25)	24.58 (3.67)	0.41 (0.05)	155.28 (20.44)
PWS	Aug - 04	8	94.42 (14.88)	70.30 (12.65)	22.88 (4.12)	0.36 (0.08)	150.51 (31.69)

SE = southeast Alaska; KB = Kachemak Bay; PWS = Prince William Sound; un = unknown; (SD) = standard deviation of the mean; nd = not determined.

*Average of two shipments.

**Average of three shipments.

Appendix 2. Chemical composition of Alaska oysters (% w/w).

Region	Harvest	Glycogen	Lipids	Protein	Ash	Moisture	Solids
SE	Aug - 03	12.08 (0.05)	1.15 (0.02)	7.90 (0.15)	1.51 (0.49)	77.36 (3.30)	22.64 (3.30)
SE	Sep - 03	8.82 (2.95)	0.66 (0.18)	10.47 (0.34)	2.52 (0.49)	77.53 (0.10)	22.47 (0.10)
SE	Nov - 03	5.57 (0.30)	1.49 (0.28)	8.86 (0.03)	2.64 (0.22)	81.43 (0.03)	18.57 (0.03)
SE*	Jan - 04	6.94 (1.86)	1.25 (0.45)	7.88 (0.78)	2.12 (0.22)	81.81 (2.88)	18.19 (2.88)
SE**	Feb - 04	9.15 (1.07)	0.78 (0.32)	6.73 (1.75)	2.44 (0.30)	80.90 (1.86)	19.10 (1.86)
SE**	Mar - 04	8.23 (0.45)	1.64 (0.34)	8.32 (0.94)	2.27 (0.15)	79.54 (0.92)	20.46 (0.92)
SE	Apr - 04	8.06 (2.32)	1.31 (0.07)	7.52 (0.54)	1.97 (0.06)	81.14 (0.15)	18.86 (0.15)
SE	Jun - 04	8.82 (0.09)	1.06 (0.06)	9.26 (0.45)	2.12 (0.12)	78.74 (0.03)	21.26 (0.03)
KB	Sep - 03	8.76 (1.72)	1.30 (0.18)	10.82 (0.26)	2.47 (0.39)	76.64 (0.60)	23.36 (0.60)
KB	Oct - 03	10.01 (2.02)	1.28 (0.15)	7.69 (0.11)	1.86 (0.03)	79.17 (0.03)	20.83 (0.03)
KB	Nov - 03	5.01 (1.26)	1.54 (0.13)	8.07 (0.09)	2.50 (0.19)	82.88 (0.06)	17.12 (0.06)
KB	Apr - 04	5.80 (0.14)	0.69 (0.11)	5.34 (0.14)	2.37 (0.04)	85.79 (0.17)	14.21 (0.17)
KB	May - 04	7.56 (0.15)	0.81 (0.21)	5.33 (0.13)	2.15 (0.07)	84.15 (0.10)	15.85 (0.10)
KB	Jun - 04	7.86 (0.40)	0.66 (0.14)	7.37 (0.10)	1.63 (0.15)	82.47 (0.11)	17.53 (0.11)
KB	Jul - 04	6.12 (0.17)	0.90 (0.06)	6.46 (0.07)	2.41 (0.06)	84.11 (0.07)	15.89 (0.07)
PWS	Sep - 03	9.56 (0.45)	1.40 (0.38)	9.04 (0.57)	2.74 (1.60)	77.26 (0.60)	22.74 (0.60)
PWS*	Oct - 03	11.89 (3.46)	1.97 (0.11)	8.70 (1.31)	1.83 (0.36)	75.60 (1.69)	24.40 (1.69)
PWS	Nov - 03	5.68 (1.09)	1.64 (0.10)	8.10 (0.18)	2.17 (0.03)	82.41 (0.13)	17.59 (0.13)
PWS	May - 04	10.57 (0.51)	2.03 (0.13)	8.15 (0.15)	1.86 (0.10)	77.38 (0.20)	22.62 (0.20)
PWS	Jun - 04	11.88 (1.23)	1.39 (0.08)	7.36 (0.23)	1.89 (0.05)	77.48 (0.13)	22.52 (0.13)
PWS	Jul - 04	10.42 (0.70)	2.71 (0.11)	10.32 (0.32)	1.62 (0.08)	74.92 (0.08)	25.08 (0.08)
PWS	Aug - 04	9.94 (1.50)	2.86 (0.49)	9.62 (0.41)	1.78 (0.22)	75.79 (0.08)	24.21 (0.08)

SE = Southeast Alaska; KB = Kachemak Bay; PWS = Prince William Sound; (SD) = standard deviation of the mean.

Cooperation and Cooperatives

Chapter 5. Why Cooperate?

Rodger Painter

Alaskans take great pride in their independence. This certainly is apparent in coastal areas where fishermen historically have been pitted against one another in the struggle to get a share of a common property resource. While this is changing as fishermen are being awarded individual shares, competition still reigns supreme on the fishing grounds. The Seafood Producers Cooperative in Sitka is the only successful fishermen's cooperative in the United States. This fact illustrates both the difficulty in getting fishermen to cooperate and the reality of having such cooperation succeed.

Aquatic farmers should be looking more closely at the agricultural community for models on how to structure their business operations. In the U.S., there is agribusiness—large vertically integrated corporations—and smaller farms that have to work together to achieve the economies of scale necessary to operate grain silos, processing plants, and cooperative feed stores.

Having grown up as a fisherman and worked for fishing organizations, as a new oyster farmer I was amazed at how open shellfish growers in Washington were in sharing the details of their operations. After running a farm for a couple of years, it became very clear why farmers have to work together.

Running any small business is a challenge, but a remote Alaska oyster farm provides a daunting number of nearly insurmountable hurdles, particularly if you are completely on your own. Just being near other farmers is a plus. The ability to borrow a strapper or a few boxes to avoid missing a shipment alone is a real plus. Also, local services improve when there is a concentration of farmers.

There are also many ways to benefit by working with other farmers, even if they aren't close at hand. The Alaska Shellfish Growers Association (ASGA) certainly is one example. Over the past 20 years ASGA has conducted award-winning generic marketing campaigns, helped conduct important research and development projects, cosponsored and helped organize statewide conferences, and represented aquatic farmers in a variety of forums. The concept of sharing information has been a theme at ASGA's annual meetings, especially during the "Down on the Farm" sessions and joint workshops with the Alaska Sea Grant Marine Advisory Program.

Oyster farmers have also collaborated on bulk purchases of gear and materials, as well as sharing markets with other farmers in an attempt to keep important buyers supplied as they run short of product. Still others have pooled shipments to reduce freight costs and have shared the burden of collecting and shipping water samples.

While all the joint efforts discussed above have been through informal agreements, the biggest benefits might be gained through the creation of cooperatives. Formation of Alaska's first shellfish farming cooperative allowed oyster growers in Kachemak Bay to gain ownership of Alaska's first shellfish nursery, and later to attract federal, state, and private funding to build a processing plant and retail store on the Homer Spit.

Shared ownership of nurseries, processing operations, and other costly infrastructure should help significantly reduce the front-end costs of starting a shellfish farm. It will also free growers to focus on production rather than processing, marketing, and other time-consuming tasks. Growers responding to a 2010 ASGA survey said they spent more than 25% of their time running their processing operations and working on sales.

If five growers share a service raft or boat with a tumbler/sorter and a processing operation, front-end capital costs for each farmer might be reduced by $40,000-$50,000, a significant savings. If they were clustered closely together, the five farmers also could operate in the same certified waters and share PSP sampling. They could also jointly purchase materials and transport oysters to market, as well as act cooperatively in other ways to reduce operating costs.

While the benefits may be clear, it becomes more difficult to form cooperatives from more mature farming operations after each potential cooperator has spent time building up a brand in the marketplace and investing in their own infrastructure.

Chapter 6. Best Management Practices for Shellfish Cooperatives

Glenn Haight

Shellfish farming in Alaska has great potential, but it is a new industry and faces tough challenges. In the U.S. agricultural sector, cooperatives have a history of helping new industries overcome just these types of challenges.

Whether operating a formal cooperative, or behaving cooperatively, there are best management practices (BMPs) that may help. With support from the Alaska Cooperative Development Program, the Alaska Sea Grant Marine Advisory Program has compiled the following BMPs for shellfish farm cooperatives.

Use Good Business Practices
Shellfish cooperatives are businesses, and like any well-run business they should:

Set Clear Goals. Successful businesses focus on filling a need. Having a clear goal helps maintain that focus. For cooperatives in particular, clear goals are an important tool for maintaining member involvement. Co-ops that either do not have clear goals, or that fail to communicate their goals to their members, get mired in confusion and arguments. Clearly articulated goals help individual producers understand if the cooperative is right for them.

Plan
All businesses need solid business plans that outline how they will achieve their goals. Plans are even more important for cooperatives because they depend on the involvement of their member owners. Business plans identify and clarify critical issues including organizational goals, financial feasibility, management structure, and production and marketing plans. Cooperatives need to have these areas well defined so that they can communicate them to the member/owners.

Know the Numbers
A well-run business knows its finances. It knows what it is spending money on and where its income comes from, and is able to make sound financial projections. Because cooperatives exist to fulfill their owner/members' needs, they try to operate at cost. They have a tendency to starve themselves of resources at the expense of long-term business sustainability. To avoid this they must stay on top of the numbers.

Staying on top of the numbers means the business has a financial plan that accounts for maintenance, future investments, and times of low cash flow. Good financials help the business form clearly defined goals and will facilitate good communication and financial stability going forward.

Know the Industry
The more you know about your industry, not just where it is today but where it is heading, the better your plan will be. This means knowing not just the local industry but how the shellfish industry operates in the Pacific Northwest and nationally. Who are the buyers? How does the market work? What are other shellfish growers doing?

Follow Good Cooperative Practices
Because cooperatives exist to serve their members they must do more than follow good business practices. They need to constantly work with their members.

Remember the Co-op Principles
The co-op principles were established over 100 years ago. They have proven to be an excellent guide for running a cooperative business. Time and again people involved in cooperatives will point to following these principles as key to their co-op's success. The seven cooperative principles are:

Open Membership

1. Democratic control (usually one vote per member)
2. Member economic participation
3. Autonomy
4. Education
5. Cooperation among cooperatives
6. Concern for community

Embrace New Members
Cooperatives are intended to embrace new members as long as they fit within the general classification of membership, and the organization has the capacity to service them. Because co-ops primarily serve their members, the more members you have the more business the cooperative can do. These new members must know what they are "getting into" and be able to commit to the cooperative. They should understand general cooperative principles, and the cooperative's bylaws.

Establish Good Rules
Any cooperative incorporated in the State of Alaska needs to register articles of incorporation and draft a set of bylaws. These documents should provide clear rules for how the cooperative will operate. Articles give the names of the initial directors and the cooperative's address, and state how many shares and what types of shares the cooperative can issue.

The bylaws set out how the cooperative will be governed. They set out who can be a member, whether membership can be held by individuals or by corporations, or if membership will be determined by individual farm site. They set out what issues will be decided by a vote of all members and what issues can be decided by the board of directors, who gets to vote, and how votes will be taken. They also set out how the board of directors will be selected, what officers the board will have, and what duties those officers will be required to fill. The bylaws should also include meeting requirements. and mechanisms for members to call special meetings and for handling general membership issues.

Many production and marketing cooperatives also use membership agreements to clarify their rules. Membership agreements can cover a whole range of topics, from the cooperative's system of grading products, to how much will be paid for a given grade, to quality thresholds members are expected to maintain, to the percentage of a member's production that must be sold through the cooperative.

Give Back to the Cooperative

A common problem for any cooperative is not compensating the people doing the cooperative's business. When starting off most co-ops are short on cash. Often a small minority of members, who see the co-op's potential, step in and do the cooperative work without compensation just to get it going. This is unsustainable. Co-ops need to have a plan to either move to more shared volunteerism or to paying for management services. This gets back to running the cooperative like a business, knowing your true costs and planning for them. It also means that members have to know what they are getting into. Therefore, cooperatives should decide and make clear when they are going to either (1) share in the cooperative work, or (2) pay for cooperative services.

Advice for Start-up Cooperatives. In 1988 the Giannini Foundation at the University of California surveyed recently formed agricultural cooperatives and found several factors common to successful start-ups. These included:

1. *Involve more people in your planning.* While most co-ops were started by small groups, the study found that the more people involved the higher the likelihood of success.
2. *Build membership.* Cooperatives that had membership grow during the time between the initial planning and actual start-up were also more successful.
3. *Get help from consultants.* The study found that working consultants, especially with consultants from the Bank of Cooperatives, was helpful.
4. *Hire Professionals to Manage the Business.* Co-ops that hired professional managers were more successful. Even if you can't hire professionals at the start you should have a plan to grow to the point where you can.

From the Experience of Alaska Shellfish Cooperatives

Alaska shellfish co-ops have tried to provide benefits to their members both by offering production/marketing services and by helping to pool purchasing power. Here are some observations gleaned from conversations with present and past members and from observers who have watched these cooperatives operate.

Learn and Keep in Mind the Co-op's Mandatory Minimum Production

A processing or marketing cooperative will not work if it cannot get adequate production from its members. Any processing or marketing operation has fixed costs that can only be covered at a given minimum breakeven production level. If, for instance, a processing cooperative knows that its fixed expenses are its annual rent of $10,000 and manager's salary of $30,000 or $40,000 total. And if it knows that it can charge $0.50 over the cost of processing for each dozen oysters. Then it will need to process 80,000 dozen oysters to break even. If it can't process this many oysters it can't cover its costs.

A cooperative needs to know what its breakeven numbers are. It must communicate those numbers to its members, and it must have a plan for getting enough products from its members to at least break even.

If the cooperative is doing its job, and is providing a beneficial service to its members, members will want to send as much product as they can through the co-op. But in a new industry like Alaska's shellfish farming industry, member farms often do not have enough product to reach the cooperative's breakeven point. Because it takes two to three years to grow out shellfish, co-ops need to plan ahead, and know what their breakeven point will be. They need to make sure that their members are committed to producing at least that level. The co-op also needs to make sure it has enough shellfish to break even. This might require being flexible to bring in new members or giving incentives for members to grow more.

Use the Co-op to Schedule Production

A shellfish farm cooperative has a distinct advantage over a wild capture seafood cooperative in its control over production. It helps the production and marketing capacity to have a reliable production schedule. By coordinating production with its members, a shellfish cooperative can fine tune its production to meet sales demands.

This allows shellfish co-ops to tailor sales to seasonal shifts in market demand. For instance, an Alaska shellfish cooperative can take advantage of increased demand from summer tourists, by ramping up production for the summer. This is also a more hospitable time of the year to harvest product. Or a co-op might want also to establish year-round markets to avoid swings in seasonal businesses, and set up a production schedule that allows its members to access those markets too.

While it is possible that a single farm can achieve these goals, working together through a cooperative and pooling production offers more resources for managing production and meeting market demands. A cooperative could also schedule production to allow farmers to take time off or to schedule maintenance. Maintaining a year-round schedule may require offering incentives to members who produce in harsh winter months. Because cooperatives depend on their members, the schedule, the reasons behind it, and policies the co-op puts in place to meet it, should be communicated to the members.

Develop a Brand-Consistent Product/Quality

Branding is a marketing function where a product is differentiated enough in the consumer's mind to move the purchase decision beyond price. In order to effectively brand a product, production, quality, and marketing must be coordinated.

Product quality is a cornerstone of branding. Brand loyalty is built based on consumer recognition of a product of consistent quality—if they don't know what to expect you can't expect them to stick with you. Therefore, a cooperative hoping to establish an effective brand needs to establish quality parameters for production that may include meat content, shell size, shell depth, etc. The co-op system for grading and a pay scale should be clear to all members and be included either in its membership agreement or in a resolution by the board of directors.

We have already discussed consistent, scheduled production, but it bears repeating here as it affects marketing. An effective brand raises consumer expectations. In order to maintain an effective brand, the product the cooperative has on hand must meet those higher expectations. If part of the brand's marketing message promotes availability, the production needs to back it up.

Another side of branding within a shellfish cooperative is the potential to market the unique flavor characteristics that may exist between different farm areas. By offering a suite of different products a co-op may be able to intrigue high-end consumers, opening new markets and achieving higher profits for its members. It works for Napa Valley!

Bargain for Cheaper Transportation

Most Alaska shellfish farms are located in remote areas and transportation makes up one of their greatest costs. Clearly, having a pooled processing and marketing cooperative that is able to schedule production and shipping times will also be able to reduce shipping costs. But even a simple cooperative that coordinates transportation for its members might be able to achieve savings by bargaining together, maximizing loads, or organizing joint shipments.

Work Together to Lower Supply Costs
Similarly, purchasing cooperatives can help farms lower the cost of supplies. While joining together can help negotiate lower prices on all supplies it has proven especially important in maintaining an inexpensive and consistent supply of spat.

Unless the farm operations are large, hatchery and nursery production may not be cost effective. Relatively small investments in a FLUPSY (floating upweller system), nursery, or growout facilities could result in huge savings for co-op members. When building these facilities, build for growth, consider maintenance costs for long-term upkeep, and pay for your "spatsitter" (labor at the nursery).

Best Management Practices Summary
So to recap the best management practices for a shellfish farming cooperative, here they are again:

- Embrace new members who can commit to the cooperative.
- Have a formal business plan to set clear goals and communicate levels of production.
- Have solid financials prepared for financial management.
- Plan for maintenance, rainy days, and future investments.
- Pay for cooperative services or share in the cooperative workload
- Establish minimum production requirements for members
- Make sure the co-op has enough business to pay its costs.
- Match production to meet the marketing program.
- Incentivize production in the harsher times of year.
- Establish quality standards
- Coordinate production to take advantage of savings in shipping.
- Consider commonly used supplies that can be purchased in bulk.

Site Selection

Chapter 7. Site Selection Is a Business Decision

Rodger Painter

An old saw has it that the three most important decisions the owner of a new business must make are: location, location, location. While that might seem to pertain mostly to a retail business, the location of your farm can be the most critical decision you have to make when planning your new business. Unfortunately, most new farmers must make this critical decision when they are the least prepared to do so.

Certainly the environmental characteristics of a new site are critical, but a host of other issues need to be factored into the equation, such as weather protection, transportation costs and logistics, communications, access to support services and infrastructure, labor pool, and access to a local seed source.

Protection against high winds and waves are a must for shellfish farms. Fall and winter storms rage throughout Alaska's coastline and your entire investment can be lost if a single line snaps or anchors drag. Without adequate weather protection even a wind in the 20-30 knot range can make just working the gear difficult.

Sometimes even what appears to be a well-protected bay can turn out to be a blowhole with winds swooping down a mountainside or funneled through passes.

A well-protected bay might create another fairly common winter problem in Alaska—icing. Several established Alaska farms struggle with icing every winter, with ice ranging from a few inches to three feet thick. Any bay with a small entrance and a stream will have a freshwater lens that begins freezing when there's no wind and temperatures drop below 32ºF.

Access to an affordable, reliable method of moving product to market and supplies to the farm is very important. A farm located near a jet airport has a big advantage over an operation that must fly its oysters to the nearest airport. For example, in 2011 it cost about one dollar per dozen to fly oysters from my farm on Prince of Wales Island to Ketchikan via floatplane. On the other hand, the new farmers in Yakutat will be able to drive theirs to the airport in about 10 minutes for a few cents a dozen.

Reliability of the transportation is also important. Anyone who has spent a winter in a small Alaska village knows the mail planes often overfly. While this might be a disappointment and inconvenience to many, it can be a real problem for an oyster farmer. Having to unpack the product and put it back into the water so it won't freeze, or running a cooler for 24 hours, is really a hassle. Then there's the added work of pulling the product, repacking, taking new PSP samples, and rewriting the shellfish tags when the plane finally makes it. Finally, of course, are the customers who were counting on your product, and are now unhappy.

Recent improvements in communications are helping solve what was a major impediment to operating an oyster farm in rural Alaska. As cell phone access improves and satellite Internet access is more sophisticated it has become infinitely easier to communicate with buyers, handle logistics for shipping, order a new part, or call for help when needed.

Support services and infrastructure in the region can also be important. There aren't enough shellfish farms in Alaska to support specialized businesses, such as suppliers of oyster culture equipment or supplies. However, access to services such as an outboard or diesel mechanics, an aluminum welding shop, and refrigeration or hydraulics specialist might be vital. These are important to have access to in getting an operation back online after a breakdown or up and running during initial construction.

Infrastructure in the region also is important. A dock with a good hoist or ramp big enough to accommodate a pickup might be the key to offloading outgoing product or incoming supplies. Certainly, access to roads improves transportation and the ability to avoid the high cost of flying oysters to their destination. Using an existing processing plant might provide a viable alternative to building a shellstock shipping facility at the farm site.

Oyster farming is a labor-intensive activity and even the most efficient operation requires outside workers on a seasonal basis. Most small rural communities have a small or nonexistent labor pool, and many of these end-of-the-road residents may not make the best casual hire. Reliance on outside labor can be a significant obstacle in many rural areas.

The development of nursery operations in each farming region in Alaska has eased a long-standing struggle by many Alaska farmers to secure reliable sources of high quality spat. This isn't a situation that is going away, though, as the industry grows.

The increasing number of farms was beginning to concern some southeast Alaska growers as this manual was being written (2011), despite the addition of a 4 million spat capacity FLUPSY (floating upweller system) in Kake just two years earlier. Oyster farmers have gone through some pretty difficult years in purchasing spat, despite the ability to buy from outside producers. Competition for oyster spat is a reality and will continue to be for the foreseeable future.

The best seed security is to be located near a nursery operation. This also lowers the cost of securing the seed, eliminates transportation risks, and reduces the adjustments seed must make to adapt to new ocean conditions.

Chapter 8. How to Select an Oyster Farm Site in Alaska

Raymond RaLonde

The success or failure of a shellfish farming enterprise begins with selecting a prime location that provides all the needs of the shellfish and enables the farmer to operate in an efficient cost effective manner. Selecting a site within Alaska's enormous marine ecosystem can be an overwhelming process and the most challenging part for most is at the start. At my office at the Alaska Sea Grant Marine Advisory Program, conversations with aspiring farmers inevitably arrive at a point where a nautical chart spreads across my desk and the question is asked, "Where do you suggest I put the farm?"

Proximity to a Successful Farm

Before entering the site selection process, a new farmer's first step is to explore the prospect of locating near a successful farm and determine if there is space. Colocation is not always possible because prospective farmers may be personally linked to a community, family, and occupation, or other reasons. If farming enterprises exist in your area of choice, choose wisely and explore colocation first.

A farmer who has proven successful selected an appropriate site, whether deliberately or by coincidence, and any opportunity to colocate immediately simplifies your site selection process. Colocation:

- Simplifies the permit application process because information is available from a cooperative farmer to assist in completing the applications;
- Eliminates many site use conflicts as the permits go before public review;
- Reduces the cost of annual water quality testing, shellfish toxin testing; supply purchases, transportation, and product marketing;
- Eliminates the need of water quality classification from the Alaska Department of Environmental Conservation (ADEC) because the existing farmer received an approved water classification which enables you to circumvent the long and expensive process to obtain your own;
- And many more opportunities may arise.

The easiest way to begin farming immediately is to sublease a farm plot from an existing farmer. Alaska shellfish farmers currently in operation use a fraction of their farm leasing area, and the Alaska Department of Natural Resources (ADNR), the state's tidelands management agency, allows subleasing of unused land. Check with the ADNR to access contact information of permitted farmers

Connect with the Aquaculture Industry

The site selection process requires that you connect with the aquaculture industry. There are several ways to get started. Get a list of farmers and talk to farmers in your proposed area. Join the Alaskan Shellfish Growers Association and attend their annual meetings. Get advice from the University of Alaska Sea Grant Marine Advisory Program aquaculture specialist. Obtain business planning advice through free resources offered by the University of Alaska and governmental agencies. The benefit of networking is greater than just satisfying the permitting process—it also gives you valuable contacts and information that will help you succeed as a shellfish farmer.

Selecting the site for your shellfish farm is probably the most important decision you will make in developing your business. Many past farmers dreamed about their farms in the Alaska wilderness, possibly a special place of personal experience, and then had their dreams dashed and bank accounts emptied. Working hard to compensate for a poor site selection decision left them exhausted and they ultimately abandoned the farms.

Other farmers were deliberate, taking the time to locate an appropriate site through careful examination of the characteristics required to operate their business. In developing a business, your first priority is to make a profit or at least provide a comfortable living. Lifestyle farming, without substantial sources of discretionary income, is not sustainable. This publication will help you along your way to becoming a successful farmer by guiding you through the process of site selection.

Environment, Biology, and Gear

Site selection is an interactive process between three essential aspects, as displayed in Figure 1. The components to consider in planning your farm are the biology of the species you will culture, environmental characteristics suited for farming the species, and gear you intend to use.

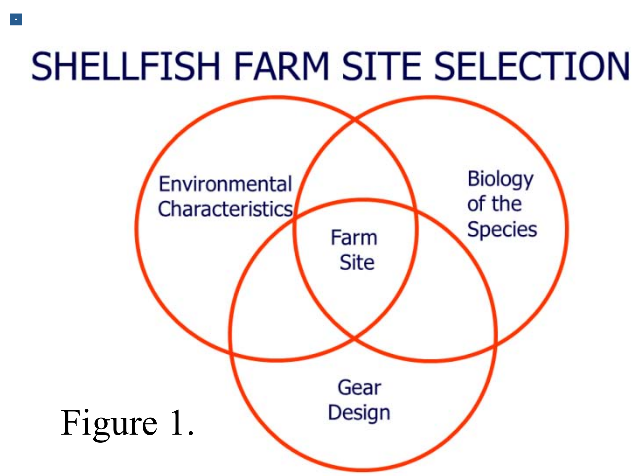


Figure 1.

While this manual focuses on an oyster farm, you may want to later incorporate another shellfish species into farm production. The potential inclusion of another shellfish species may need consideration in site selection. The gear for oyster farming is reasonably well defined. In Alaska, you likely will use suspended farming techniques, either floating longline or raft culture. Some beach culture operations are in practice, but they are geographically limited to southern southeast Alaska.

The site selection process encompasses complex interactive physical, chemical, and biological processes. More complexity is added when considering site permit-ability, logistics, management practices, and regulations. Environmental characteristics include the general features of the region and the specific characteristics of the farm site (Figure 2).

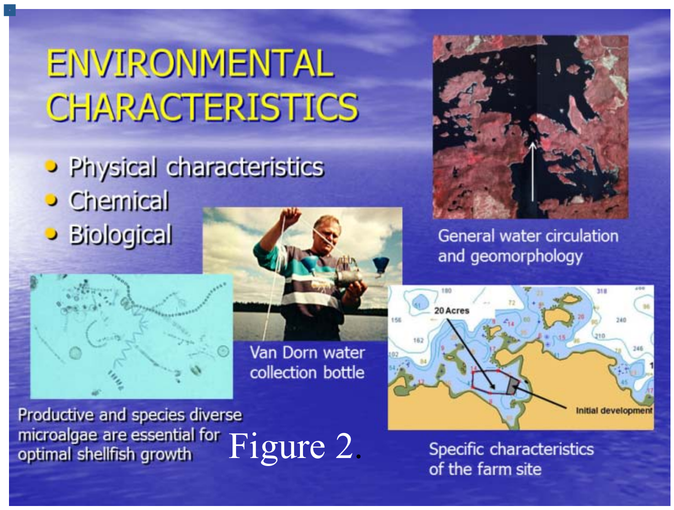


Figure 2.

Physical characteristics of the farm site, which include uplands and water, are very important in placement, anchoring, and design of the farm. Water parameters such as temperature and salinity are important physical features. Assessment of light is essential because microscopic phytoplankton require ample light for optimal growth and reproduction.

Chemical characteristics include the dissolved gases, minerals, and nutrients that influence farm productivity. You will probably not be involved with nutrient analysis of the water. Laboratory testing of water is an expensive process and chemical nutrients like nitrate (NO_3) change dramatically in a short time and are not reliable for predicting long-term success.

Biological characteristics include assessment of phytoplankton quality and productivity, competitive species in the area, fouling organisms, and predators. Personal and local knowledge and simple low cost tests performed on site will provide much of this information.

This chapter presents specific methods to assess physical, chemical, and biological characteristics of the site. The assessment methods are often simple and inexpensive, and necessary materials are locally available.

Don't be intimidated by the details and complexity in this chapter. Much of the information needed for site selection is available through traditional knowledge of local residents, fishermen, and shellfish farmers. The Alaska Department of Fish and Game (ADFG), ADEC, ADNR, U.S. Forest Service (USFS), local municipalities, and the Alaska Sea Grant Marine Advisory Program are also good sources of information. Joining the Alaskan Shellfish Growers Association to receive their regular newsletter and attending their annual meeting is imperative.

Physical Characteristics of the Site

Physical characteristics include the geomorphology (geology and land forms such as orientation and topography of the surrounding uplands), movements of water, and light availability (Figure 3). Light penetration can be decreased by turbidity or "muddy" conditions, often from silt originating from freshwater.

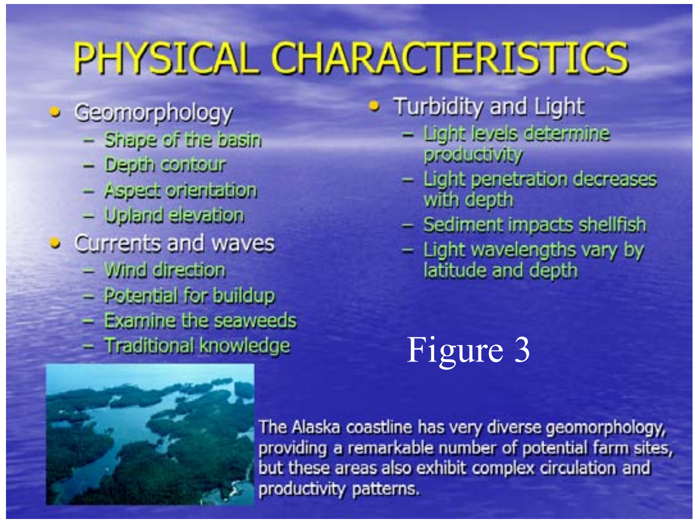


Figure 3

The shape of the water basin influences water movement and availability of light. High surrounding topography generally has small watersheds, lessening freshwater influence on the farm site. If the basin receives direct wind access, water forces may result in transportation problems and can dislocate or damage floating farm buildings and gears. If the orientation is north/south relative to high topography, the basin may be significantly shaded, blocking light needed for optimum phytoplankton production. The depth contour must allow for anchoring; steep bottom slopes, particularly with hard bottom substrate, will not allow for adequate anchoring.

Adequate water movement and exchange are necessary, but must not be excessive. Long, open runs affected by prevailing winds will build waves. Examining seaweeds is helpful in determining water movement. Abundant bull kelp (*Nereocystis luetkeana*) on the surface indicates significant surface chop, and the presence of giant kelp (*Macrocystis integrifola*) indicates subsurface surges. Traditional knowledge is valuable in site assessment because infrequent site visitations may give a false impression of water conditions.

Photosynthesis for phytoplankton production uses light wavelengths that approximates the range seen by the human eye. In northern latitudes, the atmosphere filters out the far-red spectrum, but this is not significant in reducing phytoplankton production within the range where shellfish farming occurs in Alaska.

Water clarity is reduced by phytoplankton blooms and by silt transported in freshwater that flows through the farm site. Turbidity caused by phytoplankton is an indicator of food abundance; but very red water indicates a *Noctiluca* algae bloom that is poor food for shellfish. Avoid excessive turbidity from local streams by not locating the farm near a source of significant turbidity during periods of rainfall. Persistently high concentrations of silt block sunlight penetration in the water, inhibit phytoplankton production, and reduce feeding behavior in shellfish.

Estuaries

In Alaska, shellfish farms are sited in estuaries. An estuary is a semi-enclosed body of marine water that receives significant dilution by a freshwater source. Estuaries are very productive environments, constantly changing, and complex to study and describe (Figure 4).

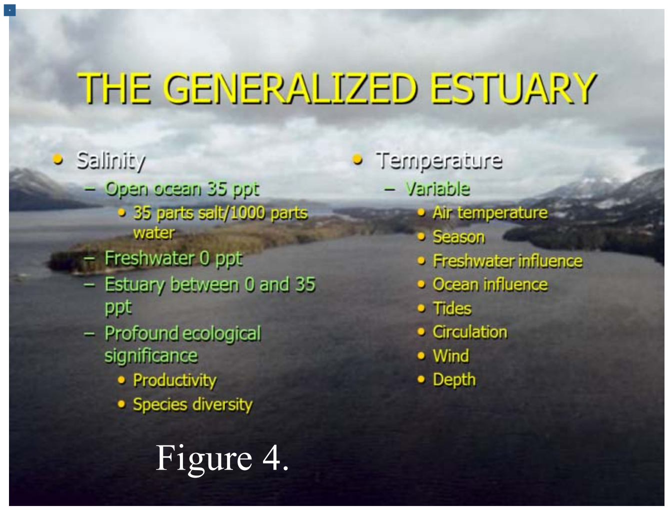


Figure 4.

Full strength seawater contains salt at about 35 ppt (parts per thousand); that is 35 parts of salt for every thousand parts of water. The concentration of salt in water is called salinity. In estuaries, salinity can fluctuate between 0 and 35 ppt, the difference caused by changing of the tides, freshwater input from land runoff, mixing deep and shallow water by winds or currents, and upwelling to the surface of high salinity deep water.

Estuaries are highly productive because the reduction in salinity enables greater species diversity, and greater contribution of nutrients from freshwater can develop productive phytoplankton blooms.

Estuaries have seasons because they are closely associated with land and the atmosphere. In colder areas with significant surface freshwater, some estuaries freeze and can destroy floating aquaculture gear. Oyster growth slows in cold water regions, which can lead to over 30% loss in meat content. In warmer areas in Alaska, oysters actually grow through the winter.

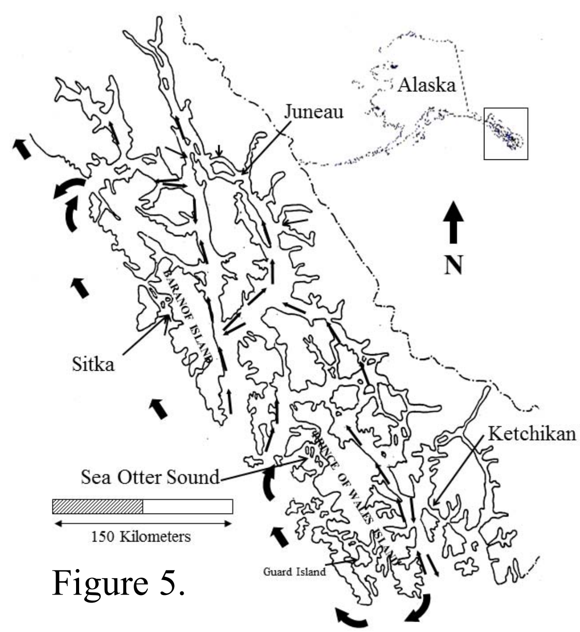


Figure 5.

Ocean influence affects salinity and water temperatures in estuaries to varying degrees. Sitka Sound, for example, has substantial ocean influence that maintains relatively high salinity and controls variation in water temperature. Conversely, Sea Otter Sound salinities and temperature vary more due to high rainfall and the input of freshwater from numerous streams (Figure 5).

Shallow depths allow winds to mix deep and shallow water. When the wind is calm, warm, low salinity water floats atop colder high salinity deep water.

Water circulation patterns are complex and they have a profound influence on productivity and operational practices of a shellfish farm.

During the modern era of the Alaska shellfish farming industry, which began in the late 1970s, the prevailing thought about siting a farm was to locate it in an area that achieved warm water temperatures similar to the native range of the Pacific oyster, which is south of 50ºN.

Achieving the desired warm water conditions meant water temperatures consistently exceeding 15ºC, but in Alaska high water temperatures required siting a farm in confined areas with poor circulation. The results were disastrous, causing high summer mortalities. Nutrient input was too low to sustain phytoplankton food production when oysters needed the energy for survival and growth.

Water Movement

Adequate water exchange and flushing is necessary to sustain a shellfish crop by providing nutrient input, but the cooler water temperature also slows growth. Overall, exchanging some loss of growth for producing a healthy oyster is a wise choice.

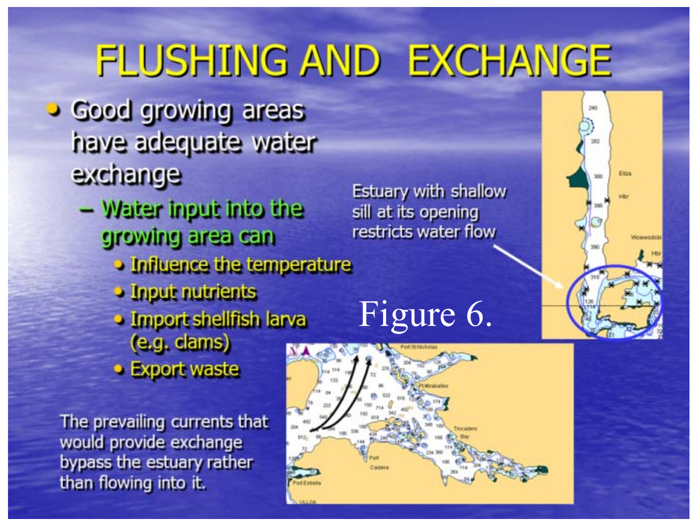


Figure 6.

In Figure 6 the diagrams show primary reasons for inadequate flushing and exchange. If currents bypass entry into the farm growing waters due to orientation of the water body, optimal water exchange is prevented. A shallow sill at the opening of the water body can also constrain exchange of water.

The lower diagram in Figure 6, south of Craig, shows Trocadero Bay, a long water body oriented southeast to northwest. Doyle Bay and Port St. Nicholas, located immediately to the north, are oriented in an east/west position. The prevailing currents flow into the area from the southwest as indicated by the arrows. In my scallop research, productivity was profoundly different between the embayments. Doyle Bay and Port St. Nicholas, highly productive water bodies, received direct exchange of water from the dominant north-flowing current while bypassing Trocadero Bay, which received water exchange primarily from tidal flow.

However, you need to pay attention to high-energy water forces. For example, the orientation of Port St. Nicholas makes it susceptible to storm events, but islands on the entrance provide protection. The rule is: exchange is needed but protection is necessary. The top embayment is oriented north/south and islands provide protection, but the long and narrow structure of the water body may be subject to winds developing rough water. A shallow sill at the entrance could restrict water exchange.

Water movements in an estuary include vertical currents that produce various types of mixing. These movements are common in estuaries and are essential to developing and sustaining phytoplankton productivity.

An important water property is that warm water is lighter than cold water and less saline water is lighter than water with a higher salt concentration. Light water has the tendency to float on top of heavy water, creating separate layers during calm conditions. A layered state is called a stratified or a stable water condition. Stratification breaks up in windy conditions and/or when the surge force of water mixes the layers (Figure 7). The surge of water causing the break-up of stratification may be freshwater or marine.

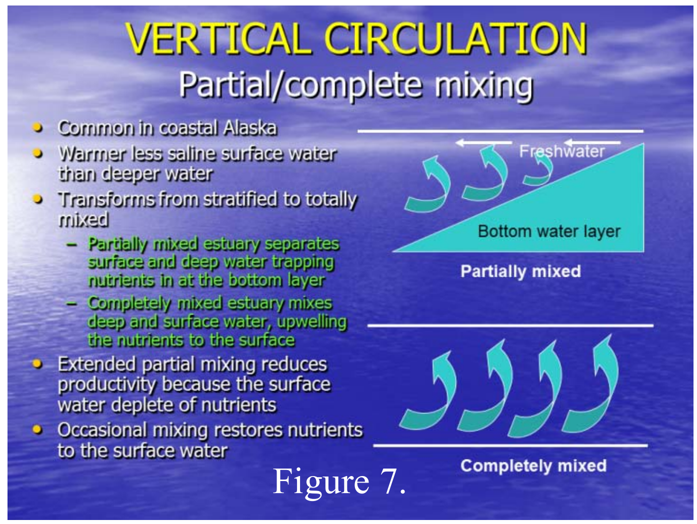


Figure 7.

Coupled with the processes of stratification and mixing is the distribution of nutrients. In water, organic material generation by the death of living organisms eventually sinks to deeper water where decomposition generates and stores nutrients. In stable stratified water conditions, nutrients remain trapped in the deeper water strata. In addition, deep water receives limited illumination from the sun as the light filters out with depth. In a clear ocean, only 25% of the light penetrates 33 feet and less than 5% to 100 feet.

As photosynthetic organisms, phytoplankton must have water, nutrients, and energy from the sun to grow and reproduce. If any of these three are deficient, photosynthesis declines and phytoplankton productivity reduces. In an estuary, deep water–stored nutrients need to flow vertically into the light-rich surface water, a process called upwelling. This occurs when mixing provides the water flow that vertically transports nutrients.

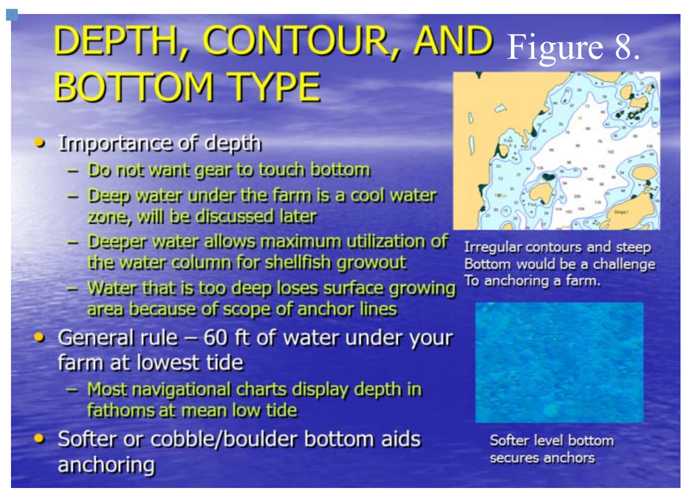


Figure 8.

Optimal primary production contributed by phytoplankton is unsustainable during periods of long-term stratification; mixing must occur frequently. A partially mixed estuary may have three layers: a freshwater layer, called a freshwater lens, floating on mixing area, and deep stable water. In this scenario, phytoplankton productivity reduces through time as surface nutrients deplete. Mixing periods develop a fully mixed estuary where nutrients upwell to the surface water. The net consequence of this process is that phytoplankton productive increases. The general rule is that a shellfish farm must locate in an area of regular mixing.

Depth and Bottom

Water depth has implications to consider in shellfish farm design and construction (Figure 8). Raft and longline culture systems require 2-6 feet of drop lines to attach the growout gear to buoy or raft flotation. Stacks of trays or a 10 tiered lantern net may add an additional 6-8 feet (Figure 9). In Alaska waters, the maximum tidal swing in shellfish farming areas can approach 28 feet. Adding these values together requires that you place the farm at a site deeper than 40 feet at minimum low tide to prevent your gear from touching bottom. Preferably, locate at 30 feet water depth at mean low water (MLLW).

Lantern net Wire cage

Figure 9.

Another important aspect to consider is that when you lease tidelands for your farm from ADNR, you are leasing the bottom area. By regulation, the anchors securing the floating farm structures must be within the farm boundaries. Including anchors and the scope of anchor line within the farm boundary reduces the amount of surface water available from a 10 acre bottom lease to 7 acres of usable surface water (Figure 10). The deeper the water, the more surface production acreage is lost to allow for anchoring.

Some of the older Alaska farms are sited in water shallower than 30 feet (MLLW). To keep the gear off the bottom during the lowest tides requires that they use 5 tiered instead of 10 tiered lantern nets, cutting the potential farm production in half.

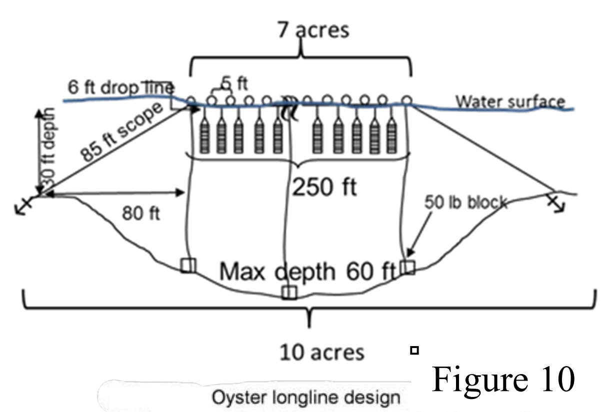


Figure 10

The bottom slope and substrate composition are important for anchoring. A bottom slope that is too steep along and a bedrock substrate are not ideal anchoring conditions. Softer bottom composition and flatter contour are the best anchoring combination. For depth information, navigational charts give adequate measurements and computer tide software provides accurate tidal information.

In addition to your farm gear, you will need some type of floating facility to manage farm maintenance, store equipment, and process and refrigerate harvested oysters. Housing facilities may also be required. The center of Figure 11 shows a processing and storage facility, and the house shows that the person is fortunate to have land-based housing, dock, and storage space.

Figure 11.

Farm support facilities are often floating because access to uplands is often limited. Caretaker housing must be located away from the farm because of potential water quality problems. A separate lease agreement must be obtained from ADNR for housing. In southeast Alaska and Prince William Sound, USFS and ADNR manage most of the uplands, making leases extremely difficult to find. Alaska Native corporations own the largest tracts of private land and suitable state land is limited. In Kachemak Bay, private uplands are available but expensive. Farmers are increasingly using intertidal tidelands to farm clams and oysters in southeast Alaska.

Access

Access is a major issue to consider because the farm needs attention at certain times. Postponing farm maintenance and harvest because of bad weather is poor farming practice.

Vandalism and theft occasionally happens to Alaska farms. To avoiding these problems:

- Make yourself visible on the water and working the farm;
- Clearly mark the farm boundaries to let people know your farm exists;
- Educate local residents about your farm;
- Keep the peace and do not resort to enforcement if at all possible; and
- Maintain vigilance by yourself, a neighbor, or a farm caretaker while you are away for extended periods.

Where your farm site is located will determine which security measures are necessary.

Measuring Water Temperature

Water temperature is important in site selection. Temperature is the time clock of the marine ecosystem. Water temperature significantly influences the diversity and abundance of species living in an area and the rate of oyster growth and reproductive condition, and it regulates every biological process in the waters surrounding your farm. Every farmer should be collecting water samples and measuring temperatures regularly to understand the biological schedule that governs farming practices.

Knowledge about water temperatures at your site is enormously beneficial to evaluate its shellfish production potential and to forecast problems. To begin the topic of water temperature as a site selection criterion, how to collect water temperatures needs some attention.

Thermometers come in many shapes, sizes, and capabilities (Figure 12). Every farmer needs reliable manual thermometers. Two types are used: the direct reading thermometer to get the current temperature and a maximum/minimum (max/min) thermometer that records the highest and lowest temperatures over a time period. The direct thermometer generally takes at least one minute of emersion in water to measure an accurate temperature. A max/min thermometer should be hung from a float to a depth of six feet. Read the max/min thermometer as often as possible, reset as indicated in the instructions, and redeploy. Be sure to record the initial date deployed and every day the thermometer is read. All water temperature readings should also include the air temperature.

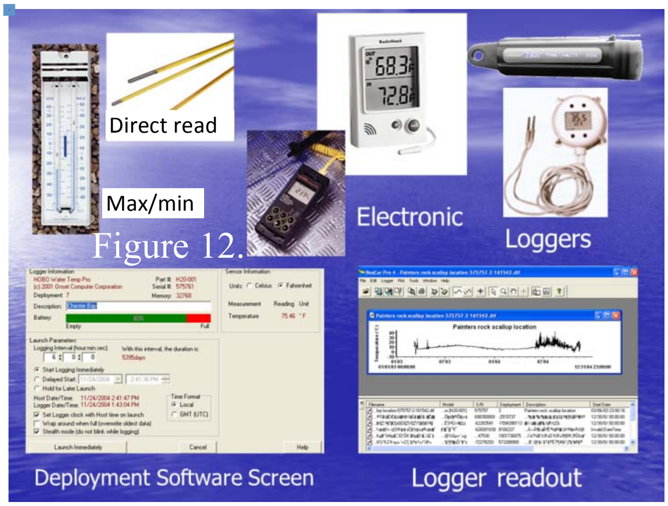


Figure 12.

Electronic thermometers are simple and take temperatures quickly. They are sold as hand-held and wall-mount units. Some have data storage capabilities. Protect electronic recorders from exposure unless the manufacturer recommends otherwise.

A third kind of thermometer is a temperature logger. These devices come with small or large memory capacities. The loggers are launched by communication with a computer through an optical reader where the time and frequency of temperature recordings are programmed, and the device is started immediately or delayed to a specified date and time. Temperatures should be set for a minimum of every 4 hours to account for temperature changes caused by the changing tides. Temperatures are recorded and stored at the designated time, but cannot be read until the logger is retrieved and the data downloaded into a computer for viewing or printing. Downloaded temperature readings are in tables and can be graphed as shown in Figure12.

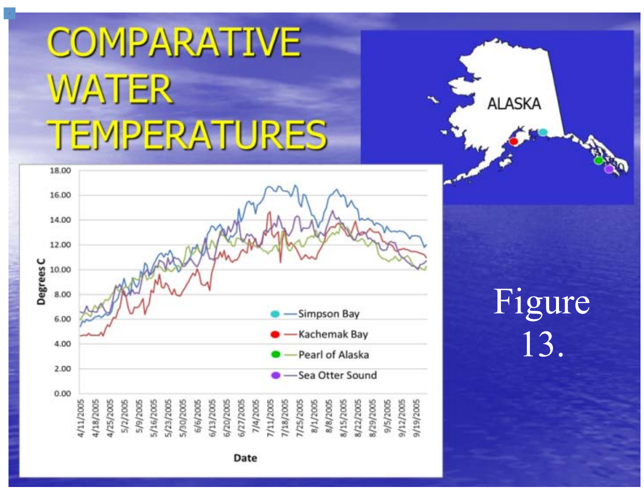


Figure 13.

Temperature loggers are very handy because the water temperatures are recorded at regular time intervals, and if set to record every 4 hours, can capture and store readings for several years before the battery is discharged (Figure 13).

When presented graphically, a time interval pattern of temperature data is very revealing. Figure 14 shows summer temperature patterns for four locations in Alaska and the effect temperature has on oyster growth to market size.

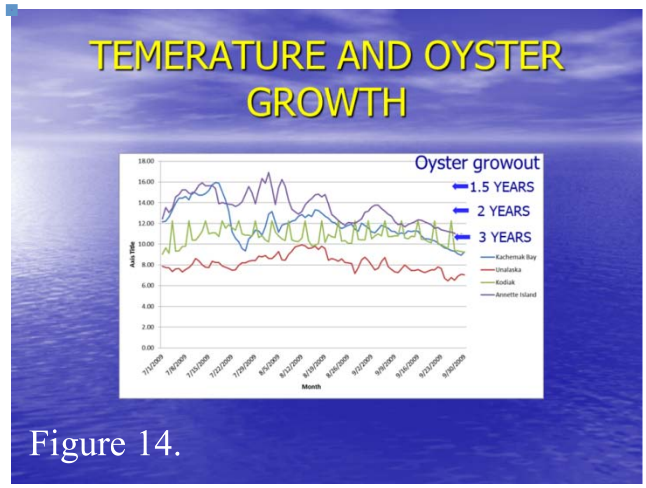


Figure 14.

Taking water column temperatures at regular intervals of depth is very useful because the temperature pattern exposes stratification events. Evidence of stratification appears as a sudden change in water temperature, which is called the thermocline (see Figure 16). The warm water above the thermocline is the epilimnion and the cooler water layer below is the hypolimnion.

The thermal profile shows changes in temperature with depth; it varies during the year with surface water temperatures higher in the summer and lower in the winter when compared with deeper water (Figure 15). A straight vertical line, such as the red line, indicates complete mixing. Other profiles show different temperature profiles at depth that lead to stratification.

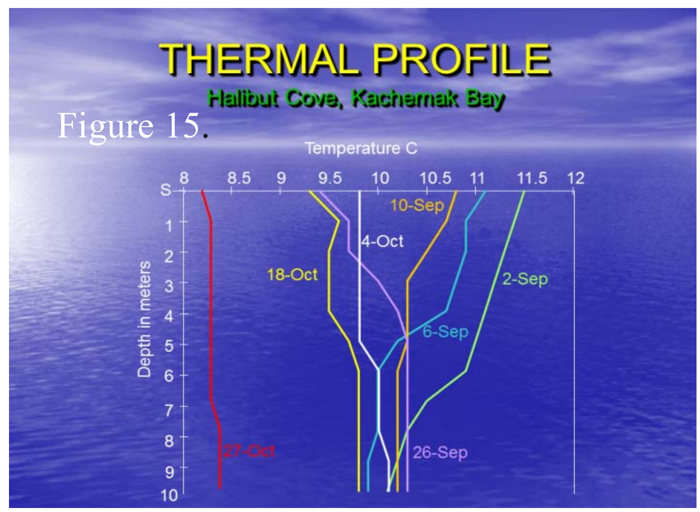


Figure 15.

Determining the thermocline requires taking water temperatures at regular depths, preferably every 3 feet. There are two ways to get water temperature: collect the water at a given depth and measure the temperature manually or use an electronic long-wire temperature probe attached to a reader (Figure 16).

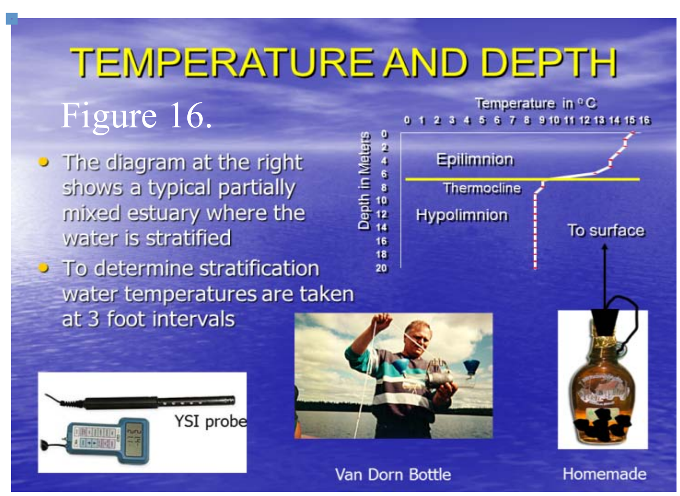


Figure 16.

A Van Dorn bottle is a tool to collect water at depth by first launching a tube in an open position to allow water to enter, as shown in Figure 16. Two closure plugs that trap the collected water are attached in an open position and attached to a trigger. A line marked every three feet is attached to the Van Dorn bottle, which is lowered in the water to a designated depth. A tubular weight, called a messenger, is attached to the line sent down to the bottle. The messenger strikes the trigger, releasing the two plugs to close the ends of the tube and trapping the water. The bottle is brought to the surface, opened, and the water temperature manually measured. Van Dorn bottles cost about $150.00.

A homemade Van Dorn bottle can be made using a narrow neck glass bottle with a long (50 feet or more) heavy cord attached to the neck of the bottle. The cord is loosely looped and attached to a cork as shown in Figure 16. The remaining length of the cord is marked every 3 feet and functions to lower the bottle in the water. Weights are put into the bottle so that it will sink. To collect a water sample, plug the bottle with the cork, and lower the bottle carefully to the appropriate depth. The bottle must remain plugged with the cork while being lowered in the water. At the designated depth, the cord is yanked to pull the plug and capture the water. The bottle containing the water sample is retrieved, the depth determined by counting the markings on the cord as it is retrieved, and the temperature manually measured.

Temperature with depth can also be determined using an electronic meter attached to a long wire temperature probe. One popular model is a YSI temperature meter that measures the temperature at predetermined depths and the measurement read in real time at the surface (Figure 16). Digital probes are expensive, costing several hundred dollars, but are easy and rapid to use, measuring temperatures to determine a profile with depth in just a few minutes.

Not only does temperature provide an estimate of growout time to market, but also determines when growth starts, prevents human illness when oysters are eaten raw, and indicates how close oysters are to sexual maturation and spawning. Below are some examples.

Shell growth in Pacific oysters stops below 10ºC and the days of growth vary by location. For example in 2007 Sea Otter Sound on the west side of Prince of Wales Island in southeast Alaska (55º50N) had surface water temperatures above 10ºC for 142 days, while Kachemak Bay (59º45N) recorded 92 days when growth could occur.

In Pacific oysters, reproductive maturation begins when the water temperature reaches 10.55ºC. With development of eggs and sperm (gametes) oysters develop unappealing milky colored tissue with a bitter taste. This condition is called spawniness. The problem with spawniness is that oysters do not spawn in Alaska because the waters are just too cold, and the oyster retains the eggs and sperm and the poor quality for some time. As shown in Figure 17, oysters at most locations in Alaska are

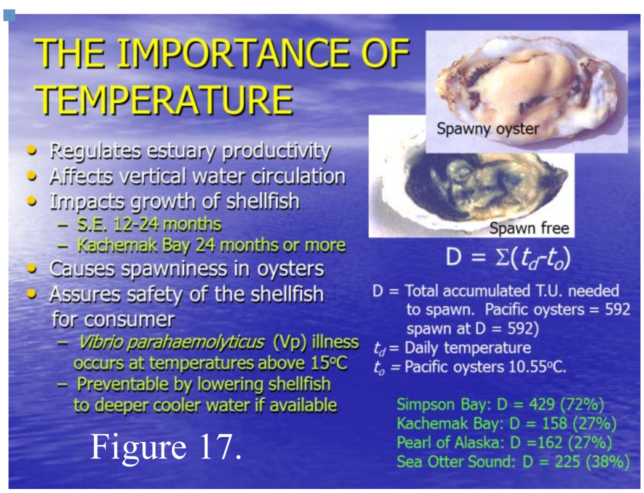


Figure 17.

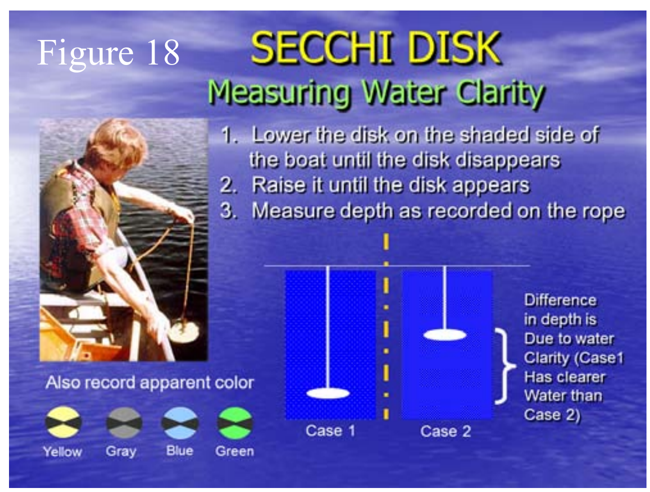
not even close to sexual maturity, and definitely not spawning or establishing any local natural reproducing populations, yet spawniness is evident during warm summers (see Chapter 4 for equation details). The general rule is to choose a farm site with cooler temperatures to avoid the spawniness condition and sacrifice some growth in the process.

High water temperatures above 15ºC can lead to growth of the bacterium *Vibrio parahaemolyticus* (*Vp*). *Vp* causes gastrointestinal illnesses in humans and can result in loss of markets. Noted for its cold water, Alaska seems an unlikely location for *Vp*, but in 2004 Prince William Sound recorded the third largest *Vp* illness outbreak in U.S. history. With surface temperatures exceeding 20ºC, *Vp* flourishes. ADEC has a *Vp* control plan enabled, where farmers take daily water temperatures to sink their oysters in the cool waters below the thermocline, provided deep water is available under the farm. At whatever farm site you choose, be wise and know the depth of your thermocline and take water temperatures in the summer to avoid *Vp*.

Turbidity, often called muddy water, is the loss of clarity causes by suspended particulate matter. Most troublesome turbidity originates from freshwater soil erosion washing suspended solids into the marine environment. Heavy loads of suspended solids reduce light penetration of the water and reduce feeding efficiency of oysters as they attempt to separate the unwanted solid from their phytoplankton food. Dense phytoplankton blooms also affect water clarity but are an indication of productivity that is beneficial to the oysters.

Measuring Water Clarity

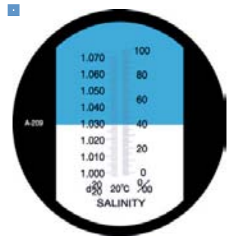
Measuring water clarity is a simple process, using a device called a secchi disk. The secchi disk is a white and black colored disk that is lowered into the water on a rope marked every foot. The disk eventually disappears and as the disk is retrieved, the number of feet on the rope from the surface to the disk is counted. The more turbidity, the shallower the disk disappears from sight. The same process is used to measure the density of a phytoplankton bloom. The apparent color of the disk is also interesting. Silt causes a gray to brown color and yellow indicates a diatom bloom (Figure 18). In practice, siting a farm away from significant freshwater influence helps reduce problems for freshwater origin turbidity.



Measuring Salinity

Salinity is measured with electronic probes or a salinity refractometer in Figure 19. The refractometer uses bending of light in saltwater as a way to measure salt content. An adequate refractometer costs around $110.

Figure 19.



Salinity has a number of important impacts in marine waters and in selection of a farm site. Salinity determines the species composition of an estuary because some organisms are more salt tolerant than others. Species such as the pinto abalone, scallops, and giant kelp prefer higher salinities than clams, oysters, and green algae. As a farmer, if you intend to grow scallops in the future, you need to be at a site where the salinity is consistently over 29 ppt. If you want to farm clams, lower salinities are best.

Salinity increases the density of water. A cubic foot of freshwater weighs 62.4 lb and a cubic foot of full strength seawater (35 ppt salt) weighs 64.1 lb. This is one reason that deeper waters are more saline, being located at depths away from freshwater. The density difference between seawater and freshwater during calm weather conditions causes the freshwater to float on top of higher saline deep water. Surface freshwater may be high in nutrients and minerals such as iron. Productive waters require mixing to make nutrients accessible to phytoplankton near the surface.

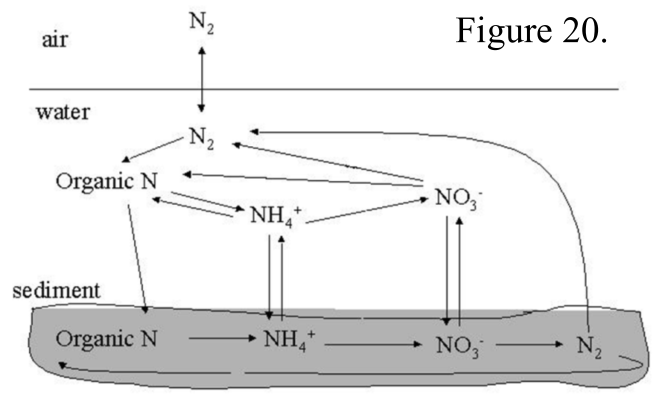
Low salinities in the winter can cause serious problems since the surface freshwater will freeze, forming an ice pack, and during spring break-up chunks of ice can damage farm equipment. This is another good reason to avoid significant freshwater influence.

Freshwater influence can cause the farm to fail tests for fecal coliform bacteria required by ADEC. Fecal coliform bacteria originate from intestinal tracts of mammals and birds. The test is easy and inexpensive to conduct as an indicator of potential pollution from water sources that contain fecal coliform bacteria even though evidence of high counts may not prove to be pathogenic. The fecal coliform test has been a water quality standard for decades and proven effective in preventing human illness caused by consumption of raw or undercooked shellfish. Even in the middle of a wilderness, a farm can fail the fecal coliform test if water flushing out of muskeg marshes during heavy rainfall carries bacteria from wildlife waste onto the farm site. Siting a farm away from freshwater reduces the potential of fecal coliform contamination. Testing for salinity is a simple inexpensive method of measuring freshwater influence on water quality of the farm site.

Nutrients

You likely will not be measuring nutrient properties of the water other than salt content. Nutrient properties of water are constantly changing. Figure 20 shows the basic process of the nitrogen cycle in marine waters.

Figure 20.



Optimal oyster production requires nitrate (NO_3) to sustain phytoplankton blooms. The atmosphere is the origin of nitrogen that enters into an organic form in living organisms that die and decompose, contributing NH_4^+ which forms into nitrate and feeds phytoplankton blooms or returns to the atmosphere. Within the sediment, organic nitrogen also undergoes transformation to nitrate and gaseous nitrogen. These processes are complex, undergoing constant transformation to various nitrogen compounds by living organisms and chemical reactions. Nutrient cycles are so complex and dynamic that any nutrient measurement at a specific time has little value in site selection.

Trace minerals are extremely important for sustaining phytoplankton blooms. Table 1 lists mineral concentrations in freshwater and saltwater. Of particular importance are iron (Fe) and silicon (Si), essential for marine phytoplankton, particularly diatoms; deficiencies can cause blooms to decline and crash. Interestingly, all of these important minerals have higher concentrations in freshwater than saltwater. Mineral maps of Alaska show an abundance of micronutrients in coastal soils available for feeding phytoplankton during freshwater runoff.

Table 1. Mineral concentrations in freshwater and saltwater, parts per billion.

Mineral nutrient	Marine water µg/L (ppb)	Freshwater µg/L (ppb)
Silicone (Si)	5,000	13,100
Iron (Fe)	3	670
Copper (Cu)	3	7
Manganese (Mn)	2	7
Selenium (Se)	0.1	0.2
Cobalt (Co)	0.1	0.1-0.5

Biological Characteristics of the Site

Primary producers derive energy from the sun, water, and carbon dioxide to produce glucose sugar. The energy converted into glucose through biochemical reactions forms living matter and fuels all the life processes, called primary production.

Primary producers are mostly plants and algae. Seaweed, often identified as a plant, is actually large algae called macroalgae, and phytoplankton is microalgae. The diversity of microalgae phytoplankton is enormous, possibly exceeding 5,000 species.

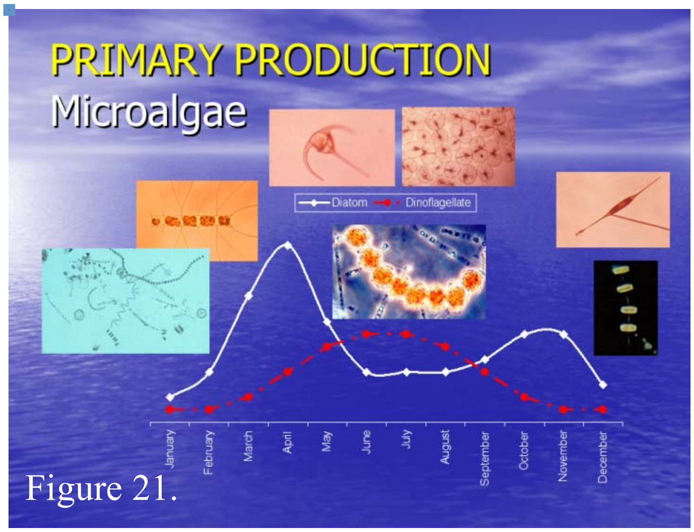


Figure 21.

Figure 21 shows the cycle of phytoplankton blooms and examples of a few of the hundreds of microalgae species in Alaska estuaries. The graph shows a typical bloom cycle with a large diatom bloom in the spring, dinoflagellates during summer, and a small diatom bloom in the fall.

Phytoplankton photos from left to right are:

- A spring sample showing a diverse composite of phytoplankton with a minimum of eight species of diatoms;
- *Chaetocerus* diatom chain of four cells showing long spines, dominant during spring;
- *Ceratium* dinoflagellate showing three long spines, a summer species;
- *Noctiluca* dinoflagellates with large spherical cells visible to the naked eye, producing a very red nontoxic bloom;
- *Nitzschia* diatom, elongated and pointed at both ends of the cell, often a fall bloomer;
- *Thalassiosira* diatom with a number of species distributed from spring through fall; and
- Center photo of *Alexandrium,* one of several species in Alaska known to produce paralytic shellfish poison (PSP) toxin.

Your site probably will follow the bloom pattern in the Figure 21 graph. Diatoms are more nutritious than dinoflagellates and farmers often report growth spurts in the spring and fall. To be a nutritious food source for shellfish, a phytoplankton meal must be composed of diverse species that include diatoms, flagellates, and very small ciliates. Single species alone cannot supply all the nutritional requirements to oysters.

Sampling phytoplankton to determine the species and abundance is very technical, time consuming, and expensive, and, like nutrient testing, bloom event timing and duration are unpredictable. Explaining the process is beyond the scope of this publication. If you want to sample phytoplankton, contact an expert source at OceansAlaska or the Alaska Sea Grant Marine Advisory Program.

PSP Testing

PSP is caused by toxic phytoplankton and in Alaska has been a pervasive problem for centuries, causing illness and death (Figure 22). Shellfish that feed on toxic phytoplankton are the most serious problem. The symptoms of PSP in humans are initial numbness around the lips and face, followed by paralysis beginning in the hands and feet. High doses are fatal due to respiratory failure or cardiac arrest. Symptoms can occur in less than a minute, and at low doses minor symptoms may persist up to six hours, leading to a full recovery.

In Alaska, 52.2% of PSP illness is associated with consumption of butter clam (*Saxidomus gigantia*) and noncommercial species, and 26.4% is associated with consumption of blue mussels (*Mytilus trossulus*) and species currently under development for farming. Alaska farmed oysters have never caused an illness—for all Pacific oysters certification is required for safe levels of PSP through a stringent testing program.

Figure 22

Test results for farmed shellfish product between 1988 and 2006 show that PSP is not a serious problem for shellfish aquaculture, with only 120 toxic samples from 7,323 tests. ADEC operates a Uniform Shellfish Monitoring Plan for PSP. The plan starts with new farmers submitting a shellfish sample from every harvested batch. After three years of toxin-free samples submitted at least once a month, the farmer is eligible for reduced sampling. The plan is on the ADEC website at http://www.dec.state.ak.us/eh/fss/seafood/Docs/PSPSamplingPlan2007.pdf.

Since butter clams hold onto PSP toxin for as long as two years, submitting a 150 gram sample to the ADEC laboratory for testing is a good way to assess the past level of PSP. The test will cost $125, but the experience is worth the peace of mind. Before shipping a sample, be sure to phone the laboratory to give notice that you will send in a sample and get shipping instructions.

Fouling Potential

Fouling is a persistent nuisance that requires intensive and timely maintenance to clean the farming nets and cages. Site selection must include assessing the potential for serious fouling problems (Figure 23).

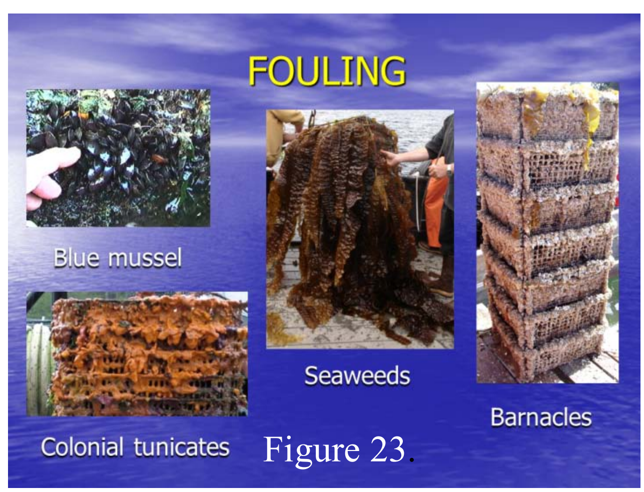


Figure 23.

The most serious fouling organisms are barnacles, tunicates, sponges, seaweeds, and blue mussels. Each fouling organism's life history follows a predictable schedule. Barnacles are usually the first to occur in April and May when their larvae are abundant. Tunicates occur during the summer, and blue mussels show up from late July through August. Seaweeds distribute their spores in the fall, and grow through the winter to yield an abundant crop on your gear by early spring.

To understand the exact timing of a fouling cycle on a farm likely will require several years of operation. The best strategy to prevent and control fouling is to look for clues that can forecast a coming event or indicate when new fouling has attached to your gear.

Assessing fouling potential is not easy. The best method is to hang out some gear on the site, allow the fouling to settle, and then retrieve and assess the amount covering the gear. A shoreline survey to look for the abundance of fouling organisms in the intertidal zone is helpful. A fouling assessment for barnacles and blue mussels includes an estimate of abundance and counting the number of size classes in the beds. Multiple sizes can indicate repeated fouling events called pulsing. Barnacles are notorious for contributing multiple fouling sets in a single year.

Predator Potential

Predators can be problem, especially sea otters, sea stars, and crabs. If sea otters are in the area, seriously consider using wire cages instead of lantern nets. Sea stars and crabs require hand removal from the gear.

Sea stars also have a larval stage that sets during late summer, transforms to an adult, and ends up in your gear even when your nets are off the bottom. Sea stars are fast growers and can cause considerable mortalities if they are not removed. Also, the presence of sea stars causes oysters to close their cups and thus suppresses feeding.

Testing for Contaminants

During feeding shellfish also circulate seawater through their internal body cavity, potentially collecting and concentrating contaminants. When shellfish is eaten undercooked or raw, the consumer takes the risk of illness caused by harmful bacteria and/or viruses that would be killed or neutralized during cooking. Consequently, the water of the farm site must pass fecal a coliform bacteria test administered by ADEC.

Testing for fecal coliform bacteria does not test directly for pollutants, but is an indication of pollution. The test for fecal coliform bacteria is useful because it is relatively easy laboratory test, it is inexpensive, and it has proven its usefulness through time. Shellfish farming and seafood processing have a higher standard of water quality than any other marine use, requiring water to contain no more than 20 bacteria per 100 milliliters of water; recreational use is 100 bacteria per 100 ml of water.

Passing the water quality test is **NOT** included in the shellfish farming permit application. You can receive the tidelands lease and permit to operate and start farming, but you need to pass the water quality test before the first product sale, which for many is at least two years in the future. Once you are permitted, getting your water quality classification may take more than a year, so start the process early.

The most likely source of pollution affecting marine water quality is rainfall runoff. The easiest solution is to avoid excessive freshwater influence in areas inhabited by significant wildlife populations. Higher salinity at the farm site provides good protection from runoff. The best time to collect a water sample and have it tested is a late summer or an early fall day when a rainfall event was preceded by a dry period. Check with ADEC to find out about their procedure before sampling and shipping (Figure 24).

Figure 24.

In addition to the fecal coliform test, the site must pass the shoreline survey, which examines the current and potential uses of uplands near the farm site. If development is in the vicinity, your farm can fail the test. Avoid areas of development.

Nursery Culture

One form of shellfish aquaculture exempted from the water quality requirement is a shellfish nursery. Growing hatchery oyster seed from 2-5 mm in length to 17-25 mm, nurseries provide a bump start in farm production by starting with large seed. Several nurseries operate throughout the state and some farmers have their own nurseries at their farm sites (Figure 25).

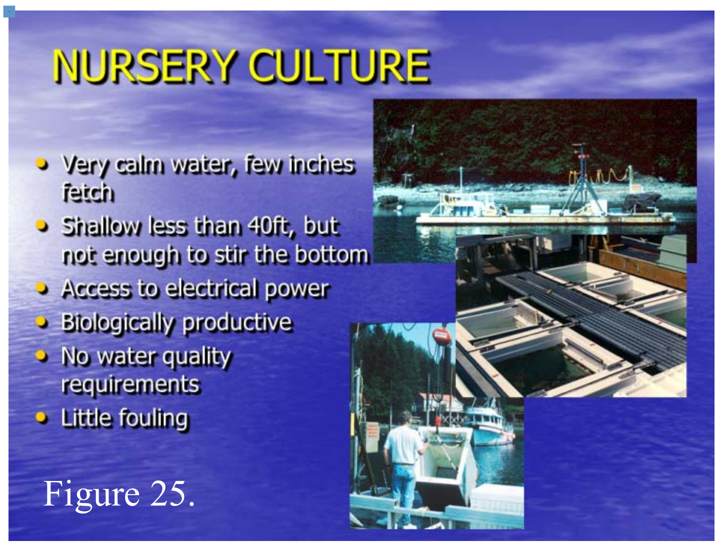


Figure 25.

Nurseries are exempt from water quality requirements because the oysters are not grown to full market size or sold directly to the seafood market. The ADEC rule is that nursery cultured seed must not exceed 2 inches in length when sold and purchased seed must be grown on a farm that meets water quality standards for at least 6 months prior to sale.

Permit-ability

A fundamental rule is to site a farm where the location is permit-able. Avoid areas where permitting could be denied for any number of reasons (Figures 26-28).

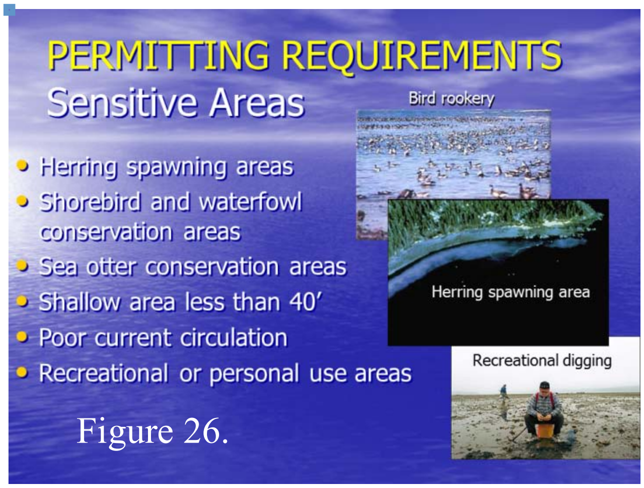


Figure 26.

Sensitive areas and conflicts with existing uses such as wildlife and personal use areas can cause problems. Pristine water quality and areas of good circulation have been previously discussed, but these areas may also have valuable ecological functions that result in denial.

Some sensitive areas are permit-able, but may cause production problems. An example is a herring spawning area where the farm cannot be worked until the spawned eggs hatch, which may be several weeks in the spring when farm maintenance is crucial.

Figure 27.

Preexisting uses, such as recreational shellfish harvesting or commercial fishing anchoring sites, can cause significant controversy and should be avoided where possible.

Eelgrass is a critical habitat for fish rearing. Seaweed beds are also important as fish habitat and can cause significant operational problems. To avoid areas of high seaweed concentration, the site must be examined in the late summer when seaweed reaches full size. You may not find any seaweed in the spring, but a full crop may develop by August.

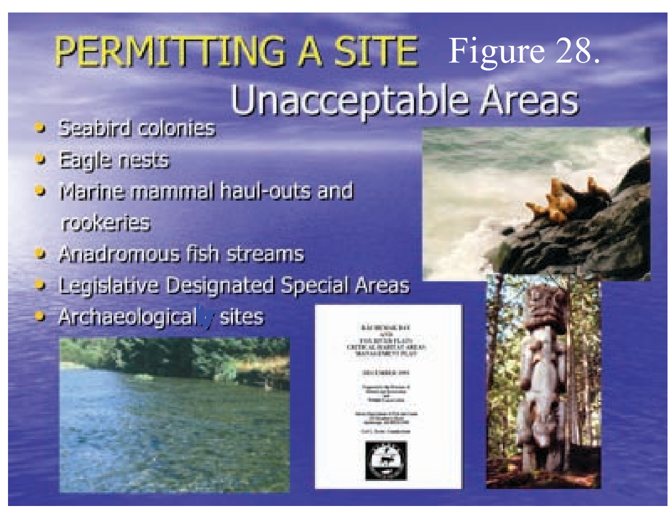


Figure 28.

Heavy use areas, such as protected anchoring or recreational areas may be permit-able, but water quality concerns from ADEC can result in conditional harvest closures that will not allow sale of shellfish during periods of intensive use.

Finally, examine your proposed site for unacceptable permitting criteria. Most of the reasons for denial are obvious, but may be unknown to you. Check with local residents, the ADFG Mariculture section, and ADEC to determine possible reasons for denial.

Many communities have a coastal zone management plan or area plan that clearly designates unacceptable areas.

Websites for more information are: Alaska Department of Natural Resources: http://dnr.alaska.gov/mlw/aquatic/index.htm

Alaska Department of Fish and Game: http://www.adfg.alaska.gov/index.cfm?adfg=fishingaquaticfarming.main

Your Infrastructure

The ultimate goal of shellfish farming is not only to make an income but to make a profit. Farm site features and location can contribute significant farming costs and largely determine your chances of having a successful business enterprise.

Six topics must be considered by potential farmers: financing, transportation, security, manpower, proximity, and marketing. Do not ignore them because they determine your ability to supply the work effort needed, acquire and efficiently use operational funds, and sustain production and income.

Access to financing likely is essential at some point in your endeavor and financial institutions will closely examine the potential of your farm site to make a profit and repay the loan. Your business plan must address each of the six issues if you are to get a loan.

Distance to the market can be a major constraint to farming transportation and logistics of product delivery to the market. The number-one reason buyers decide to purchase oysters is the reliability of the farmer to provide the amount of product at a predetermined date. The quality of your product does not matter for the buyer if the farmer cannot meet the supply requirements. Transportation also includes equipment and personnel. One reasonable criterion is—can your workers return home after their shift? Do not expect them to live on the farm site.

Site security has been mentioned previously, but security also includes protection against storm hazards and worker safety that may be site related. Remoteness has employee boater safety implications, and the distance to medical attention must be considered by you as the employer.

Conclusion

Reviewing an aquaculture business plan and obtaining information about shellfish aquaculture in Alaska will be beneficial. A helpful source of online information is the Alaska Sea Grant Marine Advisory Program aquaculture website at http://seagrant.uaf.edu/map/aquaculture/index.html.

If you need information, ask. Resources and links are provided in this manual for you. You need to be connected to the industry, regulators, and experts to improve your chances to become a successful farmer by following the principles necessary for selecting your farm site.

Culture Systems

Chapter 9. Evolution of Oyster Culture Methods in Alaska

Rodger Painter

History

Alaska's involvement in culturing Pacific oysters dates back nearly a century, but there are few success stories in the business of growing oysters in Alaska. There is general agreement, however, that oyster farming in Alaska has the potential to be very successful if done right, with support from involved agencies.

Early efforts to farm oysters in Alaska involved trying to duplicate the efforts of pioneer growers in Washington who were planting spat from Japan on the beaches of Willapa Bay and Hood Canal. Small dikes often were constructed to prevent the juvenile oysters from being swept away.

Of all the beaches that oysters were planted on from Ketchikan to Kachemak Bay, the oysters fared the best in southeast Alaska. Life on the beach in Alaska is much harsher than for our southern neighbors, and despite some spotty success, including stories of planted oyster beds that reproduced, beach culture didn't produce many oysters. Production peaked in 1943 with reporting of 550 gallons of oyster meats.

A floating tray system being worked by long time oyster farmer Don Nicholson. Abandoned in the early 1980s, the system is composed of a floating rectangle of logs with a bottom of various screen sizes depending on the seed size. (Photo by D. Nicholson)

Oyster farming experienced a rebirth in the early 1970s when a group of farmers based out of Wrangell begin farming single spat with suspended culture techniques. Many of these farmers tried farming oysters in "floating trays," which were heavy-duty extruded plastic mesh hung between logs.

The floating trays were low budget and very labor intensive, requiring almost non-stop raking of the oysters to prevent fouling. Since the oysters were suspended only a few inches below the surface, many growers also discovered their oysters became very "spawny" during the growing season. High summer mortalities also compelled farmers to search for another growout method.

Ten tiered lantern net. Holds about 70 market size oysters. per tier. (Photo by D. Garza).

Original 1995 FLUPSY at Halibut Cove, Kachemak Bay. With an efficient paddlewheel pump, water flows through bins of oyster seed providing abundant food. Seed can grow from 5mm to over 25mm in length with three months of growout (Photo by I. RaLonde)

The farmers who survived the floating trays then shifted to lantern nets. Most growers suspended lantern nets from longlines, while some southeast Alaska farmers hung them from logs. While lantern nets proved a much better option than the floating trays, few farms were mechanized and many farms suffered heavy oyster mortalities as they fell behind in maintaining their crops.

Introduction of oyster nursery culture in the mid 1990s profoundly changed oyster farming gear selection. Prior to nursery culture, called floating upwelling systems (FLUPSY), farmers were compelled to purchase small seed from hatcheries outside of Alaska. Nursery culture enabled farmers to purchase seed at more than twice the size that could be planted directly into larger mesh gear, rather than starting with small mesh seed culture and then making the transfer to larger mesh for final growout. A number of FLUPSY nurseries supply oyster seed to Alaska farmers.

A few farms experimented with suspended trays in the 1980s, but tray culture of oysters wasn't used extensively until sea otters in Prince William Sound began stealing oysters from lantern nets and homemade trays. After shifting to stainless steel trays manufactured by AquaPacific in British Columbia, two of Alaska's largest farms began reporting major improvements in labor efficiency.

Intertidal bag culture system.

Eight stack wire tray system. Each tray holds about 120 market size oysters.

Presentations on tray culture of oysters by B.C. aquaculture expert Brian Kingzette at Alaskan Shellfish Growers Association meetings helped convince other growers to experiment with raft and tray culture. Many newer farms are now employing raft and tray culture.

More recent experiments using bag culture, conducted as cooperative projects between the Alaska Sea Grant Marine Advisory Program and farmers, have convinced a handful of farmers to shift some production to intertidal and floating bags. At least two southeast Alaska farms are using both techniques almost exclusively.

At the time this manual was written, the single farm that employed traditional beach culture, where oysters are spread in the intertidal area, had far more oysters in the water than any other operation in Alaska.

Every Culture Method Has Good and Bad Attributes

The first step in developing the *Alaska Oyster Grower's Manual* was to survey existing farmers. We asked them to rate the attributes of different culture systems and asked for gear-specific husbandry recommendations. The responses were informative and sometimes surprising. A summary of the findings are in this chapter.

Generally, respondents using rafts and trays were very happy with the performance of the system, while agreeing that the biggest disadvantages were the cost and the amount of space needed for storing trays while not in use. All five growers agreed it is easy to work the crop, oysters grow quickly, and the trays are very durable.

After farming oysters for 20 years in lantern nets and criticizing them for the past decade, I was surprised to find that most fellow growers rated them favorably. Most growers agreed that on the plus side the oysters grow quickly in lantern nets, and the gear is easy to store and is very durable, while the disadvantages are the amount of labor required to work the gear, and the difficulty of working the crop and defouling the nets.

Only two growers responded to questions regarding floating bags and both had limited experience with the gear. However, both respondents rated the gear very favorably. Respondents estimated they spent 25-30% of their time processing, marketing, and selling their product. Following are the responses for each gear type.

Husbandry—lantern nets			
No. responses		**Experience (yrs)**	
9		4	2
		6	1
		>15	6
Advantages		**Disadvantages**	
Easy to work crop	3	Difficult to work	5
Low labor	0	High labor	7
Easy to defoul	3	Defouling difficult	5
Fast growth	8	Slow growth	0
High survival	3	Low survival	2
Easy to store	9	Too much storage space	0
Inexpensive	4	Expensive	3
Durable	7	Repair frequently	0
Produces good oysters	6	Bad oysters	0
Deployment easy	5	Deployment difficult	1
Frequency of sorting		**Frequency of moving crop during growing season**	
1/yr	3	Monthly	1
2/yr	4	Once	2
		Twice	5
		Method	
		Shaking	3
		Hosing	2
		Tumbling	1
Spat size (mm)		**Stocking densities (initial)**	
12 mm	1	120/tier	2

15-20	1	125/tier	1
20-25	6	200/tier	3
25-30	1	250/tier	1
Optimum size		500/tier	1
20-25	7		
25-30	2		
Stocking density (final growout)		**% time acting as processor/seller**	
60/tier	2	(3 responses)	
75/tier	3	25-30% of time	
80/tier	2		
Husbandry—trays			
No. responses		**Experience (yrs)**	
5		2	1
		4	1
		6	2
		14	1
Advantages		**Disadvantages**	
Easy to work crop	5	Difficult to work	0
Low labor	3	High labor	0
Easy to defoul	4	Defouling difficult	0
Fast growth	5	Slow growth	0
High survival	4	Low survival	0
Easy to store	1	Too much storage space	4
Inexpensive	0	Expensive	5
Durable	5	Repair frequently	0
Produces good oysters	4	Bad oysters	0
Deployment easy	4	Deployment difficult	0
Frequency of sorting		**Frequency of tumbling crop during growing season**	
1/yr	1	1/yr	2
2/yr	2	2/yr	1
4/yr	1	4/yr	1
6/yr	1	Every six weeks	1
Spat size (mm)		**Stocking densities (initial)**	
20-25	3	250/tray	2
25-30	1	700/tray	1
20-35	1	1000/tray	1
Optimum size			
25-30	2		
Stocking density (final growout)		**% time acting as processor/seller**	

100/tray	2	25-30% of time	1
250/tray	2	50% of time	1
Husbandry—floating bags			
No. responses		**Experience (yrs)**	
2		2	2
Advantages		**Disadvantages**	
Easy to work crop	2	Difficult to work	0
Low labor	2	High labor	0
Easy to defoul	2	Defouling difficult	0
Fast growth	2	Slow growth	0
High survival	2	Low survival	0
Easy to store	0	Too much storage space	1
Inexpensive	2	Expensive	0
Durable	2	Repair frequently	0
Produces good oysters	2	Bad oysters	0
Deployment easy	1	Deployment difficult	1
Frequency of sorting		**Frequency of flipping bags during growing season**	
1/yr	2	Every 2 weeks	1
		Once every 2 months	1
Spat size (mm)		**Stocking densities (initial)**	
20-25	1	200/bag	1
Optimum size		150/bag	1
25-30	1		
% time acting as processor/seller			
25% of time	1		
50% of time	1		

Shake, Rattle, and Roll: The Key to Growing the Perfect Oyster

When Alaska's first oyster nursery was constructed in Homer, Dick Poole, long-time manager of Lummi Shellfish, told a group of farmers during an Alaskan Shellfish Growers Association meeting that the most important step in oyster farming was to "shake, rattle and roll."

Original sorter for the Kachemak Bay FLUPSY. Regular tumbling and sorting for oyster seed is a necessity. This sorter was converted from sorting onions in the Midwest.

As any nursery operator will attest, adequate tumbling and sorting is the most important step in producing high quality seed. Also, as many farmers have discovered in succeeding years, moving and sorting a crop of oysters frequently is the key to good product quality, high survival rates, and ultimately, profitability.

Pacific oysters are extraordinarily tough animals. They are not quite as hardy as the eastern oyster that can survive an entire winter out of the water or the European flat oyster that journeyed over the Alps on the backs of elephants, but they are still one of the toughest creatures to grow on a beach.

In the wild, oysters often grow in clumps, and each oyster often must be separated from the others with hammers and chisels. In a clump of oysters, the path of least resistance is the part of the shell that grows outward. This results in shells that are misshapen, and the harvested oysters tend to be long and flat.

Hand tumbling and sorting is time consuming and laborious. Mechanization is necessary to develop a productive farm.

Single oysters dumped in a lantern net or tray will end up piled in one spot. If left unmoved, the oysters on top will do well, those on the next layer will grow outward and be long and flat, and those on the bottom will hardly grow at all. If left untouched for 1-2 years the result will be heavily fouled, muddy clumps of misshapen, small, and dead oysters.

If your goal is to make money by growing oysters you need to pay close attention to the labor efficiency of your operation, because you are likely to be dealing with three to four crops of oysters totaling more than a million shellfish. To reach peak efficiency, a farm should move and sort its crops 4-5 times during the growing season. This means you might be handling 4-5 million oysters over a six-month period.

Tumbler/sorter on Mike and Kathy Sheet's farm in Sea Otter Sound in southeast Alaska. (Photo by Mike Sheets)

Alaska oyster growers employ a wide variety of methods to move and sort their crops. Most methods are dictated by the type of culture system used for growout, degree of mechanization, sophistication of infrastructure developed to handle the volume of oysters, and availability of labor.

Nearly all farmers growing oysters in trays use a mechanical tumbler/sorter. This system can be very efficient and produce high quality oysters.

Some growers using lantern nets also use tumbler/sorters, but the process is slower because of the inefficiencies of stocking and lacing shut “doors” to the net chambers. Other growers have non-mechanized systems and cut back on sorting to once or twice a year. One southeast Alaska grower is producing high quality one-year-old oysters by washing down lantern nets with a high powered water pump and shaking the nets vigorously once a month, without emptying the nets until the end of the growing season.

Shellfish growers around the world are using the power of ocean tides and wave action to eliminate the need to move and sort their oyster crops during most of their life cycle. Two approaches to harnessing ocean power were incorporated into the operations of a handful of southeast Alaska farms in 2008.

The “flip-flop” system was developed by Puget Sound shellfish grower John Lentz, who expanded his oyster production by putting used oyster bags back to work. Lentz strung horse wire along “fence posts” driven into the soft substrate of a nice, flat beach. The bags are attached to the horse wire with metal clips, with flotation attached to the other end of the bag. The oysters are then tumbled four times a day as the tides go in and out.

Flip-flop intertidal bag system on Wyatt’s Alaska farm. The bags have a float attached to the bottom the bag. The bags float up and down during tidal changes, tumbling the oysters inside.

Another system using the standard oyster growout bags takes advantage of ocean wave action. The floating bag system has been employed by farmers in New England and the Canadian Maritimes for decades, and, more recently, by a few British Columbia farmers.

A couple of farms in the Naukati area are using the Lentz and floating bag technology almost exclusively, and were happy with their results over the first few years.

Chapter 10. Developing Your Systems

Rodger Painter

Plan for Efficiency
One day after processing and shipping about 12 boxes of shellfish, I started to wonder why I was so tired at the end of the day. After examining each step in the process, I discovered I was picking up each 65 lb box and moving it about 10 times by the time it was loaded on the plane.

After calculating that I had moved about 4 tons that day, I began figuring out how to cut it in half by just changing a decade-old packing system. I made good progress, but small improvements to the processor and the addition of a pallet jack could have eliminated nearly all of the heavy lifting.

When developing an oyster farming operation, it is important to pay close attention to the details of each job and attempt to design systems to make the job easier. Whether you're worrying about your own back or wondering how you're going to pay an employee to help out, reducing labor and heavy lifting is important. After a quarter century as an oyster farmer, I have vertebrae fused in two different points in my spinal column as testimony.

An oyster farm might be viewed as a series of systems that you integrate into an operation that produces high quality shellfish at the other end. However, there's no cookbook approach for designing the perfect system for each farm site and individual farmer.


Maintenance and processing raft at Wyatt's farm. (Photo by Deborah Mercy, Alaska Sea Grant Marine Advisory Program.)

Eric Wyatt, of Blue Starr Oysters on Marble Island near Naukati, is a strong believer in systems. Wyatt carefully studied efficient raft and tray operations in British Columbia and tried to think through each job before he began constructing his remote oyster farm.

Since Wyatt was planning to build a farm that he could operate without outside labor, each job had to be approached from that perspective. He carefully designed his system for lifting his heavy stacks of trays so that one person could hook the straps, operate a large boom arm, and move the load to his work area.
Six years later, despite the advance planning,

Wyatt was still tinkering with his systems and hopes someday to fit the different parts into the perfect puzzle. His biggest challenge was figuring out how to compensate for his absences during the growing season to run his more profitable salmon trolling business. This is a big hurdle if you have no employees.

Gravel/cobble beach for final oyster growout.

Pearl of Alaska's Tom Henderson also attempted to build a one-man operation at his oyster farm south of Kake. After years of struggling with trying to keep up with the workload of raising 300,000 spat in lantern nets, Henderson leased 10 acres of a flat cobble beach near his suspended culture site to become Alaska's first oyster beach culture operation in 40 years.

Rather than spreading spat on the beach and accepting very poor survival rates, Henderson raised the oysters for a year before moving them to the intertidal area. The workload was still overwhelming for one person, and he began hiring part-time help, harvesting the oysters during minus tides, and packaging 400-500 dozen per week. Even giving the spat a head start, he still had to make big trade-offs in poor survival and lower quality.

Realizing he had to ramp up production to make a decent living, Henderson built a new processing operation and attracted the attention of Sealaska Corporation, one of the biggest regional Native corporations. A joint venture resulted in Henderson operating a 4 million seed capacity floating upwelling system (FLUPSY) for Sealaska, with the corporation supporting two employees and providing a new boat for the long commute to the farm.

With the new tools and labor, Henderson soon had 5 million oysters in the water at his two farm sites, and product quality and survival rates improved significantly. The FLUPSY was producing high enough quality spat to attract growers from Washington, each wanting a million seed per year.

The systems at each farm are different, even though they are using identical equipment. Systems need tailoring to each situation as each farmer figures out how to make a job fit his or her site, infrastructure, availability of labor, and budget.

Design Your Lifting and Gear Delivery System to Fit Your Operation

Pulling oyster gear out of the water can involve lifting awkward stacks of fouled trays, weighing hundreds of pounds, up to 10 feet above the waterline and swinging them to your work area. The lifting system is one of the most important systems in your operation, if you are interested in efficiency and avoiding serious damage to your back from heavy lifting.

As someone who crushed two vertebrae pulling 10 tier lantern nets by hand, I can vouch for the importance of a well designed lifting system. Pulling the gear by hand can literally be back breaking work. Even hand cranking winches, pulling 250 pound nets across the deck, and walking trays from stacks deposited five extra feet from a tumbler/sorter takes its toll over the course of a full day of cleaning and sorting.

There's certainly no standardized system for this job—nearly every oyster farm in Alaska has a unique way of lifting their nets or trays. Systems in use in 2011 ranged from the sublime (a single operator lifting stacks of trays from the raft to a covered work area by operating a control switch) to the barely automated (stationary wooden davits where lantern nets are hand-cranked up to be manually pulled onto a raft as the winch is released).

The height and horizontal reach of lifting systems must vary to fit the type of gear, culture system, and configuration of the work area. For instance, a boom arm or davit needs a longer reach to efficiently service a raft and tray operation than it does to work longlines. The effective length of the boom arm may limit the size of the rafts a farmer can use.

Lifting power also will vary according to what you're pulling out of the water. A stack of stainless steel trays filled with marketable oysters will weigh more than 10 tier lantern nets, and most hand-cranked winches really aren't designed to pull the heavier gear. This situation may require stronger infrastructure.

Whatever design you choose, it is important to develop a system that is capable of lifting loads at least 50% heavier than your calculation for the average unit weight of gear. Make sure to include fouling in the calculation. Any farmer who has had to deal with massive mussel sets that have had a few extra months to grow, kelp that grows 6 feet in a month, or any number of biofouling events understands the need for having extra lifting power.

Eight stacks of the "Maxi-Flow" trays might be stocked at 10 dozen marketable oysters. At this rate, the product alone will weigh about 160 pounds when out of the water. An important consideration is that oysters weight 30-40% less in water than out because the oyster meat is nearly neutrally buoyant and seaweed often floats. Add the out of water weight of the trays and a modest amount of fouling, and the gear might weigh 250 pounds at harvest. Heavy fouling, particularly when composed of barnacles and blue mussels, might add another 100 pounds of weight to lift.

Many growers have used the hand-cranked winches designed to pull boats onto trailers. While these are well-geared for the occasional pulling of a boat and are capable of lifting a stack of trays or lantern nets, sustained use for lifting oyster hand crank pullers is shoulder-breaking work. Upgrading to an electric or hydraulic winch will speed up the cleaning process and reduce the manual labor.

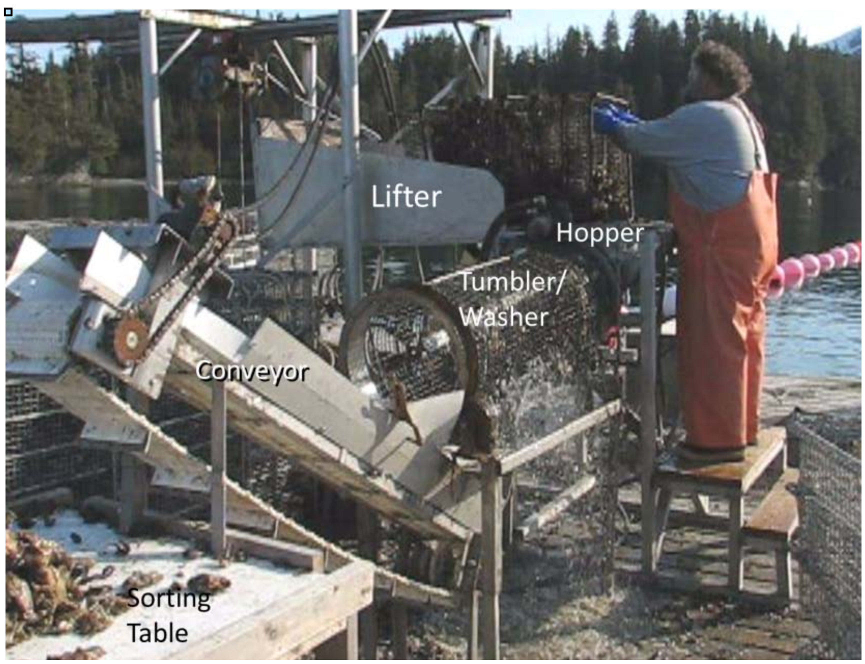
In addition to getting the oysters out of the water, the other piece of the puzzle is delivering the oyster gear to where it can be worked with a minimum amount of manual labor. Moving a full lantern net on the deck is heavy work and the distance required to move trays from where they are deposited on deck to a tumbler/sorter should be as short as possible.

In short, it's another case that requires thoughtful planning through the entire process before constructing your infrastructure. Following are some examples of some lifting and delivery systems Alaska growers were using in 2011.

Eagle Shellfish Farms, Jim Aguiar

Long-time Cordova oyster farmer Jim Aguiar is a genius behind a welding torch. He constructed a metal barge that includes a comfortable living area with room for crew, modern kitchen, washer-dryer, processing plant, shellfish hatchery, waste heat recovery system, and workshop.

His best known handiwork undoubtedly are the FLUPSYs he constructed, which are now used in Naukati, Kake, Homer, and of course Cordova. But, the highlight at Aguiar's farm for anyone using trays is his system for delivering the product once it is out of the water.



Lifting system at Aguiar's farm that shows the operation from lifter to cleaning and sorting. The entire process is mechanized and requires no bending or heavy lifting.

Two 16 ft x32 ft rafts are pulled along his longlines by hydraulic power and stacks of trays are pulled through a well by a hydraulic winch mounted on a trolley. The stacks of trays are then transferred to a hydraulic lift, which moves up so the trays can be tipped one at a time into a chute. No trays need to be picked up until they are empty. The oysters move through a tumbler and onto a sorting table before they are touched by human hands.

Aguiar estimated the cost of materials for his system at $15,000-$20,000, including the raft, hydraulics, and tumbler. If contracted out, the cost of the system probably would double.

Blue Starr Oyster Co., Eric Wyatt
Eric Wyatt's solution worked so well that the community of Naukati purchased one for its Weekend Warrior Program, to train aquatic farmers, and their first graduate went on to purchase one of the systems for his farm. Wyatt configured his system so that a single operator can lift stacks of trays from anywhere on a raft to a covered work area with an electric hoist.

Equipped with a boom lifting system, stacks of trays can be lifted easily. Attached to the raft is an oyster growout raft of suspended trays ready for cleaning and tumbling.

The boom reaches 25 feet. It swings to any point on a 16 ft x 24 ft growout raft, lifts up to 500 pounds, and can then roll the load along its length. This gives Wyatt the ability to easily transfer a stack of trays to the deck of his processor/work scow in 3-4 minutes. The trays are then slid adjacent to the tumbler, where they are emptied onto the tumbler feed table or put on the harvest packing table.

The entire farm was planned around this boom, because access to the product in an efficient manner is vital to success of the operation. The entire process takes about 20 minutes—from lifting an eight stack of wire trays from the water, cleaning and tumbling, and returning the stack. The boom can service two rafts moored to the scows, allowing Wyatt to set aside sorted, cleaned, and counted marketable oysters.

Wyatt warned growers to properly ground electric winches to the saltwater to prevent shocking experiences when it's raining. He also recommended AC over hydraulics because it is less expensive and eliminates fluid leaks.

Pearl of Alaska, Tom Henderson

Tom Henderson, with the only beach culture operation in Alaska, has perhaps the most unique oyster farm in the state. His needs for a lifting and delivery system also are unusual.

Naukati's boom arm can lift stacks of trays from anywhere on the raft and move them back and forth to the tumbler/sorter on the dock to the right. The community values the boom and electric hoist at $16,000.

Henderson effectively works longlines with a six-foot davit with a horizontal reach of only two feet. The davit is mounted on the gunwale at the bow of a landing craft. The lantern nets are raised about three feet out of the water with a star-roller, so they only have to be hand-cranked another six feet to clear the water, and then the nets can be swung onto the lowered front gate of the landing craft.

Henderson raises his spat for one growing season in lantern nets before scattering them on the beach of Big John Bay in Rocky Pass south of Kake. He vigorously washes down and shakes the spat nets monthly during time on the longlines; no tumbling, sorting, or emptying of the nets is needed.

Henderson's lifting system with landing craft vessel that can move oysters from initial lantern net growout to planting on the beach.

When the spat are large enough to move to the beach, the nets are pulled and the oysters are dumped on the deck of the landing craft where they can be washed out the front gate onto the beach with a hose at Big John Bay.

Henderson's system requires more labor than those of Aguiar and Wyatt, but it is efficient when worked by a two-person crew and it saved several thousand dollars in start-up costs.

Chapter 11. Lantern Net Longline Set-up

Rodger Painter

Lantern nets were developed by the Japanese for culturing scallops and other shellfish, and use of the gear has spread throughout the globe.

For two decades lantern nets were the gear of choice by nearly all Alaska oyster farmers, but by 2011 they had fallen out of favor among new farmers. Alaska oyster growers weren't the only ones to move away from using lantern nets. Farmers in British Columbia had made a complete shift to trays and bags, and lantern nets never really caught on in Washington or other West Coast states.

Alaska oyster growers first chose lantern nets for several reasons. The gear is exceptionally durable, it was inexpensive at the time, the nets were easy to ship and store, and the long cylindrical shape made good use of the water column. An important influence was the example set by Bill and Doree Webb at their oyster farm, Wescott Bay Oysters, in the San Juan Islands.

Westcott Bay Oysters produced what many considered the best oyster in Washington during the 1980s and 1990s. At the time, the company had the only operation of any size producing off-bottom oysters. Westcott Bay Sea Farms also sold oyster spat in Alaska and the Webbs were mentors to many Alaskans. It was only natural that this resulted in many Alaska farmers adopting the same type of gear the Webbs used.

What many Alaska farmers soon discovered was the amount of labor involved in working the gear. Lacing the "doors" of the nets is time-consuming. Emptying the gear usually requires someone to stick their arm inside each chamber to pull out oysters and fouling stuck to the mesh.

7.5 mm mesh lantern nets are commonly used by Alaska growers for spat.

Consider that a worker might spend five minutes dismantling and emptying a stack of trays, and refilling clean trays with tumbled and sorted oysters and moving the gear back into the water. It might take a worker an hour to empty and redeploy a clean lantern net with oysters. If the sorting were done by hand instead of using a tumbler/sorter, the job might take two hours.

Even so, it must be said that lantern nets can produce very high quality oysters with good survival rates from spat to marketable product if proper husbandry is practiced, particularly during the first year of growth.

The Gear

Lantern nets are made up of 11 synthetic mesh-covered metal hoops tied together with four ropes to form 10 chambers where the oysters grow. The ropes are tied to form a loop about 18 inches above the top chamber and a simple knot about the same distance from the bottom tier.

The chambers are 20 inches across and are spaced about seven inches apart. When a tag line is attached to the top loop to hang the gear from a longline, the net occupies about 12 feet of the water column.

The inside of the chambers are accessed through a “door” running the length of the gear. The nets are laced closed by threading a thin plastic line through the mesh. Lantern nets with extra mesh by the doors are much easier to lace than nets in which the webbing must be pulled together. The latter nets are even more time consuming to tend.

The mesh on lantern nets comes in a wide range of sizes. It is important to use the right mesh size for your crop as spat placed in nets with too large a mesh size will grow into the mesh and are difficult to get out without killing a lot of shellfish.

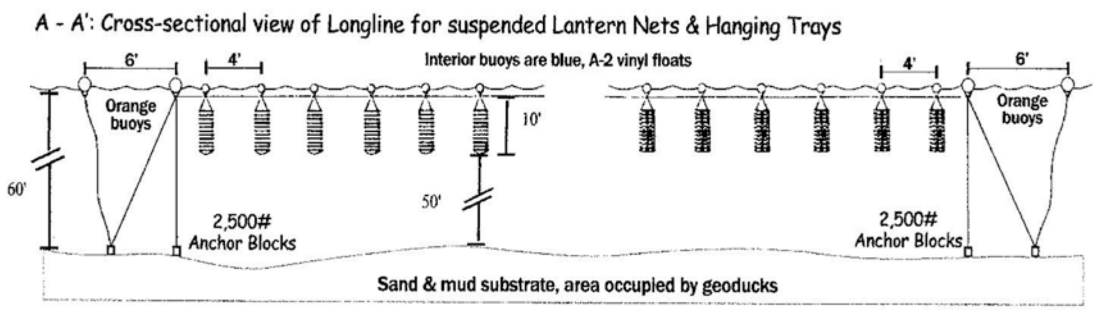
The most common choice of mesh size for spat nets is 7.5 mm. These nets can accommodate spat as small as 15 mm, but 20 mm and larger spat work better. This small mesh size fouls easily, contributing to less water flow through the nets and, consequently, less phytoplankton for the oysters to eat. While it is important to increase mesh size as the shellfish grow larger, you really don’t need to go larger than about 21 mm (about 1 inch) to get a good flow through the nets. Lantern nets are extremely durable. At the time I sold my farm in 2011 I was one of several farmers who were actively using 20-year-old nets. Yes, many of the nets have been repaired several times, but unless they are crushed it has been possible to repair damaged nets with cable ties, weed whacker string and, occasionally, a piece of salvaged webbing. Sometimes it is necessary to bend a twisted wire, but repairs are possible, although sometimes labor intensive. The biggest enemies of lantern nets are too much time in the sunlight or the water, and careless handling and storage.

A good place to defoul lantern nets is the beach. Rock crabs and other intertidal scavengers will help clean the nets and exposure during low tides kills subtidal growth.

Longline Components

Nearly all Alaska lantern net operations use longline systems, although some older southeastern Alaska farms may still hang lantern nets from logs.

The log systems certainly were inexpensive for shellfish growers in the middle of the largest national forest in the country. However, these systems were less efficient to work than longlines, gear loss is high, and logs in the water don't have a very long lifespan.



Source: State of Alaska aquatic farm packet.

Parallel independent longlines at Pearl of Alaska's farm in Rock Pass south of Kake.

Longline systems can last for decades with very little maintenance. They are also efficient for working lantern nets, and are relatively inexpensive. Rafts can also be used for hanging lantern nets, but offer no real advantage over longlines and cost more per unit of gear accommodated.

Longlines are simply ropes strung between buoys attached to anchors. These lines can be attached into a rectangular grid, which is a more efficient system, but one that creates great anchoring challenges.

Anchoring is the biggest issue involved with longlines. Keep in mind that a longline of lantern nets is like deploying a floating reef. The system needs to stay in place despite the best efforts of currents, waves, and wind to sweep the system away. My personal solution is to tie to the shore whenever possible. Wrapping chain, cable, or rope around a rock is less expensive and more reliable than most anchors. Anchors can drag but the shoreline isn't going anywhere.

Longlines should always be oriented with the currents for two reasons. It will help to avoid having your "floating reef" catch tidal flows broadside and will also keep it from presenting a great barrier for catching floating logs or kelp.

Standard $^5/_8$ inch line found at most commercial fisheries suppliers works well for lines. Anchor lines for longline grids might be ¾ inch.

Floats

Each lantern net needs a float. It is key to provide enough flotation without over-buying—while you don't want sunken longlines, you might be purchasing hundreds of floats and you don't want to pay $12 for flotation you don't really need.

Standard A-2 crab buoys work well on longlines for suspending lantern nets. These light blue buoys blend in well and avoid "visual pollution."

Crab pot buoys work well on longlines and are available at most marine suppliers. Polyform A-2s provide 68 pounds of flotation and are used by most farmers. They were available for $34 each at a Seattle fisheries supplier in 2011.

Corner buoys on longline grids should be A-3s (121 pounds flotation, $46) or larger.

Use good line for all floats and buoys, $^3/_8$ inch or larger. The floats will be moving all the time and will gradually saw through thin or old line. Floats can be attached directly over each net or halfway between each unit of gear.

One last word about floats: color. While orange buoys are easy to see, they can create an extraordinary visual landmark when you bunch 200-300 of them in a couple of acres. While "visual pollution" might not be an issue at your remote sight, it is best to avoid potential problems by choosing darker colors, such as gray, blue, or black.

Attaching the Nets to the Longline
There are different schools of thought on the best approach to attaching lantern nets to longlines. Many growers use longline snaps. This may be the fastest method, and perhaps the safest by eliminating knots that might be incorrectly tied. Other growers sacrifice a slight gain in efficiency for the lower cost method of tying a knot on a tagline.

I've used both methods and favor a snap by a slight margin. I began fishing salmon commercially when I was six years old and tying knots is second nature to me so it may not be a fair comparison.

Some growers have their taglines permanently attached to the longlines, while others attach theirs to the lantern nets.

The nets should be spaced 4-6 feet apart.

Moving Along the Longline
An invaluable tool for working longlines is a star roller. It provides a mechanical boost to some hard pulling when the currents and winds are not in your favor.

These steel rollers (pictured) have "fingers" that allow floats to move along without entangling. The units can be mounted on a skiff, service vessel, or raft. With the addition of hydraulics, it is possible to move even a very heavy service craft along a longline without any manual labor.


Star rollers are a great help in moving a service vessel along a longline.

Use of star rollers (you need two or more) also helps keep the longline at a height where nets can be more easily accessed for attaching them to a davit or boom.

Chapter 12. Rafts and Trays Focus on Efficiency

Rodger Painter

Trays have been used by Alaska oyster farmers since the 1980s when the industry was revived through the shift to suspended culture. The early trays were either homemade or a tough plastic gear known universally as "Mexican" trays, after their place of manufacture. Most trays in those days weren't very efficient and very few growers used them.

A stack of Maxi-Flow trays with liners holds a new crop of spat. The nesting trays are held together with straps made of groundline commonly used by longline fishermen.

The growth of the sea otter population in Prince William Sound convinced the two largest farming operations in the area to switch to trays capable of keeping the voracious predators from eating their oysters. While the conversion was costly, the otters couldn't get into the wire mesh trays. As an added benefit, the growers were delighted in how much labor the new system saved.

Introduced to Alaska growers at one of the Alaska Shellfish Growers Association annual meetings, AquaPacific's Maxi-Flow trays are marine grade plastic-coated, stackable wire-mesh trays. They are designed to be very durable and labor-efficient. Many British Columbia oyster growers adopted the trays and have built low-cost rafts for deploying the gear.

The Canadian model for raft and tray culture was touted by British Columbia shellfish expert Brian Kingzett during two workshops sponsored by the Alaska Sea Grant Marine Advisory Program and one sponsored by the Frank Murkowski administration in Alaska. Kingzett, a shellfish aquaculture researcher, business consultant, and former oyster farmer, said the small footprint of the rafts allow growers to take full advantage of limited tenures available in B.C.

The long boom arm and hoist at Naukati make it easy to access trays from the entire raft without shifting locations. It is possible for a single operator to lift the stacks of trays and move them to the dock for tumbling and sorting.

With the use of tumbler/sorters, growers were able to significantly boost production with efficient methods of going through the gear. Kingzett said research showed that moving the crop around more frequently actually increased growth rates and improved product quality.

By 2011, most new oyster farms were using rafts based on the design furnished by Kingzett and generally following the B.C. raft and tray model. The rafts seem to hold up well in the sheltered farm sites of the southeast Alaska growers, but most B.C. growers were shifting to a sturdier design because many leases or tenures in B.C. are exposed to larger wave action during winter storms.

A stack of trays loaded with spat is lowered into the water at Naukati's Weekend Warrior project.

Kingzett's detailed instructions on how to construct the rafts are at the end of this chapter. Some B.C. farmers mount davits on the rafts or use clamp-on davits that can be moved from raft to raft. They then put plywood decking on half of the raft, and move a portable sorter onto the makeshift deck. This allows them to use the raft for tumbling and sorting as well as for oyster growout.

The best way to hang the trays from the raft is to have a length of chain on the end of the line from the stack of trays. This chain is then fitted into the slot of a tray hanger mounted on the stringers of the raft. Many farmers also secure the trays by wrapping a tagline from the stack around the stringers and hooking a loop on the end of the tagline to a nail on the bottom of the stringer. The taglines typically are the weighted groundline favored by longline fishermen. Attaching the taglines and hanging the stacks of trays take some time, and these are areas some B.C. farmers are focusing on to save labor.

The raft and tray systems clearly offer many labor saving efficiencies when configured correctly. They must be equipped with adequate lifting ability, such as the pictured long boom arms, and a tumbler/sorter. Growers using the systems are very positive about the performance of the culture system, according the results of ASGA's survey.

Advantages		**Disadvantages**	
Easy to work crop	5	Difficult to work	0
Low labor	3	High labor	0
Easy to defoul	4	Defouling difficult	0
Fast growth	5	Slow growth	0
High survival	4	Low survival	0
Easy to store	1	Too much storage space	4
Inexpensive	0	Expensive	5
Durable	5	Repair frequently	0
Produces good oysters	4	Bad oysters	0
Deployment easy	4	Deployment difficult	0

The only complaints of the five respondents to the survey were that the gear takes a lot of storage space and it is expensive. The latter concern likely includes the cost of the infrastructure necessary to handle the trays.

The Naukati Shellfish Nursery spent $16,000 on its boom arm. While it is possible to lift trays with a much less expensive davit, if you're striving for efficiency the extra investment is likely to pay for itself over the long term. Indeed, the heavier gear generally means a bigger investment in infrastructure.

For example, it is possible to load 50 empty lantern nets in a 16 foot Lund, but you'd need a much bigger boat to move the 400 trays necessary to hold the same number of spat. How about defouling trays? While empty, fouled lantern nets can be easily dumped on a hardening beach to defoul. On the other hand, trays generally are defouled on a raft, necessitating a large enough raft to accommodate the trays.

The rafts are very efficient users of the water column. During one of his Alaska workshops, Kingzett displayed infrared photos of the water column that showed the impact of concentrations of rafts on phytoplankton in a bay. The water exiting the raft and tray system is clear for at least 10-15 feet behind each raft. Some farmers position the stacks of trays at varying levels in the water column to help ensure each stack of trays has a better shot at the food moving past the rafts in the currents.

Position your rafts so they can ride the water with the pontoons facing into predominant currents. Leave enough slack in your tie-up lines to accommodate tidal fluctuations, but not enough that storms can blow your rafts onto the rocks or kelp beds.

Following is information on the raft and tray system taken from the Naukati Shellfish Nursery website:

Each raft is 16' wide and 20' long and has 7 hangers; it would be capable of holding 42 or more stacks of trays. Growout rafts are constructed of rough sawn lumber and foam flotation. Fasteners are stainless steel and marine grade. The foam flotation is commercially shrink-wrapped. Each raft measures 16' x 20' and sits approximately 20" out of the water. Rafts are then moored to each other and anchored to the bottom.

Each raft could theoretically handle a minimum of 42 hanging stacks of 8 trays, and each tray can hold 120 oysters at marketable size for a total of 40,320 oysters or 3,360 dozen per raft. Each raft could hold up to 336,000 25 mm (1") spat when purchased from Naukati Bay Shellfish Nursery.

Estimated Cost for Raft Construction and Trays

9-2x8x20' 26.7 bf Ea. 240 bf
4-3x6x20' 30 bf Ea. 120 bf
8-2x6x16' 16 bf Ea. 128 bf
3-4x6x16' 32 bf Ea. 96 bf
Total 584 bf @ .50 per bf = $292
8-Foam flotation $43 Ea. $344
Shipping on foam $10 Ea.(depends on quantity) $80
Hardware approximately $200

Approximate total cost per raft ***<u>$916</u>*** ***(not including labor)***

Rope for hangs 37' per hang, 42 hangs @ .10 per foot $155
Rope for slings 10' per sling, 42 slings @ .10 per foot $42
Trays, 42 hangs with 8 trays each at $15 per tray $5040
Tray Liners $672

Total for one raft and trays ***<u>$6825</u>***

200,000 oysters at market size would take approximately 4.5 rafts ***<u>$30,712</u>***

Raft and tray culture plans, Brian Kingzett, British Columbia

Shellfish Culture Raft Plans Revisions Oct 2007

Materials List

			Check
Lumber	2x 6x24' (for pontoons)	12	
	2x 6x24' (cross beams) – optionally use only 10 and adjust spacing accordingly	11	
	2x 6x24' (for ends)	2	
	2x 6x24' (for walkways)	9	
	Total 2x6's	**34**	
	1"x 8"x10' (will get cut into 22" pieces)	6	
Foam	18"x24"x8' foam (wrapped or coated)	3	
	18"x24" x16' foam (wrap or coated)	3	
Hardware	1/2" x 14" galvanised carriage bolts	40	
	1/2" washers	80	
	1/2" nuts	40	
	4" galvanized Nails lbs	25 lbs	
	6" Galvanised Nails	110	
	3-4" Strapping - sufficient to wrap around foam block	6	
	1.5" x 1/4" x 24' Steel Strap (optional – see photo)	1	
Tools	1/4 drill bit	2	
	1/2" x 16" auger drill bit		
	Heavy Duty Drill		
	Skill Saw		
	Chain-saw (optional)		
	Hand Tools (hammers etc.)		
	Wrenches		
	Tape Measure		
	String		
	Long measuring tape (optional)		
	Generator & Extension cord (optional)		
	Helpers	1-2+	

NOTE: **These plans are provided as a guide only!!** Use these plans at your own risk and modify as you see fit. We make no warranty for the accuracy or usefulness of theses plans. Good luck.

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SHELLFISH CULTURE RAFT PLANS

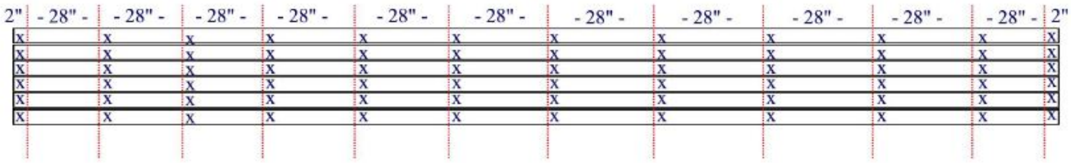
These plans are to build a 24' x 24' shellfish culture raft like the one in the picture above

The best way to build the raft is to assemble it on a piece of firm beach as the tide drops and then float the completed raft away at high tide	
This is a detail of the angle iron attached to the raft for mooring to other rafts or the anchors.	

▪

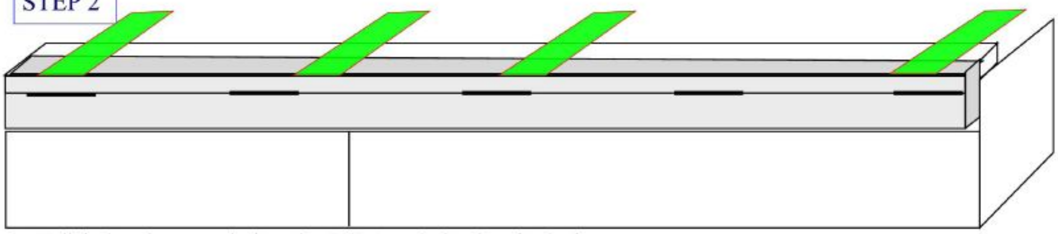
STEP 1

NOT TO SCALE!



Mark foam support boards for later construction.
Align and lay-out 6 2x6" boards (24') togther on end
Mark off 2" at ends and at 28" centres the whole length
This will be used to line-up cross beams later,
Mark where cross beams will sit as shown by x's on the above diagram

STEP 2

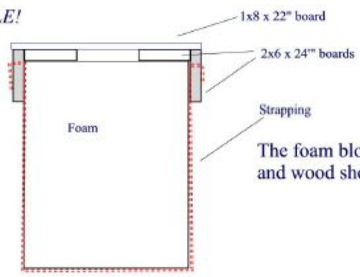


Nail the boards you marked to other 2x6's to make brackets for the foam.
Make sure the marked board (grey) is vertical.
Use a skill saw to make 5 slots to pull the strapping through.
Make 2 slots for the 8' foam block and 3 for the 16' foam block
Use 22' pieces of 1x8" to hold brackets on foam
Pull strapping around blocks and through slots, cut to length nail to boards

▪

NOT TO SCALE!

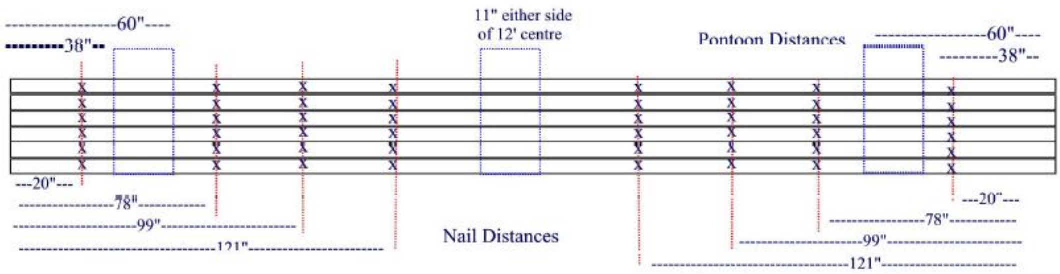
STEP 3



The foam blocks, strapping,
and wood should look like this on end

STEP 4

Line up 11 2x6 x24' on edge tack together with scrap lumber or 2x8 These will be the cross beams
Square all the ends at 24' and measure the distances shown in bottom of the diagram from each end.
At each point (x) drill a pilot hole with 1/4" drill bit and drive in 6" galvanized nail with 1-3/4" sticking out.
Mark boards for lining up with pontoon (measurements at top of diagram)



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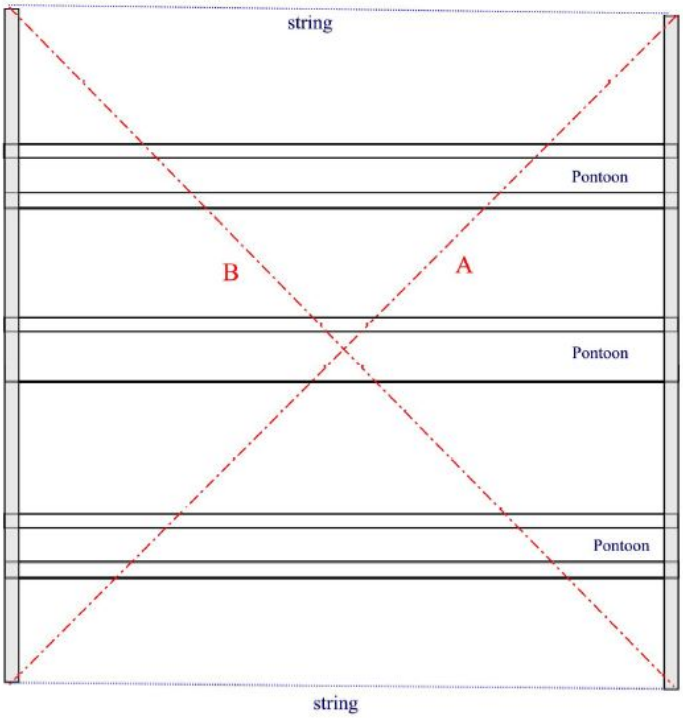

STEP 5

Put all three pontoons in position on a flat piece of ground and space according to measurments on 2x6's with nails in them.

Toe-nail a 2x6 onto the three pontoons at either end

Make sure the 6" nails are facing down!

Then adjust the pontoons to square until the diagonal measurments (A & B) are within a 1/4" of each other.

Tie a tight piece of string from one corner to the next on outside to help line up the rest of the cross beams

Lay rest of 2x6's on marks approximately 28" apart

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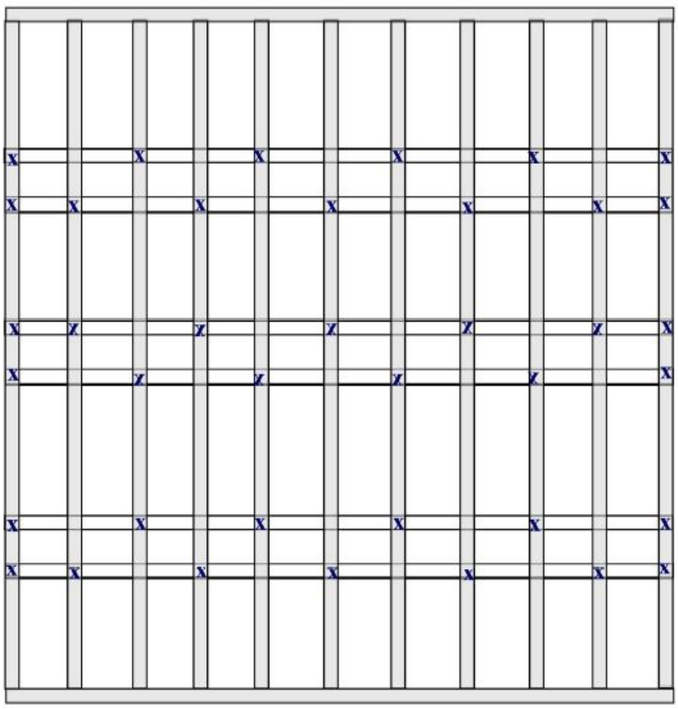


STEP 6

Toe-nail in rest of 2x6's

Tip- Make 2 spacer boards the exact length between beams and use these to make sure that you get the spacing right each time - move forward for each beam.

Make sure your nails will not interfere with where the bolts are going to go.

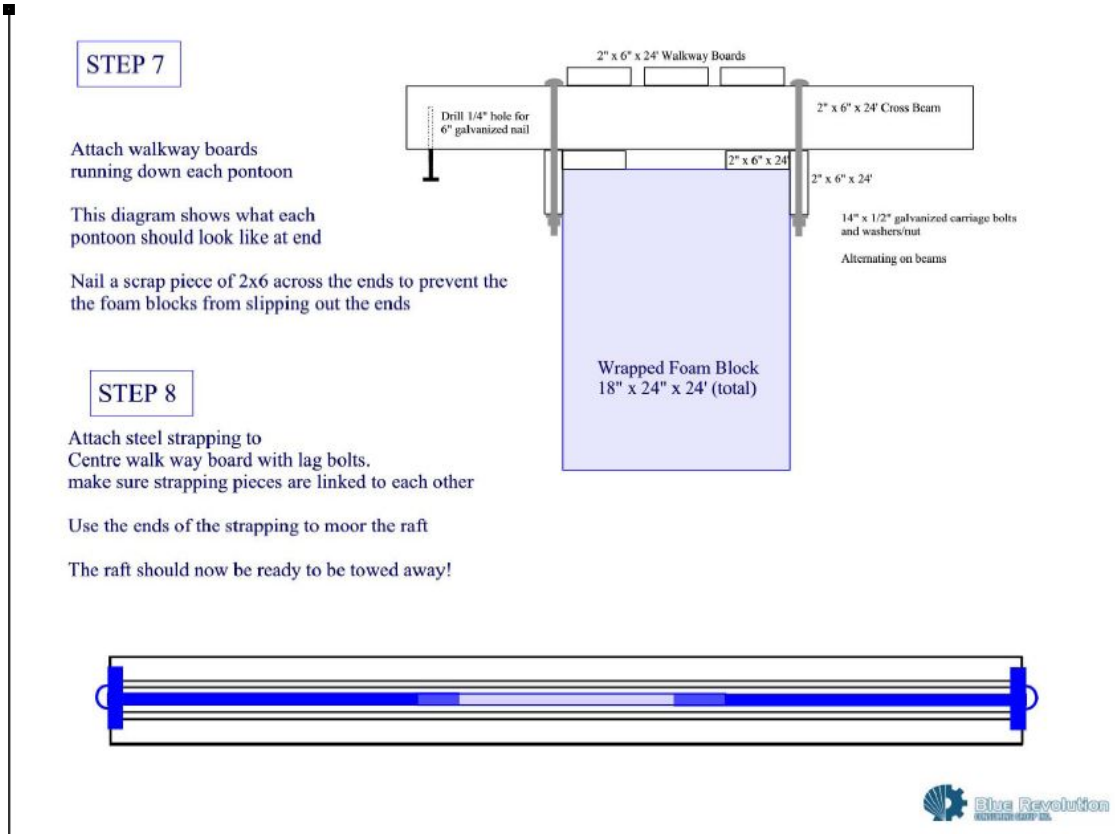
Nail 2x6's along ends of beams to finish outside of raft

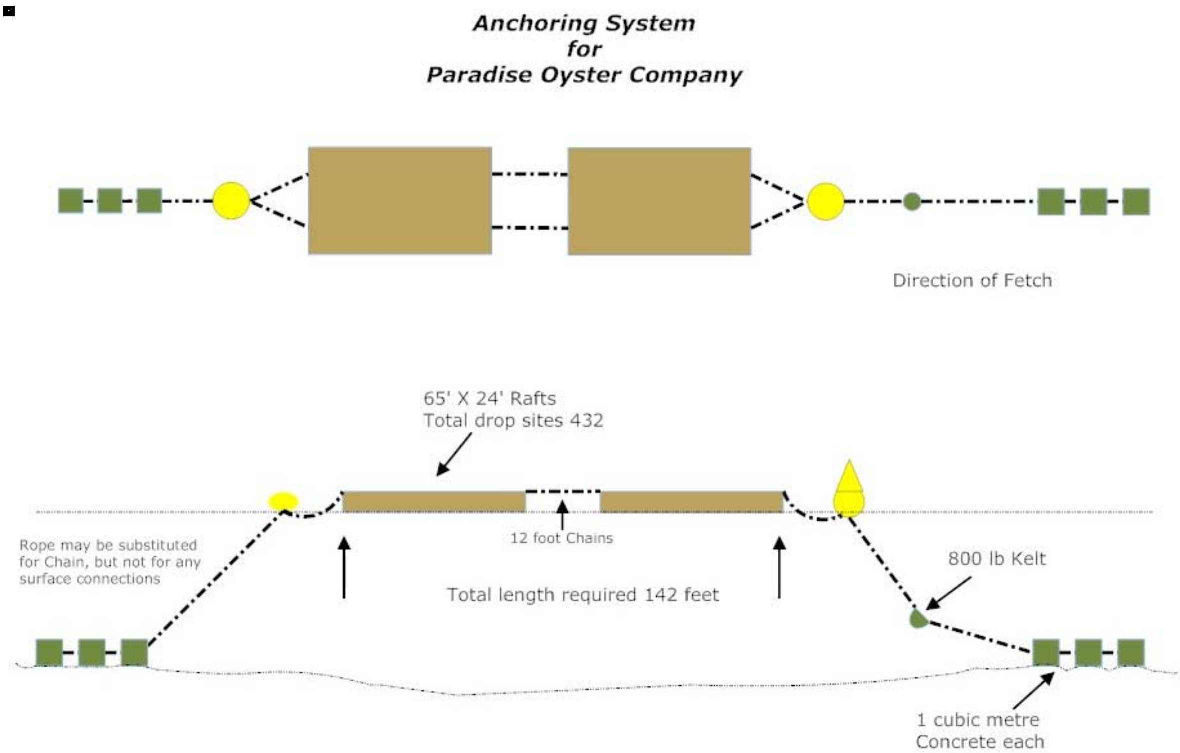
Drill holes through 2x6 beams and raft brackets in alternating pattern as shown by (X) on diagram

(see detail on next page)

Attach and tighten bolts

Blue Revolution


STEP 7
Attach walkway boards
running down each pontoon
This diagram shows what each
pontoon should look like at end
Nail a scrap piece of 2x6 across the ends to prevent the
the foam blocks from slipping out the ends
2" x 6" x 24' Walkway Boards
Drill 1/4" hole for
6" galvanized nail
2" x 6" x 24' Cross Beam
2" x 6" x 24'
2" x 6" x 24'
14" x 1/2" galvanized carriage bolts
and washers/nut
Alternating on beams
Wrapped Foam Block
18" x 24" x 24' (total)
STEP 8
Attach steel strapping to
Centre walk way board with lag bolts.
make sure strapping pieces are linked to each other
Use the ends of the strapping to moor the raft
The raft should now be ready to be towed away!
Blue Revolution


Anchoring System
for
Paradise Oyster Company
Direction of Fetch
65' X 24' Rafts
Total drop sites 432
12 foot Chains
Rope may be substituted
for Chain, but not for any
surface connections
Total length required 142 feet
800 lb Kelt
1 cubic metre
Concrete each

Chapter 13. Floating and Flip-Flop Oyster Bag Culture

Raymond RaLonde

Introduction and Rationale

Oyster farming in Alaska has enormous prospects to expand, providing much needed alternative economic opportunities for coastal communities. Oyster production has not increased substantially over the past decade, even with greater availability of tidelands and investment into infrastructure support. The current shellfish aquaculture status is transitional, moving from independent self-contained farms toward becoming an industry. Recent research shows that Alaska farmers produce high quality oysters that meet market demands, but the cost of production needs reduction to improve profitability of existing farms and attract new entrants. Cost of production is inherently more expensive in Alaska due to the remoteness of oyster farms. This drives up the cost to construct suspended farming operations and to ship to distant markets. In addition, shellfish farming demands extensive and expensive labor to maintain and sustain farm operations.

The purpose of this project was to test two low-cost oyster growout practices on Alaska farms, and determine the prospect of incorporating their application into existing farming practices. The practices tested were:

- Intertidal flip-flop bag culture now in use in the state of Washington (Figure 1).
- Floating bag systems used by the Maine oyster farming industry (Figure 2).

Four farmers participated in the program and were provided equipment and oyster seed. The Alaska Sea Grant Marine Advisory Program developed the study design, directed data collection, conducted data analysis, and reported results to farmers. Participating farmers committed to grow and maintain the oysters for two years, keeping records of on-site data, collecting and shipping oyster samples for measuring quality and growth, and participating in outreach to the industry. The functional and financial feasibility of each growout method was assessed to determine the financial risks farmers would assume by transferring to each gear type.

Project results were shared with the Alaska industry at two workshops sponsored by the Alaska Sea Grant Marine Advisory Program held in conjunction with the Alaskan Shellfish Growers Association meetings in 2010-11.

Growout Study Design

Locations

Participant farms are located at Rocky Pass near Kake, Tenass Pass and Tokeen Bay in Sea Otter Sound, and Chester Bay on the Annette Island Indian Reserve.

Rocky Pass is the most northern farm of the project, is protected from direct ocean influence, and has the coldest water temperatures. Annette Island is the most southerly farm, is exposed to significant oceanic influence, and likely has the warmest water of all the participating sites. Sea Otter Sound is home to a number of farms and is expanding in farm numbers and production. Tenass Pass is located in a highly protected area while the Tokeen site is more open and exposed to oceanic influence.

Equipment and Setup

The flip-flop system has a framework, or fence, of PVC pipe that supports one end of an oyster bag suspended off the bottom, leaving the other end resting on the bottom at low tide, propping the bag at approximately a 45º angle. A float attached to the lower part of the bag causes the bag to lift off the bottom when the tide rises. During an entire tidal change the bags rise and fall, causing the oysters to roll and toss about with the waves. Such treatment causes oysters to form a deep cup and create firm shells. With the bag is exposed to air-drying at low tides, fouling is somewhat controlled, but this has yet to be tested in southeast Alaska where the weather is very moist and fouling organisms abundant.

At production scale, the floating bag system is an array of 18 inch x 32 inch Vexar bags suspended at the surface by floats and attached together with groundline (Figure 2). For the purpose of this pilot scale applied research project, a single floating longline was used (Figure 3). Once the project was in operation fouling was controlled by occasionally flipping the bags to expose the fouling organisms to air-drying.

Experimental controls were the existing growout methods used by farmers, to which the bag systems were compared for performance. The controls were:

- Rocky Pass: using a combination of starting growout in lantern nets for the first year, and then planting the one-year-olds directly on-bottom for final growout to market size.
- Tenass Pass: using lantern net culture from seed to market size.

- Tokeen: using wire cages and raft culture to grow from seed to market size.
- Annette Island: also using wire cages and raft culture to grow from seed to market size.

Additional Data

In addition to production and growth performance data, environmental, labor, and expense data were also collected. Farmers were encouraged to provide personal input into the operational aspects of gear and to record observations on farming details and efficiency. A HOBO water temperature logger deployed at each site recorded sea surface temperature. If a HOBO was not used, these data were obtained from another source if available.

Flexibility

This project combined structured research with the flexibility to allow farmers to make changes to the experimental design as necessary and to conduct their own experiments in response to local problems and opportunities. As a result, each farm had different comparisons that enabled evaluation of various growout methods. Although the project did not follow strict research protocols, enough replication, use of controls at each site, and adequate sampling provided statistically valid results.

Seed Source

Oyster seed were purchased from the Naukati Shellfish Nursery in Sea Otter Sound. Seed size was 21-32 mm in length and originated from the same cohort. Seed planting occurred at different times for each farm during summer 2009 based on logistical considerations.

Gear Construction

Flip-Flop Intertidal Bags

Construction of the flip-flop bag system occurs in two phases: construction of a framework, or fence, and fabrication of Vexar culture bags (Figures 1 and 4). Figure 5 lists construction materials and costs for the flip-flop bag system.

The fence consists of a series of 3 inch ABS plastic pipes 36 inches long and cemented in the substrate at 6 foot intervals (Figure 6). A ½ inch hole is drilled approximately 1 inch from one end of each pipe. The fence is laid out in a straight row parallel to the beach at about a plus 5-7 foot high tide level. A hole 12 inches deep is dug, the pipe inserted, and the hole filled with a concrete mix to secure the pipe. The vertical pipes must be approximately the same height (Figures 7 and 8). A fence can be any length, but usually holds 50-100 bags. Several rows of fences can be deployed on a single beach if the beach slope is not too steep. Parallel rows should be at least 6 feet apart.

Approximately 6-8 feet past the end of the last pipe on both ends of the fence, anchors were constructed to secure the ends of the lines that hold gear (Figure 9). There are a number of ways to construct the anchors. The farmer can imbed a loop of the fence wire or cable in concrete; or use a rock drill to bore a hole in a large rock, and then bolt a loop directly to the rock (Figure 10). A turnbuckle is required to tighten the line as it stretches.

Once the fence pipes and anchors are secured, the line is strung through the holes in the pipe and attached to both anchors (Figure 8). Slack in the line is tightened with the turnbuckle until the line is as tight as a guitar string. The fence is now completed. The fence line requires regularly scheduled tightening to remove slack.

Construction of the bags starts with hand forming the flat bag into a 3 inch deep box shape. One end of the bag is permanently closed with zip ties, and a piece of fencing wire is wrapped around the center of the bag like a belt, and then secured to the bag with zip ties on the top and bottom surfaces (Figure 11).

Flotation is two pieces of 4" x 2" x 20" pink insulation foam inserted into a mussel sock that is tied closed at each end and then attached to the permanently closed end of the bag with zip ties.

Floating Bag System Construction
A production scale floating bag system design is shown in Figure 12. However, the goal of this project was not to produce a production size system, but to test the prospects of utilizing floating bag technology. Therefore, at each site, a single longline system was constructed and deployed (Figure 3).

At Tokeen, the floating bags were tethered to the longline with a single attachment line, while at Annette Island bags were attached to two parallel lines that were attached at each end to single anchor lines (Figure 13).

We were not able to obtain flotation that would normally be available from Maine because the manufacturer was not in production at the time of the project. Two improvised flotation devices were used instead: seine net floats and foam tube pipe insulation (Figures 13 and 14). Neither flotation worked well as a substitute because properly installed flotation will expose the upper half of the net to air while the bottom is submerged. I expect that pink foam insulation will work best (Figure 15). Flotation needs regular inspection to determine if more is needed as the weight of the bag increases with oyster growth.

Bag construction started with forming the bag into a box shape in an identical manner to that used for the flip-flop bags. The foam flotation was inserted into a mussel sock, attached to the long sides of the bag rather than the end, and a heavy line with longline snaps at each end was inserted through the ends of the bag that attached to the longline (Figure 15). Running the line through the middle of the bag allows the bag to be flipped occasionally to control fouling.

Both the flip-flop and floating bags were stocked with 250 seed, and the open end sewn closed with seine twine and attached to a fence or longline, respectively.

Results

Construction Challenges

Since box-shaped bags were not available for the project, bag construction was difficult and time consuming. Each bag took approximately 20 minutes to fabricate, and a fence that holds 50 flip-flop bags took about 8 hours to construct. Growing oysters in an intertidal system was challenging because of logistical problem associated with the limited time the site is accessible at low tides.

Fence construction problems occurred soon after starting the project. At Rocky Pass, in an area of significant water movement, the flip-flop system was constructed with steel fence posts instead of PVC pipe. The fast current during a storm event washed a mass of seaweed into the fence. The combined weight of the seaweed and force of the current destroyed the gear, and the site dropped from the project. At Tenass Pass, the soft substrate, inadequate anchoring, and highly buoyant flotation caused the fence to be lifted by the flip-flop bags, resulting in the loss of second experimental site. Both Annette Island and Tokeen continued and their systems had no structural problems.

Production Modifications

Fouling problems occurred throughout the project. Initially, the floating bags at Tokeen became clogged with floating debris that obstructed water flow and crowded the oysters. Cleaning the gear was challenging, causing Tokeen to abandon floating bags.

Barnacle fouling of the flip-flop bags was a modest problem at Tokeen. Solving this problem required removing fouled bags and putting oysters in clean bags for redeployment. Mussel fouling at Annette Island caused a significant problem in floating bags by spring 2011, sinking the gear and ending the floating bag portion of their project.

After the end of the first production year, Tokeen moved much of the flip-flop bag production into their raft and tray culture system. This was done to determine the viability of incorporating one year in flip-flop bag growout, and then transferring the spat into raft and cage growout for the second year.

Tenass Pass experienced no production problems for the first year with floating bag culture and transferred the bag culture oysters to lantern nets for the second year growout.

Growout Results

Tenass Pass

Tenass Pass participated in the first year of the project using floating bag culture. Oysters planted in both the lantern net and floating bags on 8/4/2009 grew remarkably well, increasing in length from 32.7 mm at seed size to over 47 mm in 60 days. Over a 397 day period, however, growth slowed, achieving an average size of 54.22 mm (Figure 16).

While oysters in floating bags and lantern nets were close in growth performance, the size distribution was more variable in lantern nets compared to bags. The overall shape of the oysters also was better in the bags; the lantern net samples tended to be longer and flatter than the rounder cupped bag oysters.

Figure 16 shows that floating bags grew oysters effectively to about 60 mm, but growth slowed thereafter and lantern net growout surpassed floating bag performance. Estimated mortality was 10% through the first year of growout.

For Tenass Pass floating bag culture, starting with seed 33 mm in length, the projected percent of sellable market size oysters is as shown in Table 1.

Table 1. Projected growout time and percent marketable oysters for floating bag cultured oysters at Tenass Pass.

Months of growout	Percent marketable
12	19
18	24
24	34
30	21

Stocking density influences growout rate in floating bags. Table 2 shows the projected harvest percentage and growout time in floating bags at stocking densities of 322 and 164 oysters per bag to growout size.

Table 2. Projected growout time and percent marketable oysters for floating bag cultured oysters grown at two stocking densities at Tenass Pass.

Months of growout	164 oysters/bag	322 oysters/bag
12	23	9
18	28	17
24	32	38
30	15	38

Lower stocking densities likely reduce the growout time to market; however, the example above requires doubling the numbers of bags and the surface area needed, and consequently higher leasing costs.

Tokeen Bay

Growout started earlier, on 6/9/2009, at Tokeen than the other sites, and also began with smaller seed of 21 mm length. In the first year of growout, Tokeen Bay utilized flip-flop bags, and floating bags, with wire cages as a control. By 11/9/2009, the wire cage system appeared to outperform the bag culture systems; however, the data are somewhat deceiving because the cage culture oysters were long and narrow, forming an undesirable “rabbit ear” shape (Figures 17 and 21).

Fouling of the floating bag culture system ensued with a considerable collection of floating debris. Particularly troublesome was the collection of conifer tree needles, eelgrass blades, and small twigs that can all enter the bag. Some bags completely filled with debris. Fouling was so bad that floating bags were eliminated from further study (Figure 19).

After 222 days of growout, on 6/17/2010, the Tokeen Bay farmer initiated a test to compare the performance of oysters continuing to grow in the flip-flop bags with oysters transferred from flip-flop bags to wire cages. The two growout lots were measured 84 days later on 9/9/2010 (Table 3).

Table 3. Comparison of oyster performance in flip-flop bag only and flip-flop to wire cage after 222 days of growout (mm).

Gear type	Date	Length	Width	Height
Flip-flop	6/17/2010	51.57	30.62	15.16
Flip-flop	9/9/2010	56.93	32.90	16.88
Flip-flop to wire cage	9/9/2010	78.81	40.29	24.02

The results indicate that oyster growth in flip-flop bags leveled off while oysters transferred from flip-flop bags to wire cages accelerated in growth.

Subsequent sorting of oysters at the Tokeen wire cage system mixed the oyster growout lots and the farmer lost track of the oysters transferred in from the flip-flop bags; however, all oysters from the from the flip-flop bags were eventually sold. Oysters that continued growout in the flip-flop bags for a total of 802 days were measured for the last time on 8/30/2011. Growth continued to be slow during this last growth period with oysters not reaching 75 mm shell length (Figure 20).

For Tokeen, flip-flop bag culture shows promise if used in the first year of growout. The floating bay system had serious fouling problems and success with this system may be site dependent.

Annette Island

Annette Island completed the project in its entirety with no departure from the original experimental design and has a completed set of data for all gear types for the duration of the project. The project started later at Annette Island than the other sites, achieving a total of 632 growout days.

In addition, a third bag system trial involved attaching bags to a longline anchored to the bottom in the intertidal zone. This system is termed the beach longline system in the data tables. Because of slow growth performance and poor product quality, the beach longline system is not discussed.

The fall planting date abbreviated the growth period, achieving only modest growth in 60 days. At day 393, wire cage oysters had the best growth in shellfish dimensions, but the flip-flop bags were the heaviest and had a larger cavity volume than the wire cages (Figure 18). Mortality was insignificant. By completion of the project, at day 632, the flip-flop bag oysters appeared to be the top performers, with the floating bags a close second. Unfortunately, apparent theft of larger oysters grown in the wire cage system significantly underestimated growth and data cannot be used for comparison. Also, the short growing season between fall 2010 and spring 2011 led to insignificant growth for the bag cultured oysters (Figure 20).

The floating bags also experienced an excessive blue mussel fouling and were not continued. The flip-flop bag system remains operational and an additional measurement was scheduled for late fall 2011.

Emphasis on Quality

Alaska grown oysters are usually sold as small or extra small sizes and sold to the live half-shell market. With the preference of the market for small live oysters, an emphasis for this project was to compare quality in addition to shellfish measurements and total weight. The measurement of quality selected for this project was cavity volume, and was used as an indicator or meat fullness.

$$\textit{Cavity Volume} = \textit{Whole Weight}\ (\mathrm{g}) - \textit{Shell Weight}\ (\mathrm{g})$$

Using a scale capable of measuring to 0.1 gram, weigh the whole oyster, then shuck the meat and weigh the shell. Cavity volume is determined by subtracting the shell weight from the whole weight.

You might wonder why measuring weights computes into a volume. The answer is that a live oyster contains both meat and water inside the shells. The meat weight is about the same as seawater per volume, and the remainder of the shell content is water. So the entire content of the shell weighs essentially the same as seawater, and 1 gram (weight) equals 1 milliliter (volume).

Examples of oyster cavity volumes were measured at Annette Island and Tokeen for all gear types during fall 2010 (Figures 17 and 18). Compared with the controls, Annette Island oysters grown in the flip-flop bags had greater cavity volume than those grown in wire cages even though the shell length was shorter. At Tokeen, the cage cultured oysters grown for the first year in flip-flop bags had a cavity volume comparable to those grown in the wire cages for the entire study. In general, both bag culture methods produced excellent cavity volumes.

The shell shapes differed by culture type (Figure 21). Wire cage cultured oysters were long and thin with a modest cup depth, abruptly shallower at the shell edges. Oysters in flip-flop bags grew a uniform deep cup along the length of the shell, all the way to the shell margins. Oysters in floating bags also developed a deep cup, close to that of the flip-flop bags, but the shell was significantly wider (Figure 22).

Meat content was often apparent by opening a few oysters to see how full they were. In almost every case, the flip-flop bags had consistently fuller meat content. Figure 22 illustrates the stark difference between internal appearance and meat quantity presented in the data tables.

Other Data

The North Pacific Ocean is going through a cooling period for sea surface temperatures. At Tokeen and Annette Island, average water temperatures were cooler than the most recent 10 year average by 7% and 2% respectively.

Labor data reveal some important information. Constructing the bags was very cumbersome and time consuming, requiring 20 minutes per bag. The up-front time to construct a 50 bag length fence for the flip-flop bags takes approximately 8 hours, and must be done during summer daylight low tides to provide enough time for the work. The Tokeen area has approximately 24 days of low tide cycles to enable fence construction.

Constructing a raft with the 360 wire cages takes about 16 hours, while constructing a fence for the equivalent capacity takes 56 hours. The cost of constructing a raft with 360 wire cages is $9,700-$10,200, while constructing a flip-flop bag system with the equivalent capacity is $3,300.

The major cost saving for the flip-flop bag system occurs during the first year of growout. After initial fence construction, labor is required for seed stocking, deployment of the bags on the fence, removing seed from the bags after one year, and transporting the juvenile oysters to the wire cages. These tasks are not as simple as they seem, since they must be done at low tide, and the logistics of handling and transporting cages from the beach to the raft is a major hassle. However, after seed stocking, maintenance requirements are minimal for the first year of growout in the flip-flop bags, whereas wire cage culture requires extensive maintenance and handling during the summer growout months.

Summary

Throughout this chapter, most results speak for themselves. Bag culture appears to provide the greatest benefit during the first year of growout because growth slows considerably once the oysters reach about 60 mm in shell length. Bag cultured oysters are excellent quality, with a deep cup and large cavity volume. Fouling is a problem for both the flip-flop and floating bag systems, with the former subject to barnacle sets and the latter with debris collection and blue mussel sets.

Labor demand for the bag systems is greater during the construction phase and less during growout. Flip-flop bags let water movement stir the oysters to form the shell and low tide exposes fouling to air-drying. Floating bag exposure to surface waves helps to form the oyster shell, but regular turning of the bags is required to expose fouling to air-drying.

Bag systems are cheaper to build, with construction material cost at 35% that of raft and cage culture systems. Bag culture systems require more space and thus higher lease costs for tidelands. Both bag systems require close to half a mile of longline or fence for the same production capacity as a single 360 cage capacity raft.

All shellfish growout systems have their advantages and disadvantages. Much of the impact of innovation is not inventing a new production system that stands alone, but integrating new systems into existing operations. I expect that farmers will use these new culture systems as part of their oyster production cycle and will vary their application. This study was the first investigation on bag culture in Alaska, and results do not provide definitive answers that will benefit all farmers. Future innovation and integration of growout designs may provide the remedy that farmers seek: a reduction in the cost to operate an oyster farm in Alaska.

Acknowledgments

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Tom Henderson, Pearl of Alaska Oyster Farm, Rocky Pass
Annette Island Department of Fisheries, Annette Island

Figure 1. Flip-flop growout system of bags attached to a fence.

Figure 2. A production size floating bag array.

Figure 3. Pilot floating bag longline system with single line attachment, used at Tokeen. Note the pipe insulation inserted inside mussel sock used as flotation.

Figure 4. Close-up of the flip-flop bag showing its construction.

Flip-flop system item list to be Purchased locally (will need four of these systems)			Per site Approximate	
Item	Unit cost	Number of Units	Total cost	Vendor
3” ABS pipe (1) (7)	$28 /10ft	4	$ 112.00	JS/Tru Value in Craig/Ketchikan
5/8” rebar (2)	$12.60 / 20ft	1.5	$ 18.75	JS/Tru Value in Craig/Ketchikan
4” (SS clips) Bait holders (3)	$1.26 ea	120	$ 151.20	Murray Pacific Ketchikan
Ready Mix concrete (4)	$10.60 bag / for 2 posts	7	$ 74.20	JS/Tru Value in Craig/Ketchikan
14” cable tie (5)	$8 / 25	10	$ 80.00	NAPA
Floats (Recyled 1 gallon Plastic jugs		60		
Total cost of each (with PVC posts)			$ 436.15	
Total cost of 3 PVC post systems			$ 1,308.45	
Total cost of Henderson's with steel posts			$ 401.15	
Total cost of 4			**$ 1,709.60**	
Other supplies to be purchased and delivered and split among farms				
Horse wire(6)	One 1,300 ft spool @			
	$178+$165 shipping	1	$ 343.00	
Vexar clam bags @ $3.00 each	3.00 each plus	340	$ 930.00	
Freight Seattle to Ketchikan & Kake			$ 71.26	
Freight from Auburn to Seattle			$ 78.00	
Total of bulk order items			**$ 1,344.26**	
Locally purchased items			$ 1,709.60	
Bulk order items			$ 1,344.26	
Total cost for all expenes			**$ 3,053.86**	

Notes: indicated by number in ( )

(1) Each pipe cut into three equal lengths at 40" each
(2) Rebar cut into 1 ft lengths inserted through a hole near the bottom of each upright 40" pipe. Pipe buried 14 inches and cemeted
(3) Two per bag to attached to each bag to the wire
(4) One bag used to cement in two upright poles
(5) tie ends of the bags closed after oysters in stocked into the bags
(6) One spool of wire split between 4 farms, 350 ft per farm, each farm should need about 300 ft for loop in each bag and post wire
(7) Tom Henderson will use 6' heavy duty fence post at $7.00 each available at Don Abel Building Supply, Juneau

Floating bag system cost Per site Purchased locally				
Items	Unit cost	Units	Total cost	Vendor
3" ABS pipe	$28 /10ft	3	$ 84.00	JS/Tru Value in Craig/Ketchikan
3" ABS caps	$3.50 each	6	$ 21.00	JS/Tru Value in Craig/Ketchikan
Gangion line (1lb roll)	$10.99/per 1b roll	2	$ 21.98	Murray Pacific Ketchikan
Stainless steel (3/8") longline staps	0.76 each	64	$ 48.64	Murray Pacific Ketchikan
Poly rope 1/2" - 175 ft.	0.33 per foot	175	$ 57.75	Murray Pacific Ketchikan
LD Orange floats (2)	$27.00 per float	2	$ 54.00	Murray Pacific Ketchikan
3.25" Seine ring (3)	$21.00 each	2	$ 42.00	Murray Pacific Ketchikan
Foam pipe insulation 6' for 1/2" pipe (4)	2 per bag @ $1.07	64	$ 68.48	Tru Value or other hardward
Foam pipe insulation 6' for 1" pipe (4)	2 per bag @ $1.59	64	$ 101.76	Tru Value or other hardward
14” cable tie (5)	$8 / 25	3	$ 24.00	NAPA
Total cost of locally purchased item per farm			$ 523.61	
Total cost for two farms			**$ 1,047.22**	
Bulk purchase items to be split between two farms (Tennass Pass and Metlakatla)				
Groundline purchased as a 1,200' skate	$182.00 per skate	1	$ 182.00	Murray Pacific
Growout bags purchused in Lentz system bulk purchase				
Total cost of bulk purchases			**$ 182.00**	
Total cost for two floating bag systems				
Locally purchased items for two farms			$ 1,047.22	
Bulk purchases items			$ 182.00	
Total cost for two floating bag systems			**$ 1,229.22**	

Total for lentz system for 4 farms	$ 3,053.86
Total for floating bag system for 2 farms	$ 1,229.22
Gand total	**$ 4,283.08**

Notes: indicated by number in ( )

(1) These anchors are 40 halibut anchors. The $100.00 should be considered a maximum allowance
(2) These floats are two for the ends of the system
(3) To attach the ground lines to the poly anchorage line on each end of the system
(4) Insert the 1/2" pipe size into the 1" pipe size foam tube, cut 6' float in half and attached both 3' segments to one side of the bag

Figure 5. Materials and estimated costs for flip-flop and floating bag systems.

Figure 6. Construction of a fence for a flip-flop bag system. Note the fence wire used to orient placement of posts.

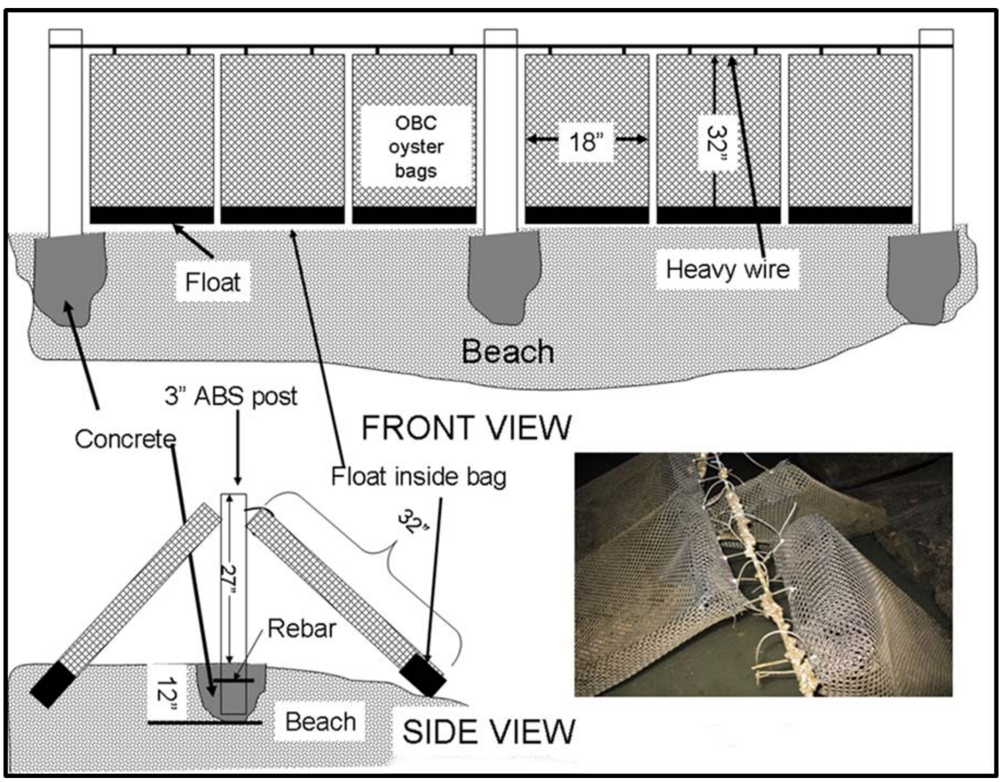


Figure 7. Basic design of the flip-flop bag system.

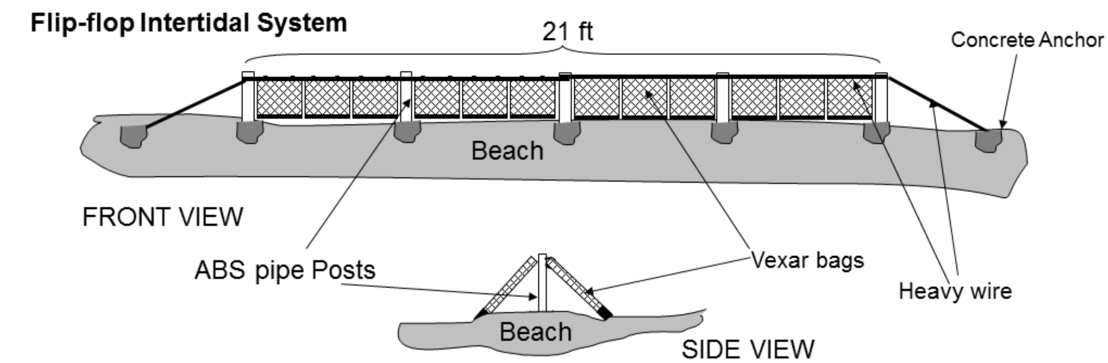


Figure 8. A completed segment of a flip-flop bag system with the fence, bags, and anchor lines on each end.

Figure 9. Note the anchor line and closing the bag for hanging on the fence.

Figure 10. Anchor formed by bolting a turnbuckle to a rock.

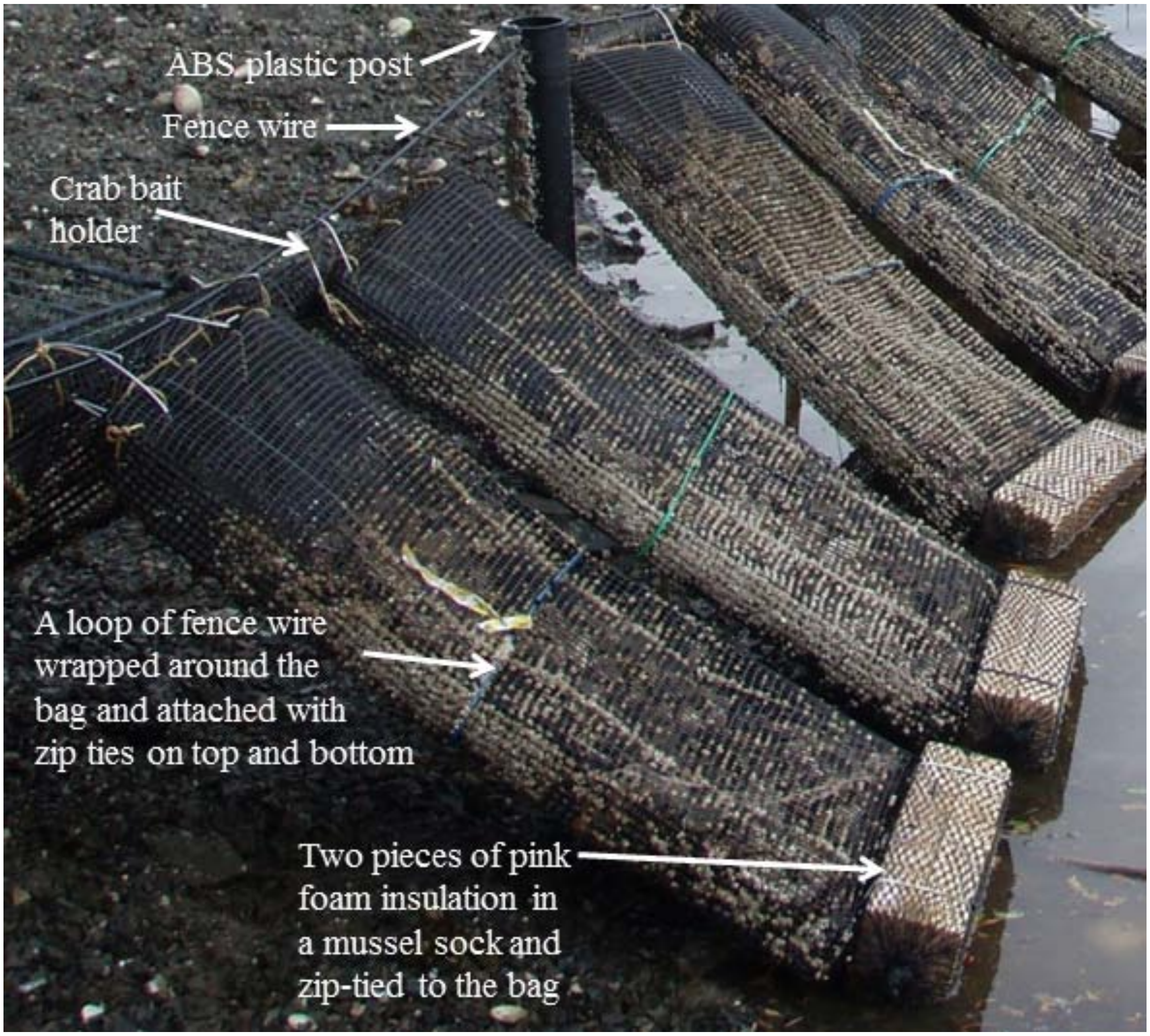


Figure 11. Design features of a deployed flip-flop bag.

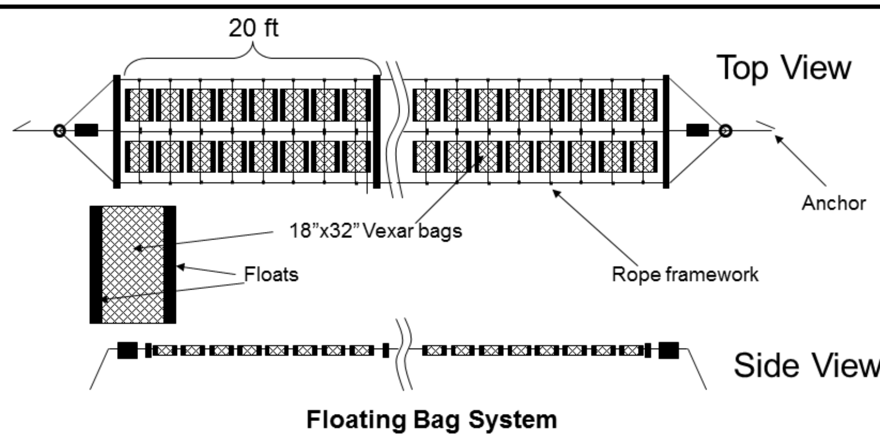


Figure 12. Design of a surface floating bag array.

Figure 13. Floating bag system with double attachments to the parallel longlines at Annette Island.

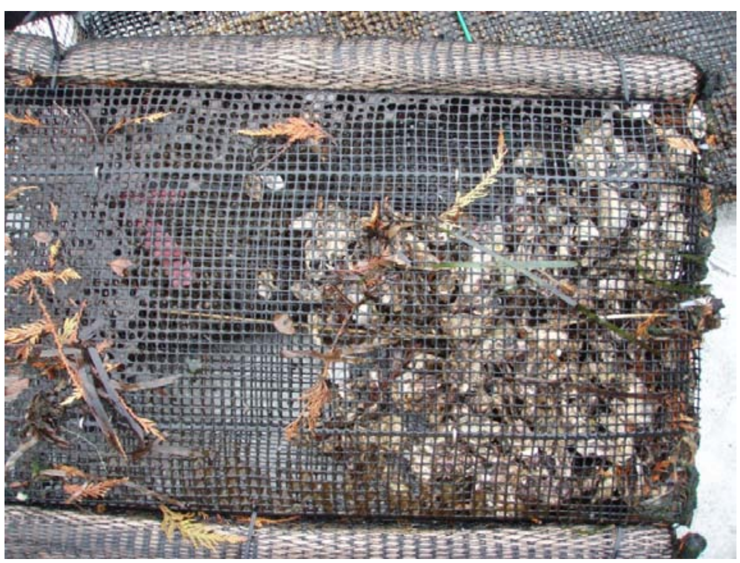


Figure 14. Floating bag. Note pipe insulation tubing for flotation, and debris collection.

Figure 15. Floating bag construction with pink insulation foam. Best if inserted in a mussel sock.

Tenass Pass (Date 10/3/09)	
Gear type	Length
Lantern net	47.58
95% confidence	2.12
Floating bag mean	47.88
95% confidence	1.25
Planted: 8/4/2009 (32.7 mm spat size)	
Growout time: 60 days	

Tenass Pass (9/5/10)	
Gear Type	Length
Floating bag mean	54.22
95% confidence	3.48
Growout time: 397 days	

Figure 16. Growth data for first year at Tenass Pass.

Tokeen (Date:11/7/09)		
Gear type	Length	Whole wt
Wire cage mean	67.37	17.88
95% confidence	2.09	1.06
Floating bag mean	54.36	13.23
95% confidence	1.63	1.13
Flip flop mean	49.65	9.89
95% confidence	1.68	0.87
Planted: 6/9/2009 (21 mm spat size)		
Growout time = 151 days		

Tokeen (9/9/10)				
Gear type	Length	Whole wt	Shell wt	Cavity volume
Wire cage mean	76.48	43.58	29.51	15.23
95% confidence	4.07	4.70	3.81	1.95
Flip flop to trays	78.81	40.29	24.02	15.60
95% confidence	4.49	4.29	2.46	1.89
Flip flop mean	56.93	17.01	11.39	6.28
95% confidence	1.96	1.13	0.97	0.71
Growout time = 457 days				

Figure 17. Growout data for first year at Tokeen.

Annette Island (Date: 11/7/09)		
Gear type	Length	Whole wt
Wire cage mean	45.56	8.75
95% confidence	1.95	0.80
Floating bag mean	39.20	7.39
95% confidence	1.16	0.50
Flip flop mean	37.45	5.99
95% confidence	1.65	0.51
Beach longline	33.87	5.01
95% confidence	1.61	0.53
Planted: 9/9/2009 (32 mm spat size)		
Growout time = 59 days		

Annette Island (Date 10/7/10)				
Gear type	Length	Whole wt	Shell wt	Cavity volume
Wire cage mean	76.56	28.64	19.54	10.35
95% confidence	4.33	3.95	2.74	1.98
Floating bag mean	66.04	28.24	19.41	9.93
95% confidence	2.42	0.80	1.24	0.89
Flip flop mean	60.79	27.97	17.53	11.61
95% confidence	6.72	3.15	1.56	1.42
Beach longline	59.04	17.74	11.70	6.04
95% confidence	4.88	1.91	1.23	1.07
Growout time = 393 days				

Figure 18. Growout data for first year at Annette Island.

Figure 19. Floating bag with debris collection.

Final growout of oysters by gear type grown at Annette Island for 632 days.						
Growout type	Length	Width	Height	Whole wt.	Shell wt.	Cavity volume
Wire cage	55.44	35.26	17.04	15.86	10.71	5.15
95% Confidence	5.12	3.14	1.24	2.74	1.84	1.00
Flip flop bags	63.43	36.86	20.07	24.41	16.00	8.41
95% Confidence	3.93	2.07	1.46	4.18	3.40	1.12
Floating bags	66.32	40.87	21.32	30.65	22.10	8.55
95% Confidence	5.33	3.11	1.83	3.90	2.72	1.51
Final growout of oyster for flip flop bags grown at Tokeen for 822 days.						
Flip flop bags	69.65	40.38	23.96	36.24	24.71	11.53
95% Confidence	3.73	1.82	1.36	4.02	2.71	1.51

Figure 20. Final growout data for Tokeen and Annette Island.

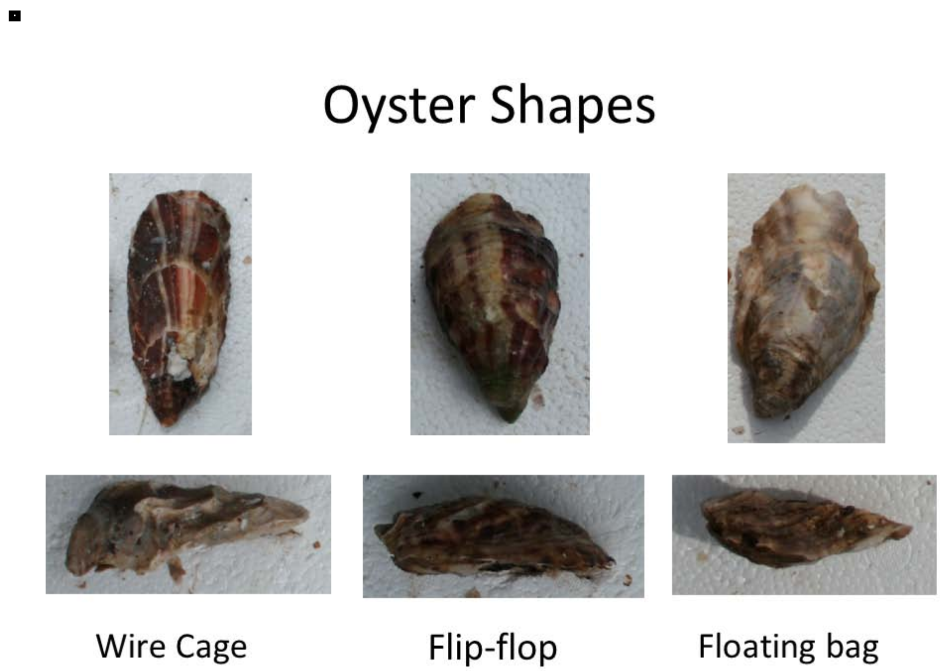


Figure 21. Various oyster shapes developed by the three growout systems.

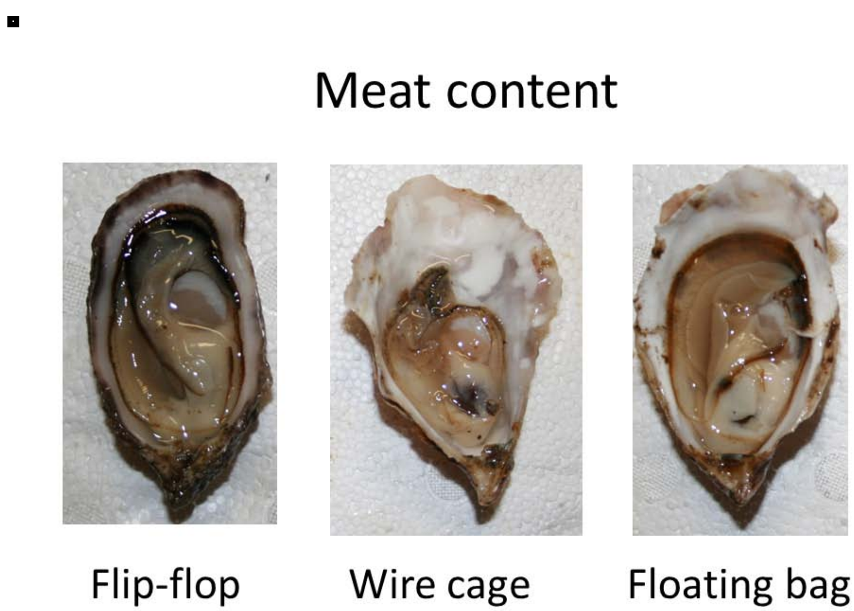


Figure 22. Shell fullness results from the three growout systems.

Chapter 14. Oysters on the Beach

Rodger Painter

If you study early production records, you'd have to conclude that life on Alaska beaches is very hard on Pacific oysters.

Beaches in southeast Alaska were seeded with oyster seed barged from Japan sporadically throughout the 1930s, 1940s, and 1950s, but harvest records show very few of these efforts resulted in adult oysters.

Picking oysters off the beach at Pearl of Alaska's farm site south of Kake. Bending over throughout a four-hour low tide can be back-breaking work; squatting for periods of time helps relieve the back strain.

Tom Henderson's experience with farming a 10 acre plot in Big John Bay south of Kake at the northern end of Rocky Pass has yielded vastly different results.

By 2011, Pearl of Alaska had far more oysters in the water than any other Alaska farm and its sales were on the upswing. Henderson estimated he had about 5 million oysters on his beach, another 1.5 million hanging in lantern nets, and a half million in his floating upwelling system nursery (FLUPSY). He hopes to meet his sales goal of 1,000 dozen per week by 2015.

Labor efficiency was a primary motivating factor in Henderson's decision to begin seeding his beach. As a one-man operation, he had a tough time keeping up with the high labor demands of lantern net culture, and survival rates were only 26%.

The path to profitability clearly meant increasing sales, but that couldn't be done without several improvements to his operational system. This meant hiring employees, building a larger, more efficient processing facility, purchasing a new vessel, upgrading infrastructure, buying a lot of new gear, and incurring high operating deficits while awaiting the new production to come online.

The transition to beach culture was enabled by an unusual natural asset close to Pearl's suspended culture site: a large, flat, highly protected and very productive beach. Although southeast Alaska has more miles of shoreline than most coastal nations, pocket beaches predominate in the Alaska Panhandle.

Tucked behind barrier islands at the north end of 10-mile-long Rocky Pass, the cobble, sand, and mud flats at the head of Big John Bay supported a modest cockle population and a few clams, and almost no sea stars. Hundreds of buoys dotted Big John during the Dungeness crab season, but there was little other human use of the bay.

Picking oysters off the beach in Big John Bay often means reaching for shapes hidden by kelp and algae. Pickers with experience in sorting and grading oysters are better at grabbing the right size oyster.

Much of the beach leased by Henderson has water percolating through the substrate from the time the beach is exposed until the tide comes back in, allowing the oysters to continue feeding at low tide. The beach is so well protected that there are seldom waves of any size to wash away or bury the oyster crop, eliminating the need for the dikes and fences used by many beach farmers in other regions.

If your goal is to produce single oysters suitable for sale to top end half shell markets, while achieving acceptable survival rates, beach farming isn't as easy as it sounds at first blush. In a nutshell, here's the schedule for farm work at Pearl of Alaska by growing season for one crop of oysters:

1. Into the FLUPSY at 3-5 mm. Washed weekly, sorted every 1-3 weeks, depending upon growth rates, then moved into lantern nets at 25 mm.
2. Lantern nets cleaned with high pressure hose and shaken thoroughly monthly. When seed reaches 50-60 mm they are planted on the beach.

3-4. Oyster growout growing on beach.

5. Oysters picked by hand on minus tides and moved to a hardening beach in Stedman Cove for bleaching and cleaning. Oysters picked off hardening beach, washed, sorted, and hung in bags for sale.

The year in the lantern nets provides Pearl of Alaska with an extra start-up growing season to help shape the seed into deep cupped oysters and avoids high rates of reverse cups and other shell deformities that can result from planting small seed directly on the beach. In addition, the heavier oysters don't wash away by currents that can run as high as five knots at Rocky Pass.

Yes, it's still a lot of work, but Pearl of Alaska was handling all the work with annual seed purchases of 2 million with only a crew of Henderson and two full-time workers during a seven month season.

Picking can be challenging. When there are a lot of large oysters, a good picker can collect up to 400 dozen on a good minus tide. At 64 years of age, I picked more than 300 dozen oysters on a tide, collecting as many buckets as Henderson's two young workers (24 and 30). Two-hundred dozen oysters per tide per worker might be a more realistic target.

Moving the picked oysters from the beach to the landing craft can also be a labor-intensive proposition. Henderson used a handcart capable of carrying two tubs of oysters weighing about 80 pounds, but he was investigating alternative methods of moving larger volumes of oysters. As the size of the harvest grows, a more efficient method will be necessary.

The transition to the beach took many years, but it was accomplished with very little additional investment. Henderson's 28 foot landing craft certainly was a key asset, enhancing his ability to work the beach.

The quality of Henderson's oysters increased significantly as he added two employees and improved husbandry. By 2011, Pearl of Alaska's oysters had deep cups and good meat content, and were in high demand. After 3-4 weeks high on the beach, the oysters get bleached and look very much like suspended culture oysters.

Additional labor will be necessary as Henderson meets his goal of selling 40,000 dozen oysters a year. A thousand dozen oysters per week will probably require at least one additional full-time employee or a crew of part-time pickers. Still, that's a pretty good employee-oyster production ratio.

On this picking day, the crew arrived late and Pearl of Alaska's landing craft was parked close to low tide. Since the handcart was out of service, they ended up paying for the tardiness by the long pack back to the boat as the tide rolled in.

Husbandry

Chapter 15. Lantern Net Husbandry

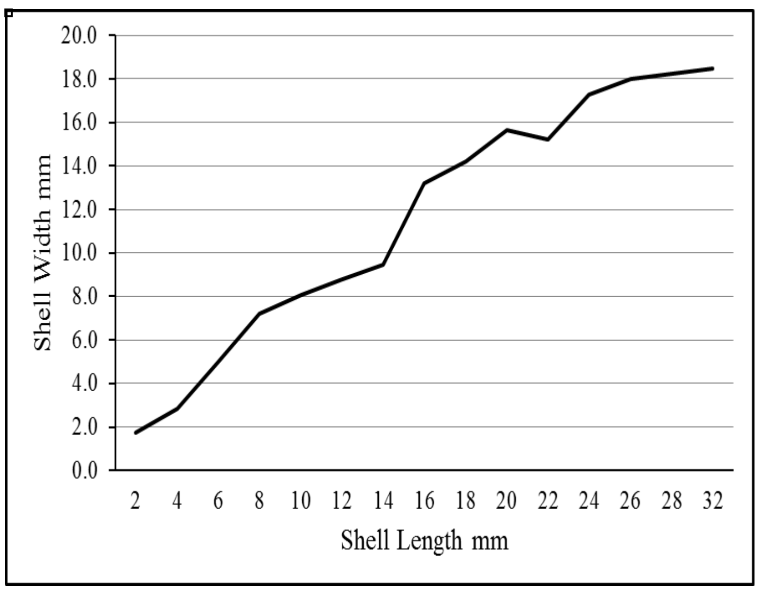
Rodger Painter

Shell Size Must Match Mesh Size

Two millimeters seems like a very small measurement. But when you are stocking lantern nets, mesh that small can result in crop losses of up to 20%.

Grading is imprecise, and some nursery operations are better than others when it comes to sorting oyster seed. An order of seed might include 10% or more shellfish that is smaller than the size you purchased. If, for example, you order 15 mm seed to plant in 7.5 mm mesh, you'll find that a few fall through the mesh.

The biggest problem will become painfully evident when you dump the seed out of the net for the first sort. It may not be obvious why 15 mm spat will fall through 7.5 mm mesh. The reason is that the 15 mm is the length of the spat; the width of the spat is about 11.5 mm, allowing some of the spat to fall through the mesh. In addition, a 7.5 mm mesh is the length of the side not the diagonal length where a seed is likely to fall through. The diagonal measurement of 7.5 mm mesh is 10.7 mm, allowing smaller than average seed to fall through the mesh. If the spat were mistakenly planted in a 9 mm net, the losses might double or triple.



Oyster seed length and width measurements after FLUPSY nursery culture in Kachemak Bay. (Data from R. RaLonde Alaska Sea Grant Marine Advisory Program)

Here's the problem: the small spat become lodged within the mesh and becoming impossible to extract alive as the shells grow. When you pull up a net and see spat growing out of the mesh, you know you have a problem. Up the 25% of a crop can be lost this way if the mismatch in spat and mesh size is large enough.

Grading spat and smaller oysters involves sorting the shellfish into a range of sizes that fall through a certain size screen or hole. The highly irregular shape and size of oysters in any given lot of the shellfish guarantees many of them will be smaller and larger than the target size.

Nursery operators use volumetric calculations when "counting" the number of oysters you purchase. In other words, they estimate how many spat will fit into a liter container, and give you the appropriate number of liters of the small shellfish.

When Alaska farmers imported all their spat from Washington and California, most growers ordered 15 mm spat to take advantage of lower unit and freight costs. Many of the smaller spat would grow into the mesh of 7.5 mm nets and 9 mm nets were a disaster.

The development of regional nurseries allowed oyster growers to buy larger spat and those problems disappeared, as the 20-25 mm oysters are a good fit for the small mesh nets.

Sorting larger oysters by machine or hand also results in a range of shell sizes, and the same problems occur when the shell size of the crop doesn't match the bigger mesh sizes.

Recommendation: Use 7.5 mm nets for 20-25 mm spat. For larger grades, 21 mm nets are recommended. A good rule of thumb might be to pick a mesh size about one-third the average shell size of your sorted oysters.

Spat Stocking Guidelines

The Alaskan Shellfish Growers Association survey of growers found a diversity of opinion on optimum stocking levels for lantern nets, particularly when planting spat. Nine respondents reported stocking numbers ranging from 120 spat per tier to 500. Here's a breakdown of responses.

Years experience	Respondents
4	2
6	1
>15	6

Spat/tier	Respondents
120	2
125	1
200	3
250	1
500	1

The higher numbers probably reflect the grower's intent to dump out the nets and sort the crop in fairly short order. Heavily stocked seed nets will result in shellfish fused together in clumps because the oysters grow very quickly during their first few months in the water. Moving the oysters by washing the gear down vigorously with a high pressure hose and shaking the nets can help prevent high numbers of "doubles" and larger clumps of oysters unsuitable for sale in half-shell markets.

Pacific oyster seed seem to grow better at higher stocking densities, but it is critical to move the young oysters and to separate them according to grades as they grow. If the high density crops are shaken, tumbled/shaken/hosed, separated according to grades and replanted at smaller densities before too much shell growth has occurred, stocking at the 200-250 per tier level should provide good results. Without proper husbandry, high density stocking can be disastrous.

The smaller stocking numbers likely means the farmer intends to leave the shellfish in the net for longer periods of time. While the spat might not grow quite as quickly as at higher densities, there is less risk in this strategy. If the crop is not sorted and thinned in time, the resulting damage is less. Spat planted at densities of 120-125 per tier might work better for operations that grade, sort, and thin once or twice per year.

Recommendation: Stock 7.5 mm nets at 200 20-25 mm spat per tier. Make sure you move the oysters frequently (monthly is best) and thin to lower densities by the end of the first growing season.

Stocking Guidelines for Larger Oysters
Opinions of growers on stocking densities for final growout are much closer than those for spat. Seven respondents stocked their larger mesh nets with 60-80 oysters per tier.

Oysters/tier	Respondents
60	2
75	3
80	2

Research in British Columbia revealed that Pacific oysters could be stocked to the top of suspended trays without adversely affecting growth rates. In fact, according to a presentation by B.C. shellfish aquaculture expert Brian Kingzett, the higher density trays yielded better growth rates than those stocked with fewer oysters. Experienced lantern net farmers in Alaska make similar observations. It may be counterintuitive that oysters can grow faster when grown at a higher density, but consider that water containing phytoplankton food for oysters trapped within the mass of oysters in a chamber concentrates the food, improves efficiency of oyster feeding, and increases growth.

Part of the rationale for lower densities is to make the nets easier to handle because of the lighter weights during harvests.

Recommendation: Stock nets for final growout at 75 oysters per tier.

Cleaning, Sorting, and Moving the Crop

These are the husbandry activities that frequently overwhelm lantern net farmers. Lantern nets can be very labor intensive and it is vital to have an efficient system for handling these difficult activities.

Lantern nets, particularly small mesh nets designed for culturing spat, are wonderful settling surfaces for all types of larvae and make very productive homes for many marine organisms. A 7.5 mm lantern net left in the water throughout a growing season will almost certainly yield a biomass of fouling organisms much heavier and larger than the oyster crop.

Some biofouling events, such as massive mussel and barnacle sets, are easy to deal with if caught in time, but can be extraordinarily difficult to handle if not. You can almost watch some species of kelp growing on lantern nets, and one month of growth can add 50 pounds of weight to a net. Read the chapter in this manual on fouling prevention and control.

As emphasized elsewhere in this manual, periodically moving the oysters around and sorting to size are vital to obtain good survival rates, product quality, and growth rates. The optimum frequency for cleaning, moving, and sorting an oyster crop depends on growth rates, fouling, and operational efficiency.

Growers with three-season growout cycles will need to move and sort their crop of oysters more frequently than farmers needing four growing seasons in lantern nets. Tumbling, shaking, hosing, or dumping out a net will break off new shell growth which helps the oyster develop deeper cups, rounder shape, and fuller meat content. The movement also helps reduce the frequency of "doubles," where the shells of fast-growing seed grow together into an inseparable mass, and helps prevent oyster shells from growing into the mesh of the lantern nets.

It is particularly important to move a crop around during the first growing season when the seed is putting on a lot of new shell growth and the shape of the oyster is influenced the most.

Operational efficiency also plays a major role in the frequency of moving and grading a crop of oysters. It might take a grower two hours to work a single spat net if sorting is done by hand. A grower using a mechanical sorter still has to wash down the net, pull out the oysters, dump them into the sorter, and replant undersize oysters by grade, but the job might be done in an hour from start to finish.

If each operation has 400 nets in the water, the hand sorter might be staring at 800 hours of work (20 40-hour work weeks) versus half that for the grower with a tumbler/sorter. Both are daunting, but the hand sorting operation is simply overwhelming. Little wonder that many lantern net growers fed more oysters to sea stars than to paying customers.

Here's what respondents to the ASGA survey had to say about frequency of moving and sorting their crops.

Frequency of sorting	Respondents
Once/year	3
Twice/year	4

Frequency of moving crop during the growing season	Respondents
Monthly	1
Once	2
Twice	5

Methods of moving crop	Respondents
Shaking	3
Hosing	2
Tumbling	1

During an Alaska workshop, Kingzett told a group of Alaskans that B.C. raft-and-tray operators have found that monthly tumbling during the growing season results in faster growth, improved survival, and the best product quality. Given the number of hours required to work lantern nets, it is difficult to see how farmers using the gear could sort more frequently than twice per season. However, the crops should be moved around by hosing or shaking one additional time.

Recommendations: Sort the crop twice during a growing season and move spat at least one additional time by hosing down the gear and shaking the nets.

Chapter 16. Tray Husbandry

Rodger Painter

Spat Size

There's little debate among most Alaska oyster growers that bigger is better when it comes to spat size, particularly among those using trays.

All five growers responding to an ASGA survey on tray culture said they planted spat in the 20-25 mm range or larger. The optimum size for stocking AquaPacific Maxi-Flow trays was considered 25-30 mm.

Even with the larger spat, the trays will have to be lined so the small oysters don't grow into the wire mesh. Durable plastic liners can be purchased pre-cut from the tray manufacturer or the material can be purchased in rolls.

Grading is imprecise, and some nursery operations are better than others when it comes to sorting spat. Grading spat and smaller oysters involves sorting the shellfish into a range of sizes that fall through a certain size screen or hole. The highly irregular shape and size of oysters in any given lot of the shellfish guarantees many of them will be smaller and others larger than the target size.

Mike Sheets plants spat in lined Maxi-Flow trays as part of Naukati's Weekend Warrior Program.

The result is a batch of spat that might include 10% or more shellfish smaller than the size purchased and a comparable amount above that size. Consequently, it makes sense to use liners with mesh size small enough to accommodate the smaller spat.

Periodic shortages of spat have prompted some growers to begin culturing spat as small as 3-5 mm and this might prompt the use of smaller spat.

Nursery operators use volumetric calculations when "counting" the number of oysters you purchase. In other words, they estimate how many spat will fit into a liter container, and give you the appropriate number of liters of the tiny shellfish. This can also affect the ratio of different sizes of spat in each batch.

Recommendation: Use spat in the 25 mm range.

Stocking Densities

Opinions among growers on how many spat to plant per tray varied considerably in responses to ASGA surveys, ranging from 250 to 1,000. This probably reflects different growth rates and sorting schedules.

Farmers with slower growth rates (3-4 years to first harvest) don't have to tumble and sort as frequently as those with better growth (2 years to first harvest). One grower responding to the ASGA survey sorted only once per growing season and two others sorted twice a year. One grower tumbled and sorted four times a year and another four times during the growing season.

The growers with fewer sorts stocked at lower densities. Oyster spat grows well at high densities, but if they are not moved often enough their shells tend to grow together. As the oysters get larger, those on the bottom won't grow as well as those on top.

If the crop is tumbled and sorted only once or twice a year, densities should be lower. Farmers sorting more frequently can begin with high densities and gradually reduce them as the crop grows.

Opinions also were split on final growout densities, with half of the respondents saying 100 oysters/tray and the rest answering 250 oysters/tray. Pacific oysters grow well at high densities throughout their lifecycle.

British Columbia shellfish aquaculture expert Brian Kingzett told Alaskans at an Anchorage workshop that his research showed large oysters grew as well at densities that completely fill a tray as they did at half as much. What really matters the most is tumbling and sorting frequently, according to Kingzett.

Recommendations:

1. Plant spat at 500 per tray unless you plan to tumble and sort at least three times during a growing season. For those operations, plant at 750 spat per tray.
2. Final densities should be about 200 oysters per tray.

Cleaning, Sorting, and Tumbling

The adoption of tray technology and use of tumbler/sorters represented a major step toward mechanization of oyster farming in Alaska. Prior to the introduction of trays and tumbler/sorters, the process of sorting a lantern net of oysters by hand was so labor intensive that virtually no growers were able to keep up with their crops.

During one of his Alaska presentations, Kingzett drew audience attention to the absence of washdown pumps in the tumbling and sorting pictures he showed. This is a function of the constant working of the oyster crop, he said, explaining the crews at those farms never stopped tumbling their oysters during the growing season. The rule of thumb in B.C. was to tumble (not necessarily sort) the crop at least once a month.

Only one of the Alaska growers using trays and tumbler/sorters who responded to the ASGA survey was tumbling and sorting that frequently; a second respondent was tumbling and sorting four times per year. As explained earlier in this article, growers with slower growth rates tend to sort less frequently.

Oyster growers in B.C. have slightly faster growth rates than in southeast Alaska. Growth rates in Prince William Sound are good, but the area has shorter growing seasons than the southern Alaska Panhandle. The growing season is even shorter in Kachemak Bay and growth rates generally lag a year slower than southern southeast Alaska.

Rates of biofouling also have a major influence on the frequency the gear is worked. If you are slow at responding to a major set of fouling organisms, such as mussels or barnacles, you'll have a lot of work on your hands. The best way to deal with these troublesome organisms is to work the gear right away.

A tumbler/sorter at Mike Sheets' farm south of Naukati. This unit was manufactured in a Ketchikan welding shop.

Some species of kelp grow incredibly fast during the summer months, spurting out 6-10 feet in a month, adding tremendous weight to the gear. Farms dealing with this kind of fouling might have to lift each unit of gear monthly to cut off the kelp. This also creates the opportunity to tumble frequently.

Tumbling/sorting should be done as frequently as possible within the growth rates of individual farms. In this case, it appears more is better.

Recommendations:

1. Tumble and sort 4-6 times a year if your farm has a three-year crop (two-thirds of the crop ready to sell within three growing seasons).
2. Tumble and sort 2-3 times a year if your farm has a four-year growing cycle.

Chapter 17. Prevention and Control of Fouling

Raymond RaLonde

New shellfish farmers soon discover that aquaculture gear suspended in marine water seems to attract every living variety of seaweed and attaching animal, which adopt the gear as their new home. The species diversity and abundance of these organisms amazes even seasoned biologists, and to the farmer they are a constant source of fascination and annoyance. The farmer must determine the composition of these fouling events and make an appropriate response to clean the gear. If left unchecked, fouling can reduce growth, quality, and survival of the oysters. Delaying gear cleaning to a more convenient time may cause far more labor expenditure at the later date and potential gear damage can occur.

Four major categories of fouling organisms are seen on the farm.

1. Beneficial: These organisms actually make life easier for the farmer because they consume other problem fouling organisms. A common example is sea urchins, which eat sponges and algae and other organisms.
2. Competitors: These organisms compete for food and space intended for the oysters. An example is blue mussels, which consume large amounts of phytoplankton (oyster food) and can completely fill a cage or lantern net chamber.
3. Predators: The presence of predators can cause oysters to shut their shells and stop feeding. The predator can also kill and consume the product of your labor. Sea stars are the most troublesome of the oyster predators.
4. Circulation blockers: All fouling organisms have the capacity to block the flow of water into the cage or chamber occupied by oysters. Some species are worse than others. Sponges and colonial tunicates (Appendix Figures 1 and 2) can completely coat the culture gear and oyster crop. They have the opposite effect of urchins, which actually clean the gear and improve water flow.

This chapter addresses the major fouling organisms of the hundreds you will encounter. Fouling organisms of top concern are seaweeds, sponges, blue mussels, colonial tunicates, and sea stars. All of these are presented in species categories. To effectively respond to fouling requires correct identification of the problem species, and an understanding of life histories, prevention strategies, and control.

Seaweeds

Structure and Life History

Marine seaweeds are in three groups: green algae (phylum Chlorophyta); brown algae (phylum Ochrophyta, class Phaeophyceae); and red algae (phylum Rhodophyta). Green and red seaweeds are usually not a serious problem. Green algae tend to be soft and easily washed off gear with moderate water pressure. Red algae can be soft and fleshy, requiring simple washing. They also include corallines and branched forms, which incorporate calcium carbonate into their structure making them crusty or hard and brittle. These are a bit more difficult to remove. Most red and green algae are small (Appendix Figure 3).

The brown algae are significantly larger and form blades (fronds); many are referred to as kelp. Kelps have a three-part structure composed of a holdfast, stipe, and blade (Figure 1). Growth of kelp occurs in the intercalary meristem, near the stipe not from the tip of the blade.

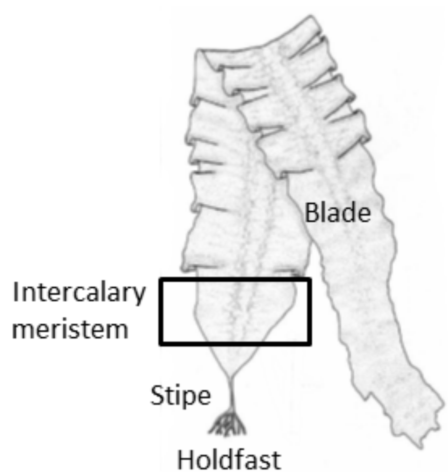


Figure 1. Anatomy of a kelp.

A variety of kelps commonly grow on shellfish gear, primarily *Laminaria* sp. and *Saccharina* sp. (Appendix Figure 4).

The life cycle follows a pattern called alternation of generations (Figure 2). On the blade (the sporophyte generation), spores develop in pouches or sporangia. As the spores mature, the sporangia appear as dark blotches when the blade is held up to a light. When spores reach maturity, the sporangia rupture, releasing microscopic mobile spores into the water. The blade at this time becomes frayed.

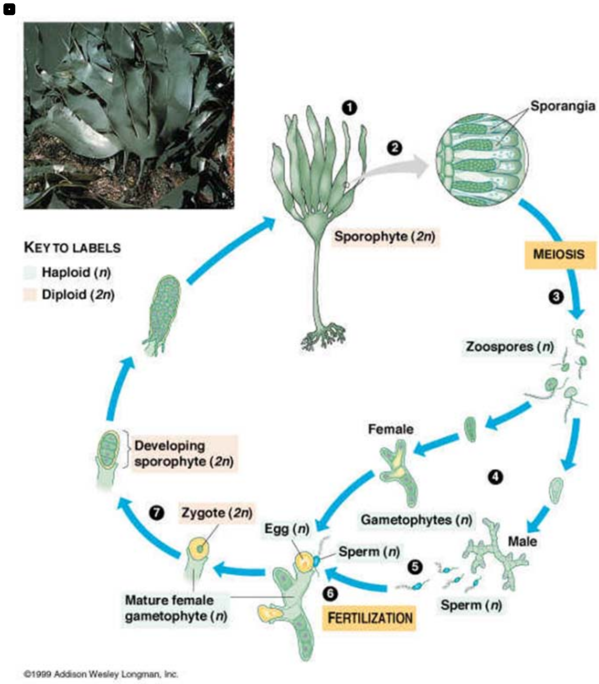


Figure 2. Life cycle of brown kelp.

The spores eventually attached to a firm substrate germinate to form separate male and female stages. This is the microscopic gametophyte stage. The males form highly branched filament sets, each several cells long, while females are generally a single filament a few cells long with an egg on top. Gametes (eggs and sperm) are produced, and the mobile sperm is released and fertilizes the nearby eggs. The fertilized egg eventually germinates to form the sporophyte, and the cycle continues.

Seaweeds can grow remarkably fast through the summer. For example the common bull kelp grows its entire length in one season. If left uncontrolled, massive seaweed fouling can block water flow into the chambers of oysters, thus reducing feeding. If spore settling occurs within the chambers, crowding can occur that affects shell shape. Seaweed fouled nets are also very heavy and mature blades require considerable labor remove.

Prevention

Seaweed fouling is far less damaging to oyster production than other forms of fouling. Lifting gear above the water surface for cleaning, particularly in the spring and early summer, exposes a mass of seaweed covering the gear. But out of water, the seaweed fouling of the gear appears worse than it really is. Much of the fouling occurs near the top of the gear where the seaweed has better access to light, and while submerged the blades float instead of completely encasing the gear.

Intervention to reduce fouling is best done while the seaweed is in the gametophyte phase, because this microscopic phase washes off easily. The span from spore settling to development of tiny blades less than 1 mm takes about 6-8 weeks. Spring, summer, and fall cleaning should prevent serious problems.

Control

Washing the gear controls massive expansion of seaweed fouling. Controlling also includes removal of mature blades. Removing the blade, including the intercalary meristem to prevent further growth, requires severing the blade at the stipe. Ripping the blade and leaving the intercalary meristem enables the blade to continue growing, and you will need to attend to the problem again at a later date.

Sponges

Structure and Life History

Sponges are multicellular animals composed of a collection of cells that perform various tasks such as generating water flow to deliver food into the sponge, contributing structure, digesting food and distributing nutrients, and removing waste from other cells. Sponges have no organs and no anterior or posterior sides (Appendix Figure 1). Supporting elements that give the sponge shape and firmness are spongin, a fibrous substance, and siliceous (glass) spicules. Spongin and spicules add a rough, firm texture to the sponge. Microscopic examination aids in identification.

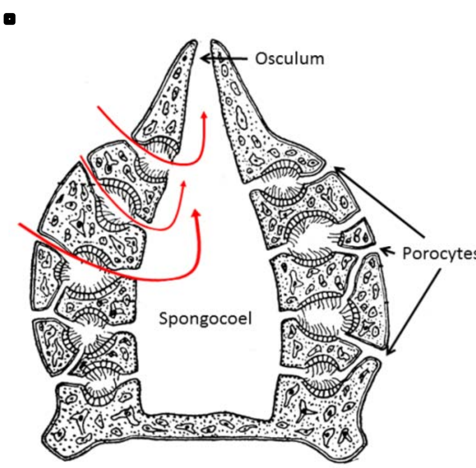


Figure 3. Sponge anatomy and water flow.

Sponges are shaped like an urn (Figure 3). Water enters the central internal chamber (spongocoel) through porocytes, and exits via the osculum. The process delivers food and oxygen to the sponge, distributes to the cells, and collects waste that exits through the osculum. Close examination of a sponge colony reveals oscula openings covering the mat (Appendix Figure 1).

Sponge reproduction is both sexual, with production of eggs and sperm, and asexual, through budding and fragmentation. Egg and sperm production, and fertilization, occur within the sponge. Within 24 hours the fertilized egg hatches into a swimming larva, which disperses to the surrounding area, attaches within a few days, and begins developing into a fully functioning sponge. Sexual reproduction enables genetic diversity and a means to spreading the population outside of the parent body mass.

Asexual sponge fragmentation (breaking into pieces) and budding allow the sponge to expand the colony to form a mat and disperse the colony to other locations. Asexual reproduction can be extremely prolific and is the primary method that expands sponge fouling on oyster culture gear.

Prevention

Prevention from initial setting on shellfish culture gear is difficult since sponges are a highly dispersed and productive feature of the marine environment. However, farmers can prevent the spread of sponge colonies by limiting reproduction by budding and fragmentation.

Typically, colonies of sponges do not blanket a significant surface area of the gear. In small patches, colonies can be removed by hand and disposed of in a container for subsequent air-drying. Washing to remove colonies from gear, which requires scrubbing with a brush, spreads the sponge colony by fragmentation. Try to collect as many of the sponge fragments as possible to prevent spreading. In circumstances where significant sponge fouling occurs, the oyster should be removed, cleaned, and placed in clean, unfouled gear. The fouled gear should be air dried for at least 24 hours to kill any remaining sponge.

Control

Some sponge fouling is inevitable and may not need an immediate response. Direct removal and drying are best for removing sponge fouling. Hot dipping is also useful.

Blue Mussels

Identification and Life History

The blue mussel (*Mytilus trossulus*) is a bivalve shellfish native to the west coast of North America including Alaska. Adult blue mussels live attached to a hard substrate, mainly rock or wood, in the mid intertidal zone.

The blue mussel is identifiable by its elongate elliptical shape that narrows into a beak at the umbo or hinge (Figure 4). The shell color is often bluish-black, but can be variable with gray and light brown coloration. The surface of the shell is covered with a shiny proteinaceous membrane, the periostracum. Blue mussels attach to their substrate by a threadlike organ called the byssus.

Figure 4. Blue mussel.

Blue mussels are extremely efficient filter feeders. A 3 inch mussel is capable of filtering 15 gallons of water in a single day. Off-bottom mussels that are in the water constantly can grow up to five times faster than those grown intertidally. By the end of the fall growing season, the new set of mussels grow to about 12-15 mm in length. By the end of their first summer they reach 25-35 mm and during the second summer achieve their full size of 50-70 mm.

The prolific nature and fast growth requires prompt removal from oyster culture gear, because mussels block water flow, are a significant competitor for space and food, and add significantly to the weight of the gear.

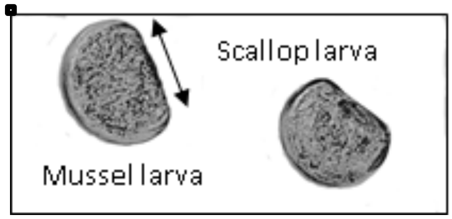


Figure 5. Mussel and scallop D stage veliger larvae.

Sexes of the blue mussel are separate and spawning generally begins in the early summer. After egg fertilization and larvae hatching, the drifting larval phase continues for about three weeks. Blue mussel larvae are distinguishable from other bivalve larvae. In the D stage veliger, a longer flat hinge is more evident than in other bivalve larvae (Figure 5), while the later umbo veliger stage exhibits an obvious protrusion, the umbo, at the hinge (Figure 6).

Blue mussel larvae are planktonic from April through November with peak abundance usually in July and August. In some areas, several periods of high and low numbers occur during their planktonic phase. The settlement time and location depends on the growth rate of larvae and occurs when the umbo veliger reaches about 350 microns in length. Larvae prefer to settle within an existing bed of mussels, but will also seek rough textured substrate such as shellfish culture gear.

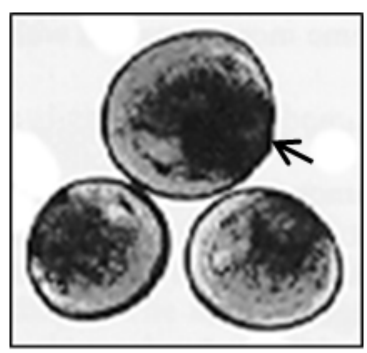


Figure 6. Mussel and scallop umbo veliger.

Prevention

With a known life cycle that has identifiable stages, prevention or prompt control is possible by monitoring for the planktonic stage of the larvae. This method requires a plankton net, microscope and clean slides, a one pint flat-bottom glass container, 95% isopropyl alcohol (available from a pharmacy), and an eye dropper. The method is as follows:

1. Collect a plankton sample with a plankton net mesh size larger than 80 microns by lowering the weighted net to 30 feet and retrieving vertically.
2. Place the sample in a clear glass container. A laboratory beaker is best.
3. Add isopropyl alcohol to the sample. An amount of alcohol should increase the sample volume by at least 10%.
4. Swirl the sample to mix and allow settling for 10 minutes.
5. Gently swirl the sample again to form a whirlpool and allow to settle out for 30 seconds. The process separates the light from heavy materials. Mussels are heavy and the lighter floating material can be poured out. Be careful not to disturb the material settled on the bottom. Add clean water to the sample to bring up the volume.
6. Repeat step 5 at least three more times.
7. Swirl the sample for the last time and allow settling.
8. The water should be clean and much of the debris removed. Bivalve shellfish larvae should have settled into the middle of the bottom of the container, and have the appearance of a tiny sand pile.
9. Collect the larvae with an eyedropper, place on a glass microscope slide, and examine under a microscope with low power. Identify the mussel larvae, stage of development, and relative size.

An abundance of larvae should be in the field of the microscope. The mussel larvae have an obvious protrusion at the hinge of the larva shell (the umbo stage). Scallop larvae do not have such a protrusion (Figure 6). With regular sampling, the mussel larvae will outgrow the scallops, and increase in number as the season progresses.

Clean the oyster culture gear within a couple of weeks after the mussel larvae disappear from the samples. Their disappearance is an indication that they have settled on your gear. This is the time to wash the gear to remove the tiny mussel seed.

To prevent mussel fouling altogether, sink the gear to greater than 30 feet when large umbo larvae begin appearing in the sample.

Control

Four primary methods to control mussel fouling are prompt washing of gear, air-drying, hot dipping, and exchanging gear when larger mussels are evident.

Washing gear requires paying attention to the mussel life cycle, and prompt action, because mussels attach firmly. Plankton sampling can help monitor the mussel life cycle. Use water pressure that will remove mussels but will not fracture oyster shells. Also, regularly inspect gear to determine if a recent set has occurred. Knowing the historic set time will help determine the schedule for cleaning gear. It would be a shame to clean the gear, and then have a mussel set follow that would require cleaning again. For small mussels (less than 10 mm length), air-drying is the method of choice; they are difficult to clean from the gear. In Alaska this is possible on a warm sunny day in July or August. Oysters can stand the time out of water, but mussels are more temperature sensitive.

In extreme conditions, when a thick coating of mussels is difficult to remove, farmers who have extra gear that is dry and clean of fouling can transfer oysters to the clean gear. To clean the fouled gear, first air-dry and then pressure wash before reuse. Avoid reusing fouled gear before it is completely dried. Mussels prefer attaching with other mussels.

Hot dipping is a technique to kill mussel fouling that makes use of the differences in heat tolerance between oysters and mussels. The lethal temperature for mussels occurs when the internal body temperature reaches 38-40ºC (100-104ºF), while oyster tolerance is 44-48ºC (111-118ºC). Alaska experience shows effective results when dipping for 30 seconds at 50ºC (122ºF) when oysters are 1.5-2.0 inches (38-58.8 mm) and for 45 seconds when they are over 2 inches (58.8 mm).

Scheduling hot dipping is crucial. It should be performed after the end of the fouling season, in September/October, before winter begins. For more information see "Hot Dipping to Control Fouling and Improve Oyster Production," In: *Alaskan Shellfish Training Program 2010,* http://seagrant.uaf.edu/map/aquaculture/index.html.

Of all the fouling organisms in Alaska, mussels cause the worst problems. If left untreated mussel fouling can extend the growout time of oysters by more than a year and result in significant oyster mortalities. Mussel fouling removal is critical and must be scheduled when the mussels are vulnerable.

Barnacles

Identification and Life History

Barnacles are a crustacean, more closely related to crabs than bivalve shellfish. Acorn barnacles occur from Unalaska to San Diego, California, ranging in adult size from the giant acorn barnacle (*Balanus nubilus*) at 18 cm (7 inches) to the little brown barnacle (*Chthamalus dalli*) at 4 mm (0.25 inch).

Naturally occurring as intertidal species, barnacles create bands of dense population at the mid to upper intertidal area. Barnacles also grow very well on culture gear that is submerged. The likely reason they do not naturally extend to deeper water and higher on the beach is that predation causes extensive mortalities. In aquaculture gear, however, minimal predation allows barnacles to thrive.

Figure 7. Common acorn barnacle.

Alaska has six species of barnacles (suborder Balanomorpha) that can potentially foul shellfish culture gear and oysters. The acorn barnacle (*Balanus glandula*) is common and likely the most abundant of the species causing the worst problems (Figure 7).

Numerous calcium carbonate plates encase adult barnacles while they are attached to hard rocky surfaces, and the barnacles feed on living plankton captured by their thoracic appendages. They grow quickly, achieving maturity within a few months and living 1-2 years.

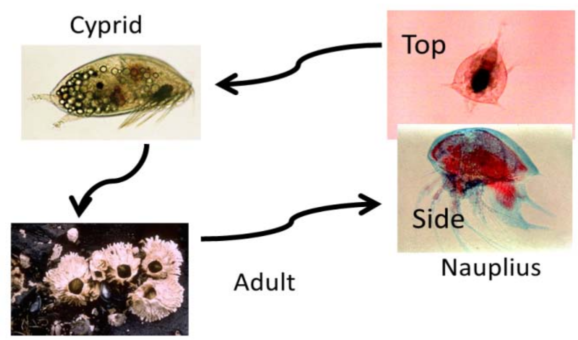


Figure 8. Life cycle of the acorn barnacle.

Barnacles are hermaphrodite sexual reproducers, contain both male and female organs, and can actually breed with themselves. Once eggs hatch, the larvae are released into the water and undergo several stages of development; most identifiable are the nauplius and cyprid stages (Figure 8).

Barnacle reproduction is so prolific that the term barnacle bloom refers to the reproduction event. In Alaska, barnacle blooms mainly occur in spring, but small pulse blooms may also follow (Figure 9). The bloom begins with nauplius stage larvae (blue), persists for a time, and then progresses with the gradual appearance of the second stage cyprid larvae (red). Figure 9 shows the progression of a barnacle bloom that is already under way on April 27 with large numbers of naulplii larvae. The proportion of the cyprid larva stage dramatically increases from May 7 to May 11, and then reduces by May 15. On May 14 the cyprid larvae that have completed their floating phase have set on hard surfaces including your culture gear, cemented their head permanently to the surface, and will spend the rest of their lives in one place kicking their thoracic appendages. Immediately following the first set of cyprid larvae, another pulse of nauplia appears. Like mussels, barnacles prefer to set around other barnacles.

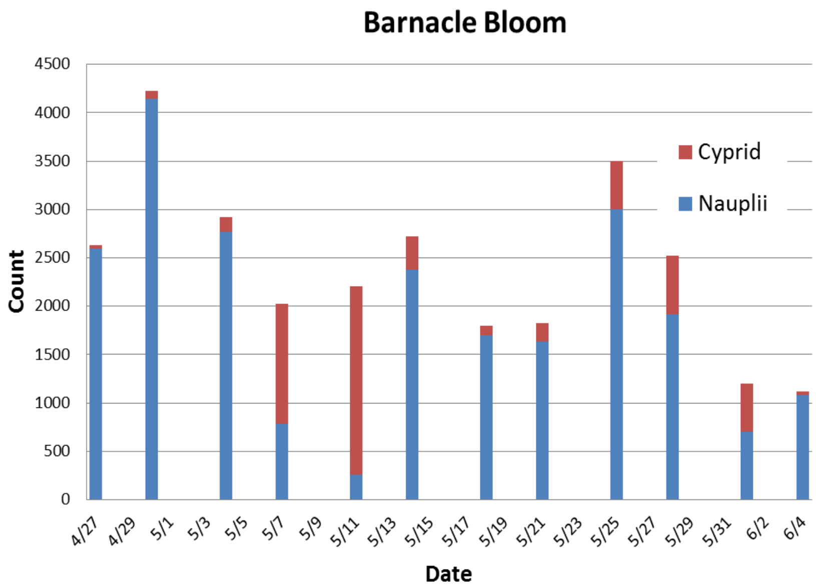


Figure 9. Phases of a barnacle bloom in southeastern Alaska.

Barnacle fouling looks awful. Gear completely covered with a white layer of barnacle shells and oysters encased inside a mass of barnacles is common. Controlling barnacles is critical to an oyster farm operation.

Prevention and Control

Plankton sampling and analysis helps to predict the setting time of barnacles. With appearance of the cyprid stage, the farmer has two response options:

1. Since barnacles are surface setters, the farmer can sink the gear to deep water (40 feet) until the set is completed, or
2. Clean the gear soon after the barnacle cyprids disappear from the plankton samples.

One commonly used prevention method is to retain the kelp fouling on the gear until the barnacle set is over. Apparently, the protection and sweeping action of the blades reduce the intensity of the barnacle set.

Other controls include air-drying for small barnacles immediately after they set, moderate to high pressure washing of gear, exchanging gear, and manual cleaning of fouled oysters. Labor-intensive hand scrubbing and scraping is often used. Tumbling oysters is also useful. The easiest way to kill all barnacles is to swap out nets or trays and leave the gear out of the water for an extended time. Gear can then be pressure washed to remove the barnacle shells, which are an attractant to new setting larvae.

Tunicates

Identification and Life History

Tunicates, commonly called sea squirts, are urochordates, the higher form of marine invertebrate life closest to vertebrate animals. In body form a tunicate is sac-shaped, containing organs such as a heart, stomach, gonads, etc. (Figure 10).

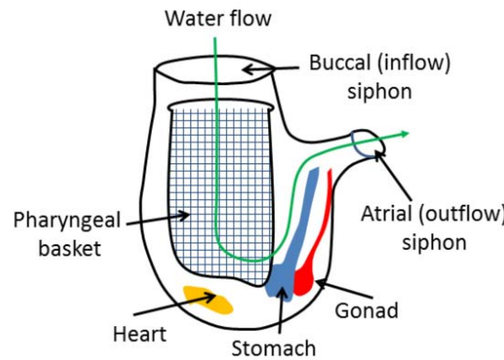


Figure 10. Anatomy of a tunicate.

Identification and Life History

Tunicates come in three forms: solitary, social, and colonial (Appendix Figure 1). Single solitary tunicates can become quite large but they are not normally a serious problem in Alaska. Social tunicates cluster and attach to each other by a thin tissue termed stolons. Colonial tunicates form mats that can cover a substantial area and are the most serious problem encountered by Alaska oyster farmers. Structurally, colonial tunicates appear similar to sponges, but they have definite organ structure.

Figure 11. Invasive tunicate mat from Whiting Harbor, Sitka Sound, Alaska.

Recently, non-native species, or invasive tunicates have entered Alaska water (Figure 11). Invasive tunicates have caused serious fouling problems in Puget Sound, Washington (Appendix Figure 5).

Tunicates are hermaphrodites with each individual containing male and female reproductive parts. Tunicates reproduce by asexual budding and sexually, but self-fertilization of eggs with sperm seldom occurs. Sperm released from the male swims to adjacent tunicates, fertilizing eggs. Because of cold Alaska water temperatures, reproduction likely occurs in the summer months. The eggs hatch to form larval stage that has the appearance of a frog-like tadpole (Figure 12). The tadpole larva settles, attaches, and reaches a mature adult in one to three years.

Prevention and Control

Tunicates have a very short larval drift period, limiting their distribution. The best control mechanism is to control transport of gear and shellfish that might spread tunicates to other locations. Be extra cautious about buying and transporting used aquaculture gear to your site.

Figure 12. Tadpole larva of a tunicate.

Prevent spreading of tunicates at the farm site by removing them individually and destroying them in a freshwater soak or thorough air-drying. Report invasive tunicates to the Alaska Department of Fish and Game Invasive Species Program.

Control

Tunicates are very intolerant to drying and low salinities. Air drying and soaking in freshwater are good controls for tunicate fouling.

Sea Stars

Identification and Life History

Sea stars are not technically fouling organisms, but cause considerable mortalities in suspended culture of oysters. Shellfish are a favorite meal for sea stars, because they can pull apart the shells, insert their stomach into the soft body tissue, and digest the shellfish while it is still in the shell. Several sea star species cause problems, but their identification is not particularly important since the control is the same for all species. Sea stars can devastate a tray of oysters over the winter (Figure 13).

Figure 13. Even diligent farmers have problems with sea stars—one for the sea stars, zero for the oysters.

Sea stars reproduce in summer, releasing eggs and sperm into the water. To enhance reproductive success, sea stars generally live in groups and spawning is coordinated. After hatching, two larval forms develop: bipinnaria followed by brachiolaria larvae (Figure 14). Larvae are common in the late summer in Alaska, and the adult stage is fully developed by early fall.

Prevention

Sea stars get into aquaculture gear via two mechanisms: when nets touch the bottom during low tides and, most common by far, when nets receive drifting sea star larvae. A simple prevention is to locate the farm where sufficient depth prevents the gear from touching the bottom. Unfortunately, preventing larvae from entering the gear and settling is not possible.

Control
The best control is to monitor your gear and remove sea stars that originated from larval entry. Since sea stars grow considerably faster than oysters, removing them as soon as possible is necessary. The best time to remove sea stars is during the fall cleaning.

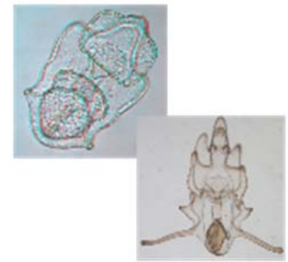


Figure 14. Sea star larva.

Crabs
Identification and Life History
Crabs are predators that enter the gear as larvae. Crabs have two primary larval stages: zoea and megalopa (Figure 15). The zoea is a very distinctive planktonic form with a large spine on the head, while the settled megalopa appears more like an adult crab. Crab larvae are in the water during late summer.

Prevention and Control
Little can be done to prevent crab larvae from settling in your gear, and once in the gear they can grow quickly and cause considerable mortalities, particularly for small oyster seed. Adult crabs soon develop after the megalopa stage appears and need to be removed by hand when they occur.

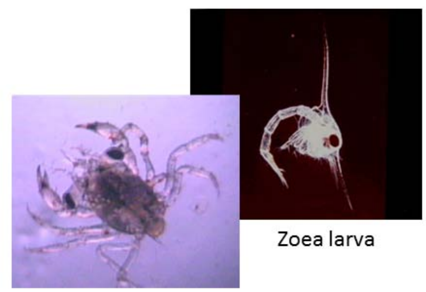


Figure 15. Crab larval stages

Fouling Controls
Shellfish farmers have relatively few choices when dealing with fouling control. Because shellfish are a food product and can concentrate toxins through their filter feeding process, chemical treatments of gear and the shellfish are illegal. This includes wood preservatives, heavy metal–based antifouling coatings, or any chemical that is lethal to fouling organisms. Farmers therefore must first resort to two choices: prevention and/or an approved control method that does not affect the safety and wholesomeness of the product. Proper antifouling techniques also have implications in the marketplace since consumers are increasingly perceptive about the quality of the foods they consume, and an emphasis on environmental costs has fostered the green labeling programs for seafood and sustainability. In the long term, these consumer preferences are good for the farmer since shellfish are good for the environment.

A quick review of prevention and control methods and some other techniques not yet presented are the focus of this section. In review, prevention methods to consider are:

1. Become an expert on identification and life history requirements of fouling species. Novel ideas combine observation, experience, and study to develop.
2. Impose methods that reduce the prospects of spreading fouling organism (i.e., sponges and tunicates) around and away from the farm. Containment and eradication is a best practice in pest control.
3. Do not transport or use equipment that has been in the water at another location, as piggyback fouling organisms may come along for the ride.
4. Pursue life cycle intervention methods that employ a feature of the fouling organism's life cycle. For example use plankton collection and analysis to predict a fouling event in advance and respond to it, as with barnacle fouling.

Regardless of how much care you take, the need to control fouling is inevitable. The best practice is to apply control techniques sooner rather than later. Control methods include:

1. Hand removal of small patches of sponge and tunicate colonies that reproduce by fragmentation, as well as predators like sea stars and crabs.
2. Wash off fouling with a water pump. A pump should be able to deliver 150-200 gpm through a 2 inch hose, with a nozzle that narrows to ½ inch to provide additional force. High-pressure washers must not be used on gear that contains oysters since considerable shell damage may occur. High pressure washing of baskets or lantern nets is appropriate. An adequate water pump costs between $500.00 and $800.0.
3. Air-drying will kill soft tissue fouling. The drying time is a function of air temperature and humidity. On a warm dry day it may take only a few hours to kill most soft organisms, while during a rainy period it may take a couple of days. If air-drying kills fouling, the results will be evident a few days after return to the water with all the fouling sloughed off and the gear clean. Air-drying is also a good method to use on gear prior to pressure washing.
4. Soaking the fouled oysters and gear in freshwater is a good method for killing species that are intolerant to low salinities, such as tunicates. A few minutes soak time is effective.
5. Mechanically tumbling and washing oysters is effective in removing any newly set small size fouling organisms (See Appendix Figure 5). If some fouling organisms have grown to a large size, they may need to be removed by hand before tumbling. A tumbler/washer costs about $5,000.
6. Hot dipping as described in the blue mussel section is effective at removing multiple forms of fouling, particularly the troublesome blue mussel. The method does require construction of a tank and heating system and heating water for treating can be expensive. Expect up to 5% mortality of your oysters from the process.

Biological Controls

One additional methods needs description: using the natural marine environment to help control fouling, referred to as biological controls. The method uses the natural foraging behaviors of marine animals to consume fouling organisms. The sea urchin, for example, feeds on barnacles, marine snails, limpets, and chitons use a rasping tongue to scrape hard surfaces for food (Appendix Figure 7). Small crab species are good since they cannot prey on larger oysters (Appendix Figure 8). Sea cucumbers consume detritus and sediment and help keep the culture gear clean. All that is necessary is that the farmer identify the beneficial animals and leave them in the culture gear during maintenance. Appendix Figure 6 shows several species that should be retained.

Last Minute Advice

Seek the knowledge of other experienced farmers and utilize their skills. Become familiar with fouling organisms and learn how the timing of their life cycle affects your farm. Each farm will have similarities to and differences from other farms. An essential habit to good farming is to pay attention to fouling events and take action to deal with the problem soon after. An appropriate saying in agriculture is to "Make hay while the sun shines." Wet straw on the hay farm can be a disaster at harvest time. Unchecked fouling should not be a problem you allow to happen on your farm.

Acknowledgments

I would like to acknowledge the people and organizations who provided the appendix photos. The photo quality and education value to Alaska shellfish farmers is exceptional and is greatly appreciated. To all farmers, please visit the websites of the photographers to get valuable information about fouling organisms and utilize the photographs and biological information provided for many species. To the following I give my appreciation.

- Mary Jo Adams, Beach Watchers of Washington State University, http://www.beachwatchers.wsu.edu/ezidweb/
- James Watanabe, Hopkins Marine Station, Stanford University, http://seanet.stanford.edu

Appendix

Figure 1. Sponges

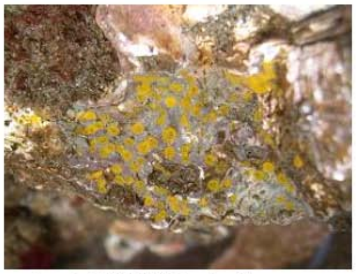


Figure 2. Tunicates

Ritterella pulchra

Ciona savignyi

Distaplia smithi

Distaplia occidentalis

Ritterella rubra

Pyura haustor

All tunicate photos by: © James Watanabe, Hopkins Marine Station, http:// seanet.stanford.edu

Figure 3. Green and red seaweeds

Figure 4. Brown seaweed (Kelp)

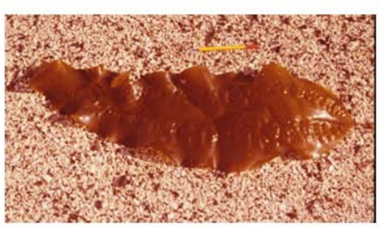


Figure 5. *Didemnum vexillum* fouling:
An invasive species

Photos from Puget Sound Partnership

Figure 6. Tumbler/Sorter

Photos from Mike and Kathy Sheets

Figure 7. Good animals to keep

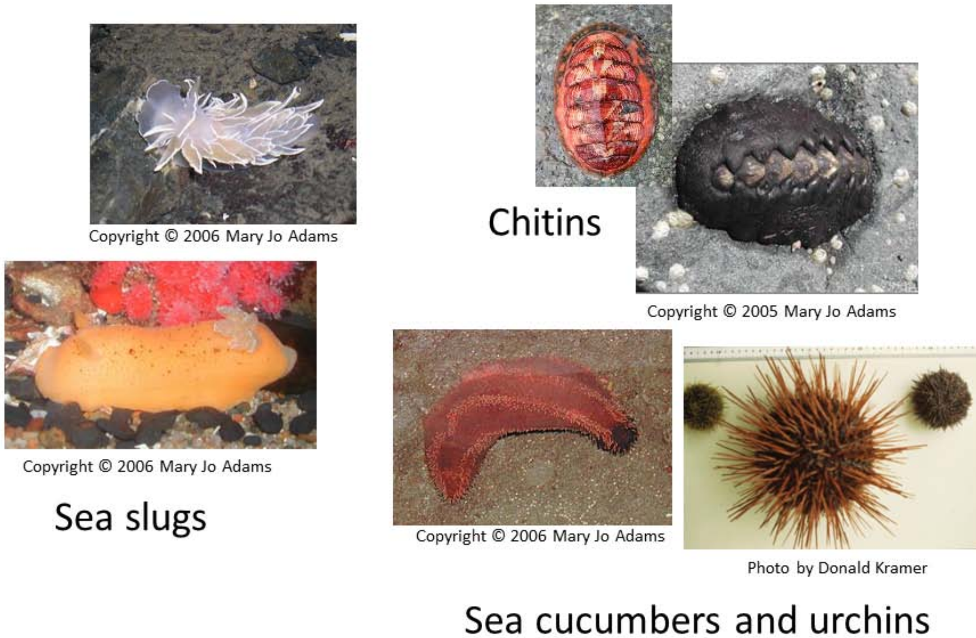
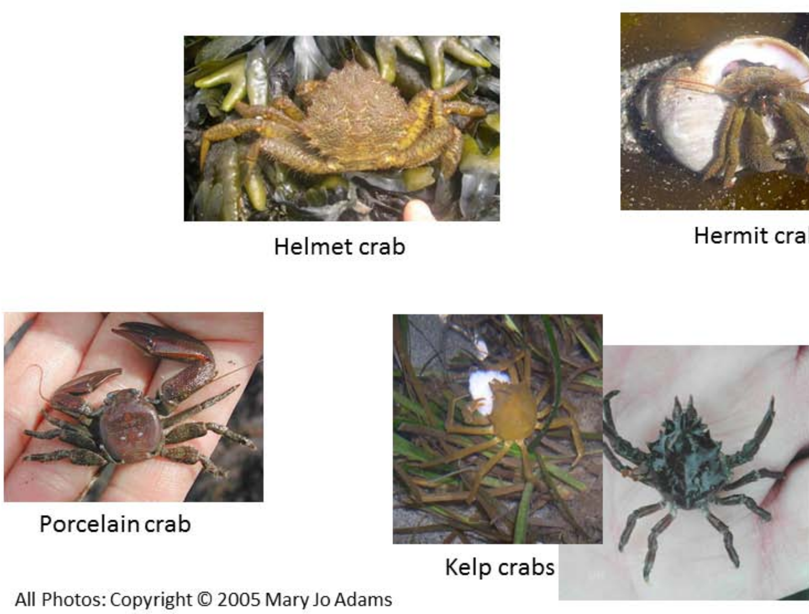


Figure 8. Beneficial crabs



Chapter 18. How Many Oysters Are Ready to Sell and Where Are They on the Farm?

Rodger Painter

Tracking Inventory

One thing you learn early on in the oyster business is that it is difficult to make a profit unless you sell a lot of product. Keeping track of those oysters as your business grows becomes increasingly important.

A two person farm might have to sell 400 dozen oysters per week to return a decent living profit for the pair of workers. Let's see, 400 dozen x 12 = 4,800 oysters. If you are working trays with a density per tray of 150 oysters, eight trays per stack, and only 75% of the oysters are marketable, you will need to go through only 5.3 stacks to obtain your harvest for the day.

So, how many stacks of trays might you need for any given harvest time to retrieve your weekly order?

Let's assume you have a three-year growth cycle where 85% of the survivors of each age class are sold after three growing seasons. If you sell oysters at that level for eight months of the year, you'd need to go through 170 stacks of trays to retrieve your weekly orders. This is enough work without having the additional problem of not knowing where your marketable product is located on the farm.

A three-year rotational cycle for your oyster really means that you will be carrying about five different age classes on the farm. The math gets elaborate from here on out. I don't want to take you through a complex mathematical equation, but it is clear there would be hundreds of stacks of trays you can choose to lift to fill your weekly orders.

The last thing you want to do is start lifting stacks of trays to find where the largest oysters are located.

Beyond finding your product ready for market, a farmer always needs to know the location of each stage of your five crops of oysters. In reality, the age classes lose meaning very quickly, as the crops become mixed after several sorts. Size becomes the most important factor in keeping track of what is located where.

Plotting weekly work plans will require knowledge of where each size class is located, what husbandry has been accomplished on each stock and when, and what needs to be accomplished that week. This becomes even more important as the operation expands and the owner/operator is no longer on the rafts or working the longlines full time.

There are many strategies for tracking inventories, but they all involve keeping records each time you work on your oyster gear. The entries can be very painless, and mostly will involve entering a small amount of data.

The simplest approach to crop inventorying is to assign a number to each unit of gear that relates to its location in your culture system. For example, you could pinpoint a location as longline 1, nets 13-28, or raft 3, stringer A, stack 3.

Establish standard stocking densities for each grade so you never have to guess how many oysters are in each unit of gear.

Inventories should be one segment of your record keeping and integrated into a logbook or data sheet. In addition to tracking the location of various grades of oysters, records should capture information on husbandry activities.

Record keeping should be very concise so it can be done quickly between jobs and wearing raingear. A clipboard with waterproof data sheets or write-in-the-rain notepad work better under these conditions than electronic notebooks, smart phones, laptops or other electronic gadgets.

Codes, such as L1, 13-28, for longline number one, nets 13-28, help make data collection easier.

Following is a simple data sheet from *The Alaska Shellfish Growers Logbook.* Chapter 19 has a copy of the logbook, and it is available from the Alaska Sea Grant Marine Advisory Program at http://seagrant.uaf.edu/map/aquaculture/shellfish/index.html. The printed logbook (waterproof) has a data sheet for recording environmental observations and expenses, is available from the Alaska Sea Grant Marine Advisory Program (contact ray.ralonde@alaska.edu).

The Alaska Shellfish Growers Logbook

A daily record of activities & expenses

Alaska Sea Grant Marine Advisory Program

Farm Name ______________________________

Farm Owner ______________________________

Starting Date ______________________________

Sea Grant Alaska
Marine Advisory Program

CSREES
Education · USDA · Research · Extension

The Western Center for
Risk Management Education
Washington State University Extension

Instructions:

The intent of this journal is to provide you a single location to record environmental, operational, production, and descriptive data about your shellfish farm. The journal is printed on waterproof paper to allow recording in the field. The first page is a fill-in-the blank set of forms to record environmental measurements (water temperature ^{o}F and salinity (In parts per thousand ppt), water clarity, observable algae blooms and weather observations. While working the gear or harvesting, the causes and level of mortality (high, moderate, low) can be recorded. Farm activity in the form of hours, cost of labor, and description of equipment used and cost is entered on a table for eight identify farm activities and a blank row to enter any unidentified activity. Many farmers have a developed location identification system to pinpoint exact locations on the farm (e.g. longline 5 and lantern net 15 might have an location ID of 1/15). Location identifier codes provide a visual orientation to the farm. It is strongly recommended that you draw a layout of your farm, including location IDs, on the blank page available on the inside of the back cover of this journal. The back of each data sheet provides a table for recording any inventory information in an abbreviated inventory table. Periodically, you may wish to measure and count shellfish from a culture unit or chamber to assess the size and number of shellfish and use this information to estimate the total for a given size of production. For example, oysters are counted and measured from a single lantern net chamber at locations 5/10. 5/21, 5/30 along longline 5 that has 35 ten-chambered nets that were planted two years ago. The average size is 74 mm in length and the count averages 66 oysters per chamber. The total number of 74 mm oysters is 35 lines x 10 chambers each x 66 = 23,100. Please use the notes section to record additional information. The person recording the information must print their name and date.

Date __/__/____	***Environmental Observations***	Water Temperature	Surface ___°F	Gear Top___°F	Bottom ___°F	Ice
		Salinity ppt	Surface _	Gear Top ___	Bottom ______	Freshwater Lens Y N

Mortality				**Comments**	Turbidity	clear ___ moderate ___ heavy ___	Algal Bloom Present Y N (describe)
cause	**H**	**M**	**L**		Weather Observations (see instructions)		

Farm Activity	**Owner Hours**	**Labor Hours**	**Labor Cost**	**Materials Used (describe)**	**Cost**	**Equipment Used (describe)**	**Cost**	**Comments**
Gear Installation								
Gear Maint. (in water)								
Gear Maint. (onshore)								
Other Maintenance								
Seeding								
Grading / Cleaning								
Harvesting								
Packing / Shipping								

Location ID	**Notes**

Inventory Information

Location ID	Average Size	Sample Size	Est. Total At Location

NOTES

Recorder Name____ Date ______________________

Chapter 20. The Importance of Product Quality

Rodger Painter

As a teenager in the early sixties, I set-netted salmon on the north end of Kodiak Island. We had a good site and caught sockeye early in the year, humpies in the middle, and cohos at the end.

Tray-cultured oysters from Mike Sheets' farm near Naukati. (Deborah Mercy photo.)

During the peak of the humpy season, on a good year, we would catch up to a couple thousand fish a day. They were stored in a large open wooden skiff and covered with burlap, and we would occasionally wet the heap with buckets of seawater. During hot July days the salmon would literally bake in the sun and you could push your fingers through the flesh.

The tender would come as it was getting dark. I always tried to see how many flat, slimy humpies I could spear with my pew and throw ten feet into the air into the hold of the tender about 20 feet from my skiff. It wasn't always easy to set a new personal record as by the time the tender came as many of the pinks were so soft the flesh would tear and nearly split the fish in half. The salmon were heaped in the open hold of the tender. No chilling.

Times certainly have changed. As a longtime outspoken advocate of increasing the quality of seafood handling in Alaska, I've been delighted to see dramatic improvements over the past decade. As an oyster farmer, the importance of quality to producers has also increased, although not as dramatically as in the salmon industry.

Most Alaska oyster growers have always been concerned about product quality, as it is an obvious key to getting the price differential we need to offset high operating and shipping costs. However, the desire to produce the perfect oyster hasn't kept substandard product out of the marketplace. This is a reflection on the financial condition of most farmers.

After some interest was expressed for uniform grading standards, the Alaskan Shellfish Growers Association (ASGA) asked growers on a survey what they thought. The response was, "Yes, but not now." While all respondents believe Alaska oyster growers should adopt grading standards at some point, most felt the standards would simply be ignored until oyster businesses become solvent. As one grower put it, "If you're losing money you're going to sell every oyster you can."

While that's a reality, it is also true that Alaska oysters have a very good image in the marketplace. However, if Alaskans want to continue to sell their oyster for more than their Lower-48 counterparts, we're going to have to sell the best oysters.

You simply can't expect to command high value in the global seafood marketplace unless you deliver a consistently high quality product. Frankly, no one cares if your production and delivery costs are higher than those of the competition—the product has to speak for itself.

Alaska's cold waters and long summer days combined with suspended culture techniques provide our oysters with a taste edge over shellfish from most other regions. As growers, we need to do our best to produce deep-cupped shellfish fit for serving on the half-shell at the country's best oyster bars. If growers are going to make a profit, more of these topend venues will need to be penetrated.

The tremendous success of Copper River fishermen in building one of the strongest "brands" in the U.S. seafood business is attributable, in part, to the attention the fleet gave to product quality. When the craze reached fever pitch several years ago seafood buyers began complaining about uneven quality. The feedback from buyers went like this: "When I'm paying these prices I expect to get only top quality fish." The industry promptly responded with better handling practices.

Another reality is that there is a market for every product. Misshapen, double, oversize and undersize oysters all can find an appropriate market. Neighbors, fishermen, and other locals generally don't mind buying these oysters. It doesn't make sense to put these substandard oysters into the mainstream marketplace.

While it may be too soon adopt industry grading standards, it's not premature for each grower to take action individually. Adopt your own standards and operational procedures. The basics are simple. Here are some suggestions.

- **Grading.** Given the irregular shape of oysters, grading by shell size is a dicey standard. This is particularly true when the oysters are skinny. Weight is a more accurate standard. After handling enough oysters, it is not that difficult to grade by heft. Bob Hartley, a former Kachemak Bay grower, had a good system at his cleaning station. If he was unsure if an oyster was large enough to sell, he'd put it on a balance beam device he used to weight oysters in order to meet his minimum weight requirement.

- **Shell Shape and Meat Content.** If this manual has any mantra, it would be that good husbandry creates good oysters and increases the potential of your business to make a profit. Move those oysters around, particularly during the first year, by tumbling, shaking lantern nets, or just by dumping oysters out of the gear and sorting. Well-worked oysters have better shapes and higher meat content. Pay attention to meat fullness because no one wants to buy skinny oysters.
- **Cleanliness.** Most Alaska oysters are very clean compared to product from other regions. When I asked a group of East Coast growers why they were displaying oysters covered with mud at their Boston Seafood Show booth, they said the mud helps keep the shellfish cool and buyers were used to it. That's not a good strategy if you're trying to keep your customers happy. Wash 'em down, but don't go overboard and scrub every oyster.
- **Shipping.** Don't over pack your boxes, or you'll end up with broken oysters. Most Alaska farmers carefully pack their oysters cup-side down in an attempt to help preserve nectar. This careful packing also reduces movement of oysters during shipping and handling. Gel ice packs are a must except when it's below freezing. Stout strapping that doesn't snap is also important.

Processing and Marketing

Chapter 21. The Farmer as Processor and Marketer

Rodger Painter

What It Takes to Process and Sell Your Product

Oyster farming might be viewed as a cradle to the grave mothering experience. As the farmer, you are responsible for every phase of the journey from spat to delivery to a distant buyer. The farmer is a planter, cultivator, harvester, processor, regulatory compliance officer, marketer/seller, and accounts receivable manager.

Most farmers would prefer to shift some of these mothering responsibilities to someone else, so they can concentrate on production. An Alaskan Shellfish Growers Association survey of growers revealed that independent farmers spend about 25% of their time on processing, selling, shipping, invoicing, record-keeping, and regulatory compliance.

As this manual was being written in 2011, most active Alaska oyster farmers were processing their product in their own facilities and selling to distributors and directly to restaurants, supermarkets, lodges, and consumers. The difficulty and cost of communicating with and delivering the product to buyers varied considerably according to logistics.

Logistics

When I first began selling oysters from my remote farm on Prince of Wales Island, I had to take a one-hour skiff ride (sometimes two with a heavy load) to use a pay phone at a logging camp to talk to buyers and ask for a floatplane to stop by the farm.

If the floatplane didn't come or was hours delayed, we'd use the C.B. to call the store in Naukati to ask when we should expect the mail plane. Since the floatplane had to fly from Alaska's rainiest city (Ketchikan) about one hour and cross a small range of peaks, these were common experiences, particularly during the winter months.

When the weather was warm, missed flights meant unpacking the boxes and putting the product back into the water, and refreezing gel ice that night so you could repack the next day. The alternative was to run the cooler for 24 hours, burning many dollars of gas powering a 650 KW generator and getting up in the middle of the night to refuel. In the winter, of course, we'd have to put the product back in the water to prevent freezing.

While satellite Internet service and cell phone boosters have improved communications considerably, the passing years haven't improved the weather or ability of the floatplanes to make it on schedule, and the price of gas in Naukati has nearly tripled.

Improvements in Prince of Wales transportation infrastructure, such as daily ferry service to Ketchikan and paved roads within 15 miles of Naukati, have created new transportation options. Some growers were cutting costs by shipping out of Thorne Bay via barge to Ketchikan.

A farm located a short boat ride from a community with a jet airport doesn't have those problems, and certainly the local market is bigger in those transportation hubs.

Cost

Then there's the cost of delivering the product to a buyer. It was costing my farm nearly a dollar a dozen to get the oysters to the Ketchikan airport via bypass mail, while a farmer in Yakutat might spend a few pennies a dozen on gas to drive their boxes to the airport.

The costs don't stop there. Several experienced farmers estimate the cost of materials and equipment at about $30,000 to construct a shellstock shipping facility in a remote area capable of handling 500 dozen oysters per shipment. And the permitting agency, Alaska Department of Environmental Conservation (DEC), needs to approve such a facility.

Public health and safety guidelines for molluscan shellfish are written for the entire country and each state adopts the rules. Interpretation of the broadly written guidelines is left to the primary health and safety agency of each state, with FDA oversight. DEC prides itself in having the best seafood sanitation program in the country, and it often interprets the rules in a manner that many experienced growers and wild harvesters and processors regard as unnecessarily costly to producers.

New shellstock shipping facilities must be inspected by DEC before they are issued their permits. Although it is a good idea to show DEC your plans before construction, you might benefit from talking to experienced growers about how to keep costs down and still meet DEC/FDA regulations. Take the requirement for a hand-washing station, for example.

The FDA rule requires that shellstock shipping facilities be equipped with a hand-washing sink where a processing worker could wash his or her hands under hot running water. When it went into effect, I added a sink faucet to a used picnic beverage thermos, pulled a 15-year-old Coleman stove from my shop, found a used stainless steel sink and bought a new teakettle. The DEC inspector complained that I should have purchased a propane water heater for $1,500 to make the hot water, but he had to concede my $15 solution met the letter and spirit of the state and federal requirements.

The $30,000 figure might seem high, but you have to consider what the requirements are to put your cleaned, sorted, and counted oysters into a box and transferring them to a transporter or buyer entails. In addition to the hand-washing stations, DEC may require you to have mechanical refrigeration capable of bringing the internal core temperature of your oysters down to 45ºF by the time the product leaves the farm.

If the water temperature is 53º and the ambient air is 65º, it will take a lot of refrigeration to meet that requirement, and if you are off the grid it means a large, gas-guzzling generator.

Of course, there are operating costs including fuel and supplies, like wax-coated wetlock boxes, liners, strapping and clips, staples, labels, gel ice, PSP sample boxes, ziplock bags, cleaning and sanitizing solutions, hand soap, and paper towels.

Regulatory Compliance

As the only seafood consumed raw in the U.S. in any appreciable quantities, oysters are subject to a massive set of federal regulations. The sweeping set of federal laws are far tougher than those imposed upon other seafood producers and have resulted in heavy government control and oversight of oyster processing. Compliance with these rules is necessary to engage in interstate commerce, and DEC is the agency enforcing those standards.

How to negotiate the regulatory process is described later in this manual, but here's my grower-to-grower advice: read the National Shellfish Sanitation Program's model ordinance so you can form your own opinion on how you can comply. Certainly you don't want to establish an adversarial relationship with your inspector, but it is important that you determine whether the interpretation of the broadly written rules by the individual inspector is consistent throughout the agency.

Help also can be obtained through ASGA, the Alaska Sea Grant Marine Advisory Program, Pacific Coast Shellfish Growers Association, and the Interstate Shellfish Sanitation Conference, a private national group coordinating industry and state regulatory agency interaction during FDA's rule-making process.

While the paperwork involved in regulatory compliance is a hassle, keep in mind that your records will be closely scrutinized and DEC has the power to impound or recall your product, suspend your ability to sell, examine the records of your buyers, impose civil penalties, and recommend you be charged with criminal sanctions for infractions.

Processing and Selling Your Product Can Be Rewarding, But Carefully Weigh the Benefits and Costs

Like most Alaska oyster farmers, my first commercial sales were to friends, neighbors, and relatives. We built one of Alaska's earliest certified shellfish shipping facilities at the farm, then rented a space in Juneau and constructed a certified outlet and began selling in the northern Panhandle of Alaska.

We later sold oysters and clams in Anchorage, Ketchikan, Craig, Petersburg, Haines, Skagway, Cordova, Fairbanks, Seattle, San Francisco, and Chicago. Our customers were a mix of distributors, restaurants, and supermarkets.

We took great pride in our shellfish as some of the best on the market and were delighted when our oysters won a taste test of Alaska oysters at McCormick & Schmidt's Seattle restaurant, taking a people's choice award and scoring by an independent panel of experts. It was rewarding to know our oysters were featured at six of San Francisco's best seafood restaurants and at the country's oldest operating oyster bar in Chicago.

These sales didn't come without an enormous investment of time, energy, and money. When we couldn't get the attention of distributors in Seattle, I adopted a cooler and photo album approach to individual restaurants in Seattle, timing my visits in mid-afternoon when the chefs were likely to be available. I never failed to get the chef to taste the oysters and look through the photos and promotional narrative I had prepared.

After lining up a half dozen restaurants buying about 150 dozen per week, I called a Seattle seafood distributor and said I would rather sell the oysters to him and avoid having to figure out a delivery system. With a market in Seattle, San Francisco became our next target.

We hooked up with an underemployed teacher who happened to love oysters and eating in Frisco's fanciest restaurants. He adopted the cooler and photo album routine and soon lined up a half dozen customers, selling about 150 dozen per week. He made $1 per dozen for the sales, but his biggest rewards were the free food and drinks the grateful chefs lavished upon him. This was a great outlet for us—San Francisco happens to love small oysters, while Alaska buyers want much larger shellfish.

That market came to an end when a West Coast oyster distributor contacted me and threatened to notify local seafood health officials about my non-approved pick-up vehicle unless I abandoned the direct sales to his favorite customers. Although I agreed to the arrangement, we never sold another oyster into San Francisco.

While direct sales have been rewarding at a slightly higher price and for morale, they came at a high input of labor as opposed to selling to distributors, and cash flow nearly bankrupted the company. About two-thirds of the direct markets required front-ending freight charges, and they were slow-paying compared to distributors. Significantly, our distributors usually paid within 2-3 weeks of invoicing, and many direct marketers were slower and some never paid.

Alaska Airlines and our local air carrier demanded to be paid within 30 days of using their services and we soon found we were carrying thousands of dollars of freight charges for our buyers. Eventually we shifted to arrangement where the buyer pays for the freight systems, and we began selling to only distributors, for a lower price per dozen. This eliminated the front-end cash-flow dilemma and the no-collection customer.

The latter became a significant factor, as the failure of one or two customers to pay for a past due bill for a couple thousand dollars effectively wiped out the higher price received for direct sales. (One of the top officers with the National Restaurant Association once told me that the average life of a white tablecloth restaurant is the U.S. is one year.)

Chapter 22. Building a Shellstock Shipping Facility

Rodger Painter

The only way for a farmer to sell oysters to most buyers, even next-door neighbors, is to have a shellstock shipping facility approved by the Alaska Department of Environmental Conservation. Farmers without an approved processor can be classified as "harvesters" and obtain a permit to sell their crops to someone who does has an ADEC-approved facility.

As long as you're not shucking, the requirements for a facility are not as stringent as those implied on cold storages or canneries that process salmon or halibut, but don't expect the cost to be minimal. Growers constructing shellstock shipping facilities during the early 2000s estimated the cost of constructing and equipping a basic facility at $15,000-20,000.

One of the biggest costs will be refrigeration. Federal rules require shellstock shippers to lower the core temperature of oysters to 45ºF. It takes a fairly large refrigeration unit to do the job when the water is 55º and the ambient air 70º. If you're off the electrical grid, you can add the cost of a larger generator to produce enough power to handle the initial surge of demand when you turn on the refrigeration.

While the requirements are fairly minimal, the costs simply add up. Unless you're really on a shoestring budget and plan to upgrade later, it is not wise to cut too many corners. For example, here's what ADEC says about the floors and walls of a shellstock shipping facility:

> **Walls and Ceilings**
> Walls in the shellstock facility need to be smooth, impervious, and easily cleanable. Commonly used materials include plywood sealed with two-part epoxy paint, or plastic wallboard including glass board, or Chem Ply.
>
> **Floors**
> Floors need to be impervious, corrosion resistant, and easily cleanable. For example, you could use concrete that is sealed, plywood that is fiberglass sealed, or plywood with multiple coatings of floor paint.

Even the best paints don't hold up well in coastal Alaska weather, particularly in rainy Southeast where unheated facilities are almost perpetually damp. A floating building only makes things worse. The best approach for floors is cement or heavy-duty fiberglass. It is an equally good idea to cover the lower 2-3 feet of the walls with fiberglass or plastic wallboard.

Plan your facility to accommodate a flow of cleaned and sorted oysters coming in the door, to boxed product going into your cooler without having to lift a box. The best remote shellstock shipping facility I've visited was Canoe Lagoon's floating processor in the Blashke Islands off the east coast of Prince of Wales Island near Coffman Cove.

Trays of cleaned and counted oysters were passed through a window onto a counter that ran down two sides of the processing room. The trays were moved to a station where the oysters were packed in wetlock boxes, strapped, labeled, and moved onto a pallet. When loaded with finished boxes, the pallet was wheeled into a walk-in cooler. No boots were allowed in the spotless processor and no one had to lift a box until they were loaded into a floatplane.

You'll be very happy with an investment in a pallet jack that's capable of eliminating nearly all lifting in your facility. Here's why: a box of 25 dozen half shell oysters with gel ice will weigh about 65 pounds. If you're shipping 300 dozen oysters, you'll be lifting a dozen boxes weighing 780 pounds each time you move the shipment by hand. It doesn't take many movements of each box to be lifting tons of product during each weekly shipment.

It is possible to meet the regulatory requirements for a processing facility with a wide variety of structures. Over the years, growers have converted used shipping containers, garages, and even a woodshed into approved facilities, although attitudes within ADEC tend to shift as personnel within the agency come and go.

Check with ADEC before you start ordering materials and pounding nails, and be prepared to spend some time interacting with agency personnel in getting construction plans approved and inspections scheduled and completed. See the next chapter for ADEC's handout explaining the requirements for a shellstock shipping facility.

Alaska Department of Environmental Conservation
Division of Environmental Health, Food Safety and Sanitation Program
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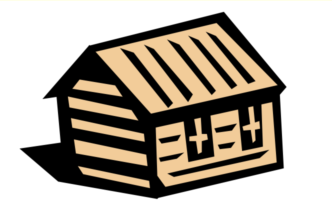

Shellstock Shipping Facility Requirements

What is a facility?

A shellstock shipping facility is where shellstock is prepared for shipping. It can be a free standing structure, or a suitable area in a permitted restaurant, grocery store, seafood processor or food processing establishment. If using one of these areas, provide a copy of the lease agreement with your permit application that clearly identifies who is responsible for sanitation of the area before and after it is used to prepare the shellstock for shipping.

Whether you use a free standing structure or an area in an already permitted facility, you will need to submit **facility plans** together with a completed current ADEC Seafood Processors Application provided by the Department.

Your facility plans will need to show the following:

Walls and Ceilings:

- Walls in the shellstock facility need to be smooth, impervious and easily cleanable. Commonly used materials include plywood sealed with two part epoxy paint, or plastic wall board including Glass board, or Chem Ply.

Floors:

- Floors need to be impervious, corrosion resistant and easily cleanable. For example, you could use concrete that is sealed, plywood that is fiber glassed, or plywood with multiple coatings of floor paint.

Lighting:

- Light bulbs must be protected or shatter proof. If you use fluorescent tubes, they should be enclosed in a protective housing or sleeve tubing with end caps. Shatter proof fluorescent bulbs are available and can be used. You can also use incandescent lighting that is either shatter proof or enclosed in a protective guard.

Water:

- Your water source must be approved by the department. An approved classified growing area is automatically approved, as is water from a DEC approved public water system

What are "shellstock"?

Shellstock are shellfish that remain in the shell. Shellfish are all edible species of oysters, clams, mussels, and scallops, either shucked or in the shell, fresh or frozen, whole or in part. Scallops are excluded when the final product is the shucked adductor muscle only.

Standards for shellstock shipper facilities are contained in 21 CFR 1240.60, and the *National Shellfish Sanitation Program Guide for the Control of Molluscan Shellfish* (NSSP) at www.issc.org .

Shellfish, Public Health & Water Quality:

Shellfish are filter feeders. They are often eaten raw or lightly cooked. Illnesses that can be caused by eating shellfish grown or harvested in contaminated areas include Paralytic Shellfish Poisoning (PSP), hepatitis, vibrio and typhoid.

CHILL your Shellstock!

If the maximum monthly air temperature is: <66°F, you have 36 hours from harvest to get your shellstock chilled. At 66°F to 80°F you have 12 hours. If it is ≥ 81°F you only have 10 hours.

Questions about Shellstock Shipping, marine reports of toxic algal blooms, paralytic shellfish poisoning (PSP) incidents or classified beaches?

Call George Scanlan, Shellfish Specialist: 907-269-7638.

Outside of Anchorage, call toll free: 1-877-233-3663.

We're on the Web!

http://www.dec.state.ak.us/eh/fss/index.htm

Ice

- Ice can either be purchased from an approved source, or you can manufacture it from an approved water supply. To protect it from contamination during storage and use, keep it covered and use a utensil to dispense it.

Hand washing:

- Hand washing facilities with soap, towels and warm water are required. At least one hand wash sink must be available in the processing area. A separate hand sanitizer is also required at the hand wash station.

Toilets:

- A toilet that is conveniently located must be provided. You may use a portable toilet, Incinolet toilet, a composite toilet or an outhouse. The toilet facility must be equipped with a hand wash sink, and supplied with soap, towels and warm water. A separate hand sanitizer is also required at the hand wash station.

Insect Control:

- Insects and other pests must be kept out of the facility. Doors should be tight fitting and self closing. Windows must be screened with 15 mesh/inch or smaller screening.

Refrigeration:

- Your refrigeration unit must maintain a temperature of 45^0F or less. You can use a commercial walk-in cooler or a self constructed unit. The walls, floor, ceiling and lighting requirements for the self constructed unit are the same as the facility requirements given above. Keep a thermometer in the unit to make sure the temperature is maintained.

Packing and Sorting:

- Tables must be impervious, corrosion resistant and easily cleanable. They can be constructed of stainless steel, aluminum or fiberglass materials.

Shipping Boxes and Liners:

- Protect boxes and liners from contamination during storage and assembly. Store them above floor level.

A sanitation plan is not required; however, proper sanitation is a must:

- Clean and sanitize each facility used for shellstock shipping daily following periods of operation.
- Routinely inspect walls, floors, ceilings and equipment, and clean them whenever necessary.
- Maintain all areas within the facility, including any equipment, in good repair so that cleaning and sanitizing is effective.
- Keep only necessary toxic substances on site, and do not store them above shellfish or food contact surfaces.
- Use all toxic substances according to the label direction.

Chapter 24. Meeting Public Health Requirements Is a Challenge for New Farmers

Rodger Painter

Compliance with government regulatory requirements is one of the bigger challenges for new farmers and an ongoing headache for more established farmers.

As a longtime direct marketer from a remote site, my recommendation is that you don't market your own oysters. Better options are to become a member of a cooperative with a processing plant, or sell to someone else with a licensed processor. If neither of these works, find some other way around having to deal with public health regulators and the other hassles of running your own processing facility.

If those are not viable options, be prepared for a long, often frustrating process of gaining full approval for your first sales as well as staying in compliance with regulatory requirements. As stressed elsewhere in this manual, reading the National Shellfish Sanitation Program (NSSP) model ordinance is important. These are the basic ground rules for each state engaged in interstate sales of molluscan shellfish in the U.S., including Alaska.

As we begin the process of scanning the regulations, your first step is to determine who you are within the NSSP model ordinance: a shellstock shipper, shucker/packer, repacker, etc. If you are selling live oysters in the shell, you are defined by NSSP as a shellstock shipper. This distinction is extremely important because once you start shucking, packing, and processing your product in its forms, your regulatory requirements skyrocket.

There are several significant regulatory hurdles new farmers must negotiate before making their first sales:

- **Harvest area water certification.** The process of certifying your growing waters as being the equivalent of drinking water pure can take up to a year. This process should be initiated as soon as possible after the lease papers for your farm site are approved.
- **Shellstock shipping facility approval.** If you intend to sell your own shellstock your facility must be inspected and approved by the Alaska Department of Environmental Conservation (ADEC).
- **HACCP training.** While not an absolute requirement, every shellstock shipping facility must have plans written and signed by a person with Hazard Analysis and Critical Control Plan (HACCP) training. The plans also need to be reviewed and updated annually by a person with training. A farmer can contract a HACCP trained person to

develop a plan and review record-keeping, or receive HACCP training and do their plan and keep their own records.

- **HACCP and SSOP plans.** Every seafood processor in the U.S. must have HACCP and Standard Sanitation Operation Plan documents.

Once these requirements are met, new farmers are faced with another major hurdle: paralytic shellfish poisoning (PSP) testing. ADEC has a uniform sampling matrix that requires those on the first level to hold oysters and clams until the results of PSP tests are available. This means holding the product under refrigeration, for as long as 2-3 days or more, when sending samples from most remote sites. This is a costly proposition when you're using generators for power and can also result in an unfortunate loss of prime shelf life for your product.

Every shellstock shipping facility must be inspected by ADEC at least once (for sales within Alaska only) or twice (interstate commerce) per year. While cleanliness of the facility continues to matter, the imposition of HACCP has made paperwork the focus of most inspections.

Keep in mind that the rules can be interpreted differently by individual inspectors and the guidance you receive might change somewhat from visit to visit by ADEC.

Growing/Harvest Area Classification

Classification is a two-step process: (1) a shoreline survey conducted by an ADEC inspector and (2) collection and laboratory analysis of marine water samples at locations designated by ADEC.

The shoreline survey is simply an examination of uplands or floating facilities to determine whether potential pollution sources can be identified. Here's how ADEC's website describes what the "sanitation survey report" covers:

1. Proposed boundaries and topography
2. Presence of anadromous streams, wild animals, or resident and migrating bird populations
3. Tides, rainfall, winds, and river discharges
4. Location of human habitation or industrial developments
5. Fisheries
6. Recreational use of the area
7. Species to be grown or harvested
8. Harvest periods and methods

The report is used to designate sampling stations where the water samples are collected. A total of 30 samples must be collected, and delivered to the ADEC Anchorage lab to be tested. They must arrive at the lab within 30 hours of collection of the first sample during each collection.

While this might not seem difficult at first blush, the tough logistics involved in beating the 30-hour limit from a remote site results in a high failure rate in many areas. It sometimes takes several tries to successfully make one sampling. Since the samples must be collected during both the wet (fall, winter) and dry (spring, summer) seasons, the process is very time consuming.

The new farmer usually has to collect most of the samples under a memorandum of understanding (MOU) with ADEC. The farmer is responsible for the logistics and cost of getting the samples to the ADEC lab within the 30-hour time limit.

The applicant must pay a $500 fee to ADEC for a new classification and $150 for each annual reclassification. In late 2011, ADEC said it intended to start charging fees for each sample analyzed beginning January 1, 2012. ADEC said the fees would start at $17 per sample and would eventually be increased to $175 per sample. At that rate, a new grower might end up paying $5,750 in fees for a new classification, in addition to the costs of transporting the samples to the lab. (At press time, it appeared the higher fees might be headed off as shellfish farmers and dive harvesters were working on securing additional state funding for the ADEC lab.)

Here's the link to ADEC's website information on classification: http://dec.alaska.gov/eh/fss/seafood/Docs/shellfishclass.pdf.

HACCP Compliance

All U.S. seafood processors must operate under HACCP and SSOP. The system was designed to shift the responsibility to the plant operator for identifying potential problems during the food handling process and figuring out how to address the threats to public health.

The plans must be drafted and signed, and updated annually, by someone who has completed a HAACP training class. HACCP training sessions are offered by the Alaska Sea Grant Marine Advisory Program (MAP). The two-day training can be cut in half by completing an online training course. HACCP training is offered at least twice each year. You can contact the MAP office at 907-274-9691 or visit their website at http://seagrant.uaf.edu/map/index.htm.

Completing the training is recommended, but if you can't schedule the travel immediately, contact another shellfish grower about helping you out. In the end, though, every operator of a shellstock shipping facility should complete the training.

Development of a HACCP plan for your facility involves a multi-step process. Here's how ADEC's website describes the process: http://dec.alaska.gov/eh/fss/seafood/Docs/shellfishhaccp4_3-30-2011.pdf.

1. **Conduct hazard analysis and identify preventive measures**. Identify biological, chemical, or physical hazards associated with the product and process. For Shellstock Shippers (SS), hazards are microorganisms and toxins such as PSP. Preventive measures include controlling the source and product temperatures.
2. **Identify critical control points (CCP).** List steps in the process. For every significant hazard identified in Step 1, identify a point, step, or procedure where you can prevent the food-safety hazard. SS will have CCPs at *Receiving,* and at *Storage.*
3. **Establish critical limits**. Each CCP must have boundaries, or critical limits, to ensure safe products. SS must meet the following critical limits established by the FDA.

   RECEIVING CCP: Shellstock must be obtained from a licensed harvester who:
   - has harvested the shellstock from an approved or conditionally approved area in open status, which is indicated on the tag, and
   - has identified the shellstock with a tag on each container or transaction record on each bulk shipment, or
   - a licensed dealer who has identified the shellstock with a tag on each container.

   STORAGE CCP: Temperature of shellstock must be controlled until sale by:
   - icing; or
   - storing in a refrigeration unit or area maintained at 45ºF or less; and
   - may not be held for more than 2 hours without temperature control at points of transfer.
4. **Monitor each CCP.** Determine what observations and measurements are needed to ensure critical limits are met. Identify who is responsible for verifying that the required tags are on containers at receiving, the temperature requirements are met during storage, and time is not exceeded during transfer.
5. **Establish corrective action to be taken when a critical limit deviation occurs.** Initiate the required corrective action when a critical limit is not met. For example, you may need to reject shellstock without the required tags, or you may need to destroy product that didn't meet time or temperature requirements during storage or transfer.
6. **Establish a record-keeping system**. Keep daily records of your CCP observations and measurements, as well as your corrective actions and process adjustments. Keep them for a year, and make them available during an inspection of your facility.
7. **Establish verification procedures.** To verify that the HACCP system is working, the permitted shellstock shipper should make on-site observations and record reviews, and periodically assess the effectiveness of the HACCP plan.

A good generic HAACP plan is at http://seafood.ucdavis.edu/haccp/plans/oysters.htm. A copy of the HACCP plan I developed for my former oyster farm is appended to this chapter.

Another requirement of HAACP is that the operator must have an SSOP. Verification of the plan is followed each time the facility is used will involve development of a weekly checklist. Here's how the DEC website describes SSOPs:

The Eight Key Sanitation Conditions and Practices

SSOP stands for **S**anitation **S**tandard **O**perating **P**rocedure. Good sanitation operating procedures are the foundation of the HACCP system. They control the in-plant environmental conditions, and provide a foundation for safe food production. While storing, handling, and transferring shellstock, you will have to monitor and keep records on your facility's sanitation conditions and practices.

1. **Safety of water**. Water that contacts food or food-contact surfaces must be from the classified area or other approved source.
2. **Condition and cleanliness of food-contact surfaces.** Clean and sanitize food-contact surfaces, equipment, utensils, and containers at start-up, following interruptions if needed, and at end of day. Maintain their smooth and easily cleanable condition.
3. **Prevention of cross-contamination.** Protect equipment, utensils, and containers from contamination during storage. Wash hands before starting work, after interruptions, after using the restroom, and anytime hands may become contaminated.
4. **Maintenance of hand-washing and toilet facilities**. Provide conveniently located hand-washing and toilet facilities. Remove and properly dispose of sewage and other liquid wastes.
5. **Protection from adulterants.** Properly store and use toxic substances, cleaning compounds, and sanitizers, use clean containers and ice from an approved source, and protect shellstock from other environmental contaminants.
6. **Labeling, storage, and use of chemical compounds.** Keep only necessary substances in the facility. Use in accordance with the label. Store pesticides, cleansers and sanitizers, and other chemicals separately.
7. **Employee health conditions**. Exclude employees with illness that might be transmissible through food from contact with shellstock or food contact surfaces.
8. **Exclusion of pests.** Exclude pests that might be a source of shellstock contamination, including insects, rodents, birds, and personal pets.

Testing for Paralytic Shellfish Poisoning (PSP)

Alaska is well known among researchers as the PSP capital of the world. PSP is one of the most deadly natural toxins and there have been many PSP illnesses and deaths in Alaska's history.

PSP is so toxic that the military extracted the poison from clams harvested in southeast Alaska during World War II as it built the capacity to wage chemical warfare. While the toxin was never used during the war, the CIA was discovered to illegally possess the toxin samples during a U.S. Senate investigation led by Idaho Senator Frank Church.

Alaska growers are responsible for collecting and shipping oyster samples for the Alaska Department of Environmental Conservation (ADEC) lab in Anchorage to analyze for PSP. While it's not difficult to shuck a cup of oyster meats, freeze the sample, and mail it off to Anchorage, the logistics of getting the sample to Anchorage can be challenging for a remote farm, particularly during winter months

Sampling rules are laid out in a "uniform shellfish sampling plan." Under the rules, farmers must hold their product at 45ºF until the tests are complete and the product is released for sale by ADEC. The prime shelf life of half shell oysters is about a week and a remotely located farm might lose 2-3 days before the oysters can be shipped.

After five years of passing each PSP test a farm can progress to "level four" of the sampling plan and begin shipping the samples and product at the same time. Growers at level four also are allowed to sell for a week after the sample is pulled without having to send in additional samples to the lab.

The wait can be particularly frustrating during periods of bad weather. If the mail plane overheads, another day of shelf life is lost. If the product is returned to the water, another sample must be collected and processed for shipping to the lab. If the weather closes in while the grower is waiting for the sample, he might have to start all over again, even if the original sample passed the PSP test.

Climbing the sampling ladder to level four as quickly as possible should be the goal of all new farmers.

PSP is caused by a bloom of the microscopic dinoflagellate *Alexandrium* in marine waters. Some growers sample with plankton nets to monitor levels at their farm site. The owner/operators of one southeast Alaska farm that had chronic PSP problems became proficient enough with the sampling procedures that they began suspending harvests in advance of a test failure and advanced to level four of the sampling plan.

The ADEC sampling plan is at http://www.dec.alaska.gov/eh/fss/seafood/Docs/PSP_Uniform_Shellfish_Sampling_Plan_updated_9-2011.pdf

Vibrio **Control Plan**

Outbreaks of *Vibrio parahaemolyticus (Vp*), a bacterium, swept through shellfish farms throughout the northwest coast of North America during the late 1900s and early 2000s. Literally hundreds of illnesses caused by *Vp* from eating raw oysters were diagnosed in Washington, British Columbia, Oregon, and, yes, Alaska.

While not as deadly as PSP or its warm-water cousin *Vibrio vulnificus, Vp* had taken center stage in federal shellfish rule-making in the early 2000s. A 2007 change in federal rules required ADEC to draft and adopt a *Vp* control plan.

Two farms located in Prince William Sound were implicated in the Alaska outbreak, but the bacteria were also found in samples of at least two southeast Alaska farms.

Following the Alaska *Vp* outbreak in 2004, the Alaska Sea Grant Marine Advisory Program, in cooperation with ADEC and the Food and Drug Administration Gulf of Mexico Shellfish Laboratory, conducted testing and experimentation in Prince William Sound to understand the *Vp* problem and find means of prevention. A fundamental outcome of the study was that sinking oysters to deeper, cooler water during warm-water periods prevented the occurrence of *Vp*.

Following the study, the Alaskan Shellfish Growers Association (ASGA) worked closely with ADEC to draft a plan to avoid the bacterial blooms by sinking culture gear below the thermocline to cooler water. The plan was accepted by FDA and was regarded as very effective in controlling further outbreaks.

The *Vp* control plan requires oyster growers to sample water temperatures if ADEC determines it is located in an area vulnerable to *Vp*. Here's what ADEC's website says about the temperature sampling:

> "Each farm site or growing area that has been identified as likely to develop Vp shall follow the water temperature monitoring plan below.
>
> Beginning June 15th through September 15th, water temperatures must be taken weekly, at the top of the suspended aquaculture gear. A permanent record must be maintained by the grower at the farm. A copy of the permanent record of weekly temperatures must be submitted to the ADEC Anchorage Office by October 1st.
>
> When water temperatures at the top of suspended gear reaches or exceeds 60°F (15.6°C), temperatures must be taken daily and ADEC must be notified. Water temperatures must be taken at or about 5 PM, when water temperatures are typically the warmest.
>
> Temperature measurements must be conducted at the specific location and depth of the gear intended to be harvested for distribution as specified below. Additional non-regulatory sampling collected at different locations and depths for research purposes will not affect the area status, as long as there is no direct correlation to the product being harvested."

ADEC will notify growers when recording of water temperatures will be required. The agency will subsequently require those farmers to submit those records.

Growers who experience a *Vp* outbreak (where someone gets sick) will have to follow a much more detailed sampling plan and procedures. The plan can be viewed at: http://dec.alaska.gov/eh/fss/seafood/Docs/Vp_General_Control_Plan_Jan_1_2011.pdf

HACCP Plan for Shellstock Processing

1. Processing Description

Aquatic product raw material:	Pacific Oysters (*Crassostrea gigas*) Littleneck Clams (*Prototheca staminea*)
Raw material harvest areas:	Oysters – Kosciusko Bay, Area #2 Littlenecks – Kosciusko Bay, Area #2, El Capitan Passage, Spanberg Island, North Island, Jihni Bay
Raw materials received:	From leased beaches to work float or hardening beach in Kosciusko Bay.
Finished product:	Live shellstock.
Aquaculture drugs, food Additives, ingredients, Processing aids.	None.
Packaging:	The shellstock is packed in wax-impregnated, lined, strapped boxes. Gel ice is added May-October, or whenever ambient temperatures exceed 50ºF.
Shipping:	Packaged product is shipped in common carrier planes and trucks.
Intended use:	For raw or cooked consumption.
Intended customers:	General public.

2. Flow Diagram and Narrative for Shellstock Processing

Receiving	Oysters are harvested from nets or trays and hung from the work floats or moved to the hardening beach. Littleneck clams are received from harvesters and hung from the processing floats or moved to the hardening beach.
Raw Material Storage	Oysters and littleneck clams are stored in bags hanging from the work floats or on the hardening beach until ready for final processing and shipping.
Washing, Culling, and Grading	Clams and oysters are washed with water pumped to the work floats from approved marine waters. Dead and broken shellfish and fouling organisms are removed by hand or with the aid of shucking knives or other similar tools. Following this cleaning, the shellstock are graded, counted or weighed, and placed into bags for storage, handing off the work floats, or on the hardening beach until final processing.
Final Processing	Bags of clams and oysters are thoroughly flushed with approved marine water. All broken or dead shellfish are removed by hand; these culls are replaced to restore weight or count.
Packaging and Labeling	Oysters and clams are packaged in lined and properly labeled wax-impregnated boxes. Tags are placed inside the boxes. Gel ice is added whenever the ambient air temperature exceeds 45ºF. The boxes are then strapped.
Finished Product Storage	The boxed product is stored in the processing facility or cooler until shipped. The following seasonal guidelines must be followed: Nov.-Feb.: (1) ambient air temperatures are consistently 45ºF or less; (2) Temperatures must be taken each processing day; (3) all product must be stored in the processor or cooler; (4) all product shall be 45ºF or less. Mar.-Oct.: (1) Water temperature shall be checked prior to packing operations. If both water and ambient air temperatures are 45ºF or less, the shellfish may be packed and shipped. When water temperatures exceed 45ºF, the product temperature must be lowered to 45ºF or less prior to shipment. Cooling may be accomplished with the use of mechanical refrigeration or gel ice. The farm site manager shall complete the temperature log each time temperatures are checked.
Shipping	Packaged shellstock is shipped via common carrier to market, with storage in refrigerated storage when not in flight.

3. Potential Hazards

Chemical contamination
Biotoxins
Food and color additives
Aquaculture drugs
Pathogens
Temperature abuse during final product storage
Temperature abuse during shipping

Assessment of the Oyster Market Distribution Chain and its Implications for Cooperative Formation in the Alaska Mariculture Industry: Research Summary to the Alaskan Shellfish Growers Association

By: Erin Harrington and Quentin S.W. Fong[a]

This research examined the importance of different attributes of Alaska oyster product in the marketplace. Seafood businesses handling oyster products were surveyed to determine the relative importance of attributes such as oyster size, seasonality, and vendor integrity. The research also analyzed whether any of the survey findings had important implications for the future development of cooperatives by oyster producers.

Introduction

The oyster culture industry in Alaska is on the verge of a significant expansion. Shellfish producers have cultured Pacific oysters (*Crassostreas gigas*) in Alaska for a century. In 2002, the state of Alaska began work on a program to expedite the development of the shellfish mariculture industry for clams, mussels, scallops, and oysters. In 2004 the state of Alaska pre-approved 158 lease sites for mariculture, of which 98 were suspended culture sites suitable for oyster production. As of June 2004, 36 of these sites have been leased for mariculture production, including 16 suspended culture sites. Prior to the lease, only 58 sites total in Alaska were permitted for oyster production and only 29 reported any production in 2003 (Timothy and Petree, 2004).

Market-sized oysters from the new growing operations will be available in 2007, at the earliest. But oyster production from Alaska stands to increase markedly when the product comes online. To present, the primary market for Alaskan cultured oysters has been within the state. However, producers and industry groups report that the Alaskan market is increasingly saturated. With the introduction of product from new aquatic farm sites, selling oysters outside Alaska will be increasingly important.

Marketers have long understood the perceived value or quality of a given product to be a composite of preferences for many attributes. Successful product marketing and sales depend not only on a core product, but on a firm's ability to provide a suite of desirable services and benefits to support the product offering. The most exquisite tasting oyster may nevertheless be undesirable in the marketplace if procurement and shipping processes are unwieldy, or if the grower is unable to offer sufficient product volumes, or is unable to assure a regular delivery pattern.

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As oyster producers move into the next phase of their industry's development they may seek organizational tools to help with their marketing and sales efforts. One such tool commonly used in food production industries, including agriculture, wild capture fisheries and mariculture, is the cooperative business form (Pollnac and Poggie, 1991). This research examined the implications of the survey findings for the potential development of cooperatives by oyster producers.

Methodology

The research processes included a preliminary assessment of the Alaska oyster industry, which involved an executive interview process with university researchers, oyster industry participants, and government regulators, to understand the current status of the Alaska oyster industry and to understand potential future changes.

To assess the importance of a variety of oyster product attributes, a survey was distributed to 987 seafood businesses in North America that handle oyster products. Surveys were returned by 87 businesses, and these results were analyzed to identify product preferences and purchasing trends.

In addition, existing literature on agricultural, maricultural and fishermen's cooperatives was examined. This research informed an analysis of the potential implications of the market research on cooperative development in the Alaska oyster industry.

Survey Findings

Eighty-seven surveys were returned from respondents in the United States. No surveys were returned from Canada. This was a total response rate of 9 percent. This is within the normal range for a mailed survey. Results were cross-tabulated by geographic region, business size (by revenue) and length of time businesses were in operation.

No significant differences were found by business size or length of time in business. Some differences were identified by geographic region. These differences will be discussed below. In general, however, results were consistent across the respondent group.

Respondents were asked to rate specific attributes of oyster product that contribute to oyster quality. Preferences for various intrinsic and extrinsic attributes, such as geographic origin or shelf life were also rated. Other survey questions were specifically designed to address the idea of a "total product," consisting not only of the physical product itself, but also in value added by the oyster business, such as supply consistency or uniformity of grading.

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The survey findings showed that a buyer's confidence in the oyster vendor is the most important of eight key attributes in their overall assessment of oyster product. (The seven other attributes, in order of decreasing importance, were shelf-life, supply consistency, price, product form, oyster size, region of origin, and method of production).

In addition, executive interviews indicated that oyster "quality" was important to a buyer's decision to purchase oysters. Survey respondents rated the importance of thirteen attributes to the total perception of quality. On a 1 to 10 scale, where 10 was most important, buyers rated the attributes as follows:

- water quality and shelf life (9.3 each)
- government safety certifications (9.0)
- absence of grit in the product (8.9)
- supply consistency and price (8.8 each)
- "fill" (quantity of meat) in the shell (8.6)
- consistent product grading (8.4)
- low levels of "shrinkage," or product discards (8.4)
- oyster size (8.3)
- geographic origin, shape, and cup depth of the oysters (7.1 each)

Buyer confidence in the vendor was also identified as the most important attribute when it comes time to actual make a purchasing decision. The ten possible attributes were rates as follows:

- Confidence in vendor (9.3)
- Taste (9.2)
- Water quality and price (8.9 each)
- Year-round availability (8.2)
- Size (7.9)
- Geographic origin of the oyster (7.8)
- Uniqueness of the product (7.3)
- Minimum order size (7.0)
- Packaging (6.8)

Implications for the Formation of Cooperatives

The general model for Alaskan oyster mariculture businesses is that of the owner/operator, where an individual or family handles all aspects of the oyster business, from cultivation and harvest of the oyster to bookkeeping and business development, to marketing and sales. In some cases producers have formed extended business relationships to share responsibility for some of the business activities or to provide contract services or networks. In a limited number of cases, harvesters have developed cooperatives to handle some of the marketing and sales functions for their businesses. This research market examined market preference

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for oyster product attributes, and considered the potential benefits of cooperative development based on the preference data.

Survey respondents showed clear preferences for a variety of key oyster product attributes. For example, results show that respondents place highest importance on their relationships with and confidence in the oyster vendor; and that taste, water quality at the point of production, and price also contribute to their overall assessment of product. Respondents are more likely to consider purchasing Alaskan oyster product when they experience supply problems at some point in the course of a year. As expected, respondents prefer lower prices in general, though respondents with supply problems are more likely to consider Alaskan product with its relatively high prices than other respondents. Finally, Alaskan oysters have perceived strengths in the areas of water quality at the point of production and overall product quality. These are among key aspects that might be emphasized in the industry's promotional activities.

A business's ability to synchronize its product offerings with the market preferences may have implications in a consideration of forming cooperative partnerships. In particular, a business's ability to establish a good name and reputation, fill supply gaps and provide a consistent supply schedule may play into decision-making processes about cooperative formation.

Establishing a Good Name

The research revealed that buyers' confidence in the vendor was extremely important to their buying decisions, ranking higher than other attributes such as taste, price and year-round availability. Based on this data, producers may evaluate how well they are able to provide customers with services and qualities that will cultivate the development of trusting business relationships. These qualities may include reliable delivery schedules, reliable product classes and consistent production schedules. They may also include less tangible qualities such as having sales personnel regularly accessible to customers, having good charisma or interpersonal skills, or having the ability to impart product information to customers in a way that satisfies their needs. Producers' analyses of possible partnership or cooperative formation would likely benefit from an examination of the most effective manner in which to develop and maintain a strong reputation and positive image.

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Filling in the Supply Gaps

Based on survey responses, respondents were separated into two categories: those who would consider purchasing Alaskan oysters, and those who would not. When analyzed more closely, the group of potential buyers revealed several interesting characteristics. The group of potential buyers was more likely to experience problems sourcing oysters, particularly during summer months, when red tide can impact oyster beds in the continental United States. Alaska's production of oysters is generally uninterrupted during these months, though in some regions oysters may experience pre-spawn physiological changes. These results would suggest that filling in the supply gaps may provide opportunities for Alaskan oyster producers. The ability to provide consistent supply to buyers may be enhanced by the formation of cooperatives or partnerships. Providing customers with a consistent supply of product, year-round or seasonal, may lead to a stable relationship with the buyer, possibly characterized by longstanding sales relationships.

Product Delivery Schedule

Survey respondents indicated a strong preference for product delivered twice weekly. As was indicated by one distributor, a regular delivery schedule aids in the maximization of shelf life, as shelf life is not squandered holding product at the business before sale. More than 50 percent of the respondents preferred delivery twice weekly, and an additional 24 percent of the respondents preferred product on a weekly basis. Alaskan oyster producers may consider partnerships or cooperatives in order to meet a regular delivery schedule and to pair it with the ability to provide product with a long shelf life.

Price

Alaskan product is currently extremely expensive relative to oysters produced elsewhere in the United States and Canada. Shipping costs, production technique and rural production combine to produce a very high bottom line for oyster producers. Survey respondents report that price is an important factor in their general evaluation of oyster product and their decision to actually purchase oysters. The oyster industry in Alaska consists of dozens of small owner-operators, and the ability of producers to achieve economies of scale is limited by the size of their operations.

Combining business functions through the development of cooperatives may allow relatively small production operations to achieve economies of scale. A cooperative can address a number of different business functions, including production, marketing or purchasing.

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Economies of scale may not be possible for all functions of every oyster operation, but producers may benefit in some areas of their business through cooperative development.

Works Cited

Timothy, J. and Petree, D. (2004). "2003 Annual Mariculture Report." Alaska Department of Fish and Game, Juneau, Alaska.

Pollnac, R. B. and J. J. Poggie. (1991). "Psychocultural Adaptation and Development Policy for Small-scale Fishermen's Cooperatives in Equador." Human Organization, Volume 50, No. 1, 43-49.

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Safe and Wholesome Oysters

I. SPECIES SPECIFIC SAMPLING PLAN FOR INDIVIDUAL GROWING AREAS.

LEVEL ONE (Years One and Two):

Summer

Sampling Period: May 1 through October 31.

- Sampling Frequency: **Each lot per species harvested.**
- Number of Samples: One (1) per species.

- Harvesting & Holding Conditions: In accordance with the National Shellfish Sanitation Program (NSSP) the entire lot must be harvested, held out of water under refrigeration, protected from contamination at the facility, and not placed into commerce until satisfactory PSP test results are received from the department. The lot must not be put back into the water pending distribution.
- Test Results and Distribution: Shellfish lots with <80 micrograms of toxin per 100 grams of tissue will be released for commerce. Lots with 80 micrograms of toxin per 100 grams of tissue or greater are rejected for commerce. The lot may be returned to the approved growing area. If returned, the lot identity must be maintained for subsequent testing prior to marketing.

Winter

Sampling Period: November 1 through April 30.

- Sampling Frequency: **Once per month per each species harvested.**
- Number of Samples: One (1) per species.

- Harvesting & Holding Conditions: In accordance with the NSSP the entire lot must be harvested, held out of water under refrigeration, protected from contamination at the facility, and not placed into commerce until satisfactory PSP test results are received from the department. The lot must not be put back into the water pending distribution.
- Test Results and Distribution: Shellfish lots with <80 micrograms of toxin per 100 grams of tissue will be released for commerce. Lots with 80 micrograms of toxin per 100 grams of tissue or greater are rejected for commerce. The lot may be returned to the approved growing area. If returned, the lot identity must be maintained for subsequent testing prior to marketing.

- Switching Procedures: See criteria for progressing to next level on page 6.

To advance to the next level at least one sample per month must be submitted during anticipated harvest period.

LEVEL TWO (Years Three):

Summer

Sampling Period: May 1 through October 31.

- Sampling Frequency: **Once per week per species harvested.**
- Number of Samples: One (1) per species.
- Harvesting & Holding Conditions: In accordance with the NSSP the entire lot must be harvested, held out of water under refrigeration, protected from contamination at the facility, and not placed into commerce until satisfactory PSP test results are received from the department. The lot must not be put back into the water pending distribution.
- Test Results and Distribution: Shellfish lots with <80 micrograms of toxin per 100 grams of tissue will be released for commerce. Lots with 80 micrograms of toxin per 100 grams of tissue or greater are rejected for commerce. The lot may be returned to the approved growing area. If returned, the lot identity must be maintained for subsequent testing prior to marketing.

Winter

Sampling Period: November 1 through April 30.

- Sampling Frequency: **Once per month per species harvested.**
- Number of Samples: One (1) per species. .
- Harvesting & Holding Conditions: In accordance with the NSSP the entire lot must be harvested, held out of water under refrigeration, protected from contamination at the facility, and not placed into commerce until satisfactory PSP test results are received from the department. The lot must not be put back into the water pending distribution.
- Test Results and Distribution: Shellfish lots with <80 micrograms of toxin per 100 grams of tissue will be released for commerce. Lots with 80 micrograms of toxin per 100 grams of tissue or greater are rejected for commerce. The lot may be returned to the approved growing area. If returned, the lot identity must be maintained for subsequent testing prior to marketing.

- Switching Procedures: See criteria for progressing to next level on page 6.

To advance to the next level at least one sample per month must be submitted during anticipated harvest period.

LEVEL THREE (Years Four and After):

Summer

Sampling Period: May 1 through October 31.

- Sampling Frequency: **Once per week per species harvested.**
- Number of Samples: One (1) per species.

- Harvesting & Holding Conditions: In accordance with the NSSP the entire lot must be harvested, held out of water under refrigeration, and protected from contamination at the facility. The lot may be placed into commerce before the PSP results are received from the department.
- Test Results and Distribution: Shellfish lots with 80 micrograms of toxin per 100 grams of tissue or greater are rejected and all product must be recalled from commerce. All products from that lot must be destroyed or returned to the approved growing area. If returned, the lot identity must be maintained for subsequent testing prior to marketing.
- Rejected lot Procedures: See page 6.

Winter

Sampling Period: November 1 through April 30.

- Sampling Frequency: **Once per month per species harvested.**
- Number of Samples: One (1) per species. .

- Harvesting & Holding Conditions: In accordance with the NSSP the entire lot must be harvested, held out of water under refrigeration, protected from contamination at the facility. The lot may be placed into commerce before the PSP results are received from the department. Once the minimum sample frequency has been met in a given month with satisfactory results, no additional sampling is required for that month.
- Test Results and Distribution: Shellfish lots with 80 micrograms of toxin per 100 grams of tissue or greater are rejected and all product must be recalled from commerce. All products from that lot must be destroyed or returned to the approved growing area. If returned, the lot identity must be maintained for subsequent testing prior to marketing.

- Switching Procedures: See criteria for progressing to next level on page 6.

To advance to the next level at least one sample per month must be submitted during anticipated harvest period.

II. NON-SPECIES SPECIFIC SAMPLING PLAN FOR INDIVIDUAL GROWING AREAS OR ENTIRE CLASSIFIED AREAS. At the time of initial evaluation, the individual growing area or all growing areas within the classified area must have a three year history of acceptable sample results per species.

LEVEL FOUR:

Summer

Sampling Period: May 1 through October 31.

- Sampling Frequency: **Once per week.**
- Number of Samples: One (1), alternate species of oysters or mussels from alternating growing areas within the classified area. Clams may be submitted if that is the only species being harvested that week.

- Harvesting & Holding Conditions: In accordance with the NSSP the entire lot must be harvested, held out of water under refrigeration, and protected from contamination at the facility. The lot may be placed into commerce before the PSP results are received from the department.
- Test Results and Distribution: Shellfish lots with 80 micrograms of toxin per 100 grams of tissue or greater are rejected and all product must be recalled from commerce. All product from that lot must be destroyed or returned to the approved growing area. If returned, the lot identity must be maintained for subsequent testing prior to marketing.
- Rejected Lot Procedures: See page 6.

Winter

Sampling Period: November 1 through April 30.

- Sampling Frequency: **Once per month.**
- Number of Samples: One (1), alternate species of oysters or mussels from alternating growing areas within the classified area. Clams may be submitted if that is the only species being harvested that week.

- Harvesting & Holding Conditions: In accordance with the NSSP the entire lot must be harvested, held out of water under refrigeration, and protected from contamination at the facility. The lot may be placed into commerce before the PSP results are received from the department. Once the minimum sample frequency has been met in a given month with satisfactory results, no additional sampling is required for that month.
- Test Results and Distribution: Shellfish lots with 80 micrograms of toxin per 100 grams of tissue or greater are rejected and all product must be recalled from commerce. All products from that lot must be destroyed or returned to the approved growing area. If returned, the lot identity must be maintained for subsequent testing prior to marketing.
- Rejected Lot Procedures: See page 6.

III. RECALLED OR REJECTED LOT PROCEDURES

In the event of a recall, the area will be closed for all species. The area must have three (3) acceptable samples from the same site, per species, over a 14 day period, to reopen. The area may reopen by individual species. All samples must test at <80 micrograms of toxin per 100 grams of tissue before area is re-opened. **Lot sampling may be used during a closure, however, this must be coordinated with the Anchorage office and the lab prior to harvest.**

IV. SWITCHING PROCEDURES

Levels One, Two and Three of the sampling plan are species specific. There is no requirement that all species achieve the next sampling level in unison. The following criteria must be met to move to the corresponding levels below:

To move from Level One to Level Two: (Species Specific)

1. All samples must have been submitted as required for the anticipated harvest months and species, over a twenty-four month period.
2. If any sample submitted during the anticipated harvest months was not acceptable, sampling starts over for that year, for that species.

To move from Level Two to Level Three: (Species Specific - Individual Growing Area)

1. All samples must have been submitted as required for the anticipated harvest months for that species.
2. At the time of initial evaluation, a growing area must have a consecutive three year history of acceptable sample results for that species.
3. Individual growing areas will be approved for harvest of individual species only during the months samples were submitted and released for sale, during the preceding twelve month period.

If samples are not submitted as required for a period of one or more years, the area will revert back one level, on a year for year basis.

To move from Level Two or Three to Level Four: (Non-Species Specific – Individual Growing Area or Entire Classified Area)

Individual Growing Area

- At the time of initial evaluation, the area must have a consecutive three year history of acceptable sample results for the anticipated harvest months, for all species to be harvested.

Entire Classified Area

- At the time of initial evaluation, each individual growing area in the entire classified area must have a consecutive three year history of acceptable sample results for the anticipated harvest months for all species to be harvested.
- Samples must be submitted for all anticipated harvest months for each species to be harvested each year, to remain at this level.

If samples are not submitted as required for a period of one or more years, the area will revert back one level, on a year for year basis.

V. SAMPLE SUBSTITUTION

The use of non-target shellfish species for PSP monitoring may be an alternative for new aquaculture farms that may not have harvestable product for three years. This could allow the operator to be at a higher level of the plan when ready to harvest to substitute for oysters; both mussels and butter clams will be required as monitoring species. Each species must be submitted at the appropriate frequency to be considered equivalent. PSP results must be < 80 micrograms of toxin per 100 grams of tissue for both species, in order for the sample to be considered acceptable.

Requests to use substitute species must be made:

George Scanlan
Shellfish Coordinator
ADEC/EH/FSS
555 Cordova Street
Anchorage, AK. 55501.

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STATE OF ALASKA
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
Vibrio parahaemolyticus GENERAL Control Plan

The Alaska Department of Environmental Conservation's (ADEC) *Vibrio parahaemolyticus (Vp*) General Control Plan is required to reduce the probability of occurrence of *Vp* illnesses during periods that have been historically associated with annual illnesses. The requirements of this plan are in addition to Chapter VIII of the 2007 National Shellfish Sanitation Program Model Ordinance (NSSP), Requirements for Harvesters, .03 Shellfish Temperature Control, and consists of the following:

1. Identify growing areas in the state that are likely to be affected by *Vp* based on hydrographic and geological parameters, and other considerations relevant to control a naturally occurring pathogen by:
   a. considering the number of Vibrio parahaemolyticus cases epidemiologically linked to the consumption of oysters commercially harvested from the State
   b. considering levels of total and tdh+ Vibrio parahaemolyticus in the area, to the extent that such data exist
   c. considering air temperatures in the area
   d. considering salinity in the area
   e. considering harvesting techniques in the area
   f. considering quantity of harvest from the area and its uses i.e. shucking, halfshell and Post Harvest Processing (PHP)

2. Establish time to temperature controls based on the growing area and month of the year by limiting time from harvest to refrigeration to no more than five hours;

3. Establishing a water temperature monitoring plan;

4. Closing affected oyster growing area to harvest;

5. Providing for oyster recall if an oyster growing area is closed as a result of illness;

6. Post harvest processing using a process that has been validated to ensure levels of total Vp after processing do not exceed the average levels found in a growing area at times of the year when the State has determined that Vp illness is reasonably likely to occur.

A. GROWING AREA IDENTIFICATION

Each growing area or farm site in the state shall be evaluated annually for the likelihood of being affected by *Vp*. Hydrological, geographical and water temperature factors are evaluated and the results documented. Any newly classified growing area or farmsite shall also be evaluated for risks associated with *Vp* annually.

B. WATER TEMPERATURE MONITORING

Each farmsite or growing area that has been identified as likely to develop *Vp* shall follow the water temperature monitoring plan below.

Beginning June 15th through September 15th, water temperatures must be taken **weekly**, at the top of the suspended aquaculture gear. A permanent record must be maintained by the grower at the farm. A copy of the permanent record of weekly temperatures must be submitted to ADEC Anchorage Office by October 1st.
When water temperatures at the top of suspended gear reaches or exceeds 60°F (15.6°C), temperatures must be taken daily and the department must be notified. Water temperatures must be taken at or about 5 PM, when water temperatures are typically the warmest.

Temperature measurements must be conducted at the specific location and depth of the gear intended to be harvested for distribution as specified below. Additional non-regulatory sampling collected at different locations and depths for research purposes will not affect the area status, as long as there is no direct correlation to the product being harvested.

1. Oyster Monitoring

When the water temperature remains at 58°F (14.4°C) for one week, or the water temperature reaches 60°F (15.6°C), whichever comes first, oysters must be sampled. Oysters must be sampled **monthly** under the plan. These are minimum frequencies, which may be increased based on sample results.

Collect one sample of shellstock oysters consisting of at least 12 oysters, and submit to the Environmental Health Laboratory (EHL) monthly for analysis, at the department's expense.

2. Growing Water Sampling

In addition to the monthly oyster sample, when water temperature remains at 58^0 F (14.4^0 C) for one week, or the water temperature reaches 60^0F(15.6^0 F), whichever comes first, a water sample must also be collected at that time, and at least once monthly during elevated water temperatures periods, and shipped to EHL for analysis at the department's expense.

3. Dropping Gear

Growers that have the ability to drop gear below the thermocline and choose to, must do so at least 10 days before it is harvested for sale between July 1st and September 15th. The line each unit of gear (stacks of trays or lantern nets) is suspended from must be clearly marked so it can be read at the surface, with the date it was placed below the thermocline. The harvest date with the corresponding date it was placed below the thermocline must be recorded in the harvest records. Water temperature monitoring must be done at the top of the suspended aquaculture gear. **If a grower has dropped gear below the thermocline, they may not sell product from a shallower depth without prior approval from ADEC. If the area is closed, no harvest may occur from product at any depth.**

C. TIME/TEMPERATURE CONTROL

1. Harvesting to Time-Temperature Control

Between June 15th and September 15th, all oysters harvested shall be placed under temperature control within five (5) hours of harvest. Temperature control is defined as the management of the environmental temperature of shellstock by means of ice, mechanical refrigeration or other approved means which is capable of lowering the temperature of the shellstock and will maintain it at 50°F (10°C) or less.

D. ILLNESS OUTBREAK

An area implicated in a *Vp* illness outbreak will be closed. The closed status shall remain in effect until two consecutive representative samples of oyster meats, collected a minimum of four days apart, show no pathogenic (tdh+) *Vp* CFU in replicate 0.1 gram portions of oyster meat and less than 5,000 total (tlh+) *Vp* CFU per gram.

If additional confirmed *Vp* illnesses occur within 2 weeks of re-opening, these illnesses will be considered a continuation of the illness outbreak. The growing area will be placed in the closed status, and reopening may only occur when environmental conditions shift to those unfavorable to the growth of *Vp*, or ADEC, develops and implements a sampling plan.
Growers will be notified of area closures by telephone or fax, and in writing by U.S. Mail.

E. SAMPLING AND MONITORING SUMMARY

- **Monitoring results of water temperatures shall be recorded and made available to ADEC upon request.** Date, time, specific location within the area and temperature readings at the top of aquaculture gear must be included.

- **Notify ADEC Shellfish Program when temperature monitoring shifts from weekly to daily. Notification shall be by phone, voice mail or email.**

- **Cost associated with lab analysis is the department's responsibility. Collection, packaging and shipping of samples are the responsibility of the grower.** All samples will be sent to the EH Lab. Contact personnel at the lab are Mathew Forester and Kimberly Osburn at 375-8204 or 375-8220.

- Samples shall be **shellstock**, double bagged, in a container with coolant (gel packs) that do not directly contact oysters. A sample submission sheet must be included with all samples with the date of harvest, farm name, harvest location and water temperatures. Indicate on the form the sample is for *Vp* testing. No shucked product or frozen shellstock will be analyzed for *Vp*.

- Samples must be randomly selected from the top of the suspended aquaculture gear from product that may be harvested for sale.

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- Sample results will be sent by phone/fax from ADEC Shellfish Program followed by hard copy in the mail.

- Once an area has been closed due to *Vp*, no product may be relayed to another area.

- ADEC Shellfish Program may request additional samples for *Vp* monitoring.

F. HARVEST PREVENTION

Harvest of affected oysters will be prevented through growing area closures, patrol visits, and monitoring of dealer sales.

G. RECALL PROGRAM

ADEC's *Vp* sampling program does not require product to be held pending results. Therefore, a recall plan is required for product sold during this time period, in the event a recall must be initiated.

A recall program must include:

Notification to all first line accounts (distributors, retailers and individuals) and maintain a record of the following information:

- the name and contact information;
- a description of the product;
- any identifying codes;
- the reason for the recall; and
- what should be done with the product.

Information to be provided by first line accounts:

- sub-distribution lists;
- proof of notification.

Press release to media in affected areas if product is in commerce.

Records with the following information:

- the date product recalled;
- the amount distributed and to whom;
- the amount recovered or disposed of;
- method of disposal or destruction; and
- means of verification.

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Paralytic Shellfish Poisoning: The Alaska Problem

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In this issue:

Imagine yourself, a few friends, and family at the beach. The weather is amazingly cooperative this time of year for Southeast Alaska, and you feel blessed to enjoy the sunshine. Even though the wind cools the temperature, the beauty of the Alaska landscape is cause enough for celebration. What a day this is! The ocean and the scenery are magnificent.

A seafood feast planned for mid-afternoon has members of your party busy harvesting shellfish from the rocky beach. In less time than expected, buckets of harvested shellfish arrive at the feet of the chef. A steamer pot of boiling salt water quickly cooks the bounty, and a few minutes later the harvest is devoured with gusto. What qualities could better represent a day in the Great Land?

Reluctant to disrupt the excitement of the outing, George tells you that he feels a strange tingling on his lips and face. Your spouse is also experiencing the same strange numbness on her face. You, too busy to eat much, don't understand as each guest complains of this strange ailment. Your spouse stumbles as she carries more food to the table. George becomes dizzy and nauseous. While helping him to a beach chair, you notice the volleyball team is leaving the playing area as each person becomes listless. The game is over, and unfortunately, so is the party.

What is happening to these people? Could seafood fresh from the ocean cause such a serious condition?

The problem is paralytic shellfish poisoning (PSP), and there is little you can do at this point except to get these victims to a medical facility and fast. A potentially lethal event, PSP is a crisis no one wants to experience. As many coastal residents know, eating personally harvested shellfish is risky. As Alaskans you need to know about PSP, what health dangers it presents, and how you can reduce your risk of contracting this dreaded ailment.

The Toxins

In Alaska microscopic single-celled dinoflagellate algae of the genus *Alexandrium* produce PSP toxins as a normal by-product. Bivalve shellfish (two shelled shellfish, like clams and mussels) feeding on these toxic algae may accumulate PSP toxins to concentrations unsafe for human consumption.

The singular term toxin is not an accurate term for PSP since there are at lease 21 molecular forms of PSP toxins. Collectively, these PSP toxins are termed saxitoxins, deriving the name from the butter clam, *Saxidomus giganteus,* where saxitoxins were originally extracted and identified. All the saxitoxins are neurotoxins that act to block movement of sodium through nerve cell membranes, stopping the flow of nerve impulses causing the symptoms of PSP which include numbness, paralysis, and disorientation (Mosher et al. 1964). The toxicity of PSP toxins is estimated to be 1,000 times greater than cyanide and symptoms appear soon after consuming toxic shellfish. There is no antidote for PSP, and all cases require immediate medical attention that may include application of life support equipment to save a victim's life. If the dosage is low and proper medical treatment is administered, symptoms should diminish in approximately nine hours (Kao 1993).

Saxitoxin molecules undergo chemical transformations that change one molecular form to another. Transformations are performed by the dinoflagellate cell and by many animals that acquire saxitoxins. One common transformation, termed epimerization, occurs when a portion of the original saxitoxin molecule rearranges. Scallop and mussel, for example, can perform epimerization of saxitoxin they receive from the toxic algae when the H and OSO_3^- switch locations on the number 11 position of the saxitoxin molecule (Figure 1) (Oshima et al. 1990). Such a transformation can decrease the toxicity of the original saxitoxin by 11 times. Some transformations increase toxicity. For example, a six-fold increase in toxicity occurs when a process termed acid hydrolysis separates the SO_3^- group from position 21 on the saxitoxin molecule (Figure 1) (Hall et al. 1990). Recall that your stomach is acidic and acid hydrolysis can occur after you eat the shellfish. Numerous other types of transformations occur as well as eventual detoxification that can render the shellfish safe for consumption.

The number of saxitoxin forms and their tendency for spontaneous transformation are major factors hindering development of a simple field test kit for measuring PSP toxins (Sullivan and Wekell 1988). Currently, only the mouse bioassay test is approved by Food and Drug Administration (FDA) because it simultaneously measures the total of all the saxitoxin toxicities from a sample of shellfish tissue. Simply stated, the mouse bioassay measures the saxitoxin level by timing the death of an 18-20 gram mouse following injection of fluid extracted from shellfish tissue. Because the mouse bioassay is so reliable, PSP is less of a human health problem than many other types of food born illnesses.

The Algae

PSP episodes in Alaska tend to be seasonal, occurring most often during late spring and summer. Off-season occurrences of PSP are most likely caused by retention of toxins from the summer. Shellfish become toxic when environmental conditions enable toxic dinoflagellate cells to rapidly reproduce causing a toxic bloom.

A bloom begins as a small population of toxic dinoflagellate cells in the lag phase or in the form of resting cysts residing in the bottom sediment (Hall 1982). Environmental conditions such as changes in salinity, warming water

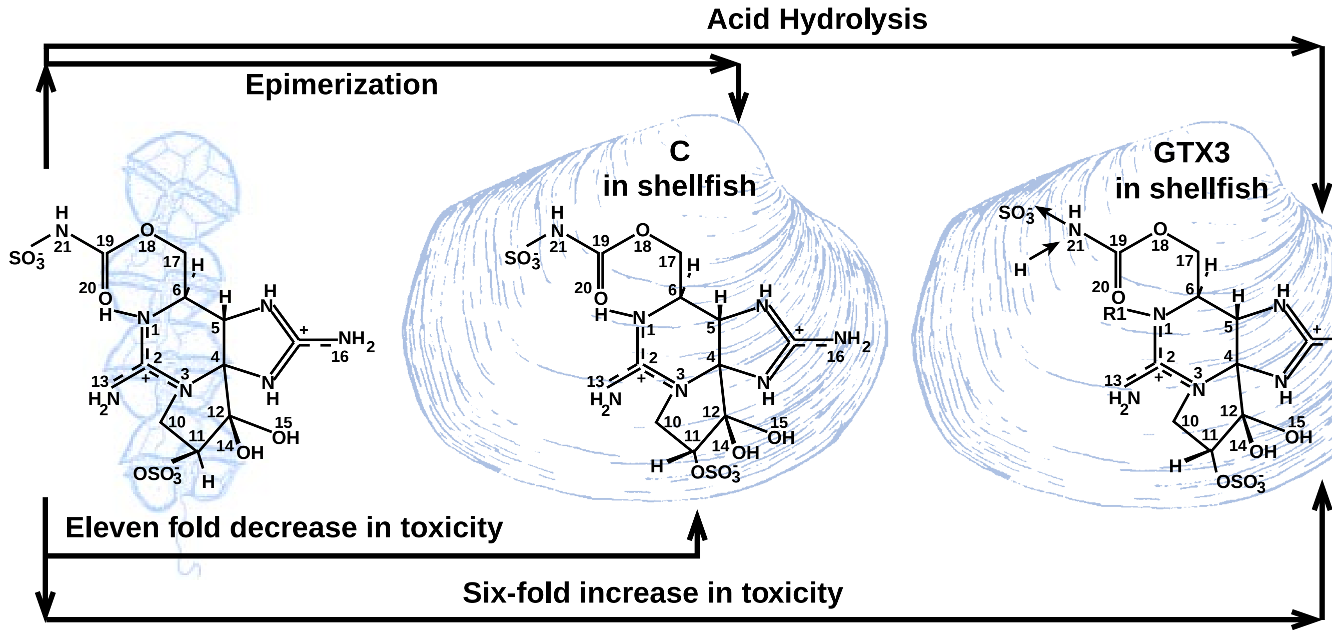

Figure 1: *Molecular transformations change the toxicity of the saxitoxin molecule. The diagram illustrates two common types of chemical transformations that occur when the saxitoxin is passed on from algae to shellfish.*

temperature, and increased nutrients and sunlight trigger cyst germination to a vegetative stage that enables rapid reproduction. Once the dinoflagellate bloom begins, an exponential growth phase causes a tremendous increase in their population. In time, depletion of nutrients and carbon dioxide in the water and degraded environmental conditions caused by the bloom decrease population growth. A stationary phase ensures leveling off the population. At this high level of the bloom, the water may assume a fluorescent reddish color referred to as a red tide. Continued environmental degradation increases cell death and ultimately leads to a population crash. At this phase of the bloom many dinoflagellate species form resting cysts that settle to the bottom, ready for the next bloom. Within this bloom cycle, the most toxic cells occur generally during the middle of the exponential growth phase, while older cells tend to undergo more toxin transformations (Anderson 1990).

PSP toxicity can exhibit a geographic pattern. For example, on the Northeast Coast of the United States dinoflagellates are more toxic in the more northern latitudes (Anderson 1990). In Alaska, varying toxin forms are found at different locations, but no clear pattern of toxicity has been determined (Hall 1982).

Toxic dinoflagellates produce more saxitoxin when nitrogen is abundant. Where phosphorus is deficient, individual algal cells become more toxic probably because the cells continue saxitoxin production but reduced cell reproduction prevents transfer of toxins to newly produced cells (Anderson et al. 1990). The net effect is that these non-reproducing cells continue to accumulate toxin.

Under laboratory culture, individual dinoflagellate cells tend to have a higher toxin concentrations when grown at lower temperatures (Anderson 1990). Again, like phosphorus limitation, the higher concentration may be caused by toxin production continuing during low temperature conditions while low temperatures reduce the rate of cell reproduction. The combined effect is higher toxin concentration in cells grown at a lower temperature.

What about a beach that has toxic shellfish while an adjacent beach has shellfish that are toxin free? This uneven toxicity is most likely caused by a patchy distribution of the toxic algae. In the ocean, cells of toxic algae are moved, concentrated, or dispersed by winds, tides, and water currents. For example, if winds and ocean currents flow in the same direction; their combined effect tends to concentrate drifting toxic algae. Opposing wind and currents often disperse the algae, decreasing the density of toxic cells. Shellfish feeding on the more concentrated patches of toxic algae will likely become more toxic (White et al. 1993).

The Shellfish

In Alaska's productive coastal waters, bivalve shellfish feed on a literal smorgasbord of microscopic algae. Bivalves are ideal conveyers of PSP toxin because they are relatively indiscriminate filter feeders, consume massive amounts of algae, are not generally killed by saxitoxins, and pass the accumulated saxitoxins on to any animal that eats them.

Six factors determine the concentration of saxitoxins in shellfish:

- The amount of toxic algae in the water as determined by the bloom size and patchiness.
- The toxin content of the individual dinoflagellate cell.
- The feeding rate of the shellfish.
- Avoidance of toxic algae by the shellfish.
- Transformation of the consumed saxitoxin by the shellfish into more or less toxic forms.
- Selective retention and excretion of the various forms of saxitoxins by the shellfish.

Shellfish nerve cells are not entirely immune from the effects of saxitoxins and degree of tolerance influences the shellfish's ability to feed and accumulate toxins. In Alaska, the blue mussel, *Mytilus edulis*, can accumulate in excess of 20,000 micrograms (mg) of saxitoxin per 100 grams of tissue, an extremely dangerous level considering that allowable limit enforced by the FDA is 80 micrograms per 100 grams of tissue. In the Kodiak area during the summer of 1993, one death and several illnesses were attributed to blue mussels containing 19,600 mg of saxitoxin. A concentration of saxitoxin that high will deliver a lethal dose of 480 mg saxitoxin by consumption of only 2.5 grams of mussel tissue or a single small mussel.

The extreme toxicity of blue mussels is due primarily to their relatively insensitivity to high toxin accumulations that enables them to continue feeding. Their high tolerance to saxitoxins and continued feeding on toxic algae can result in initially toxin-free blue mussels exceeding the FDA 80 microgram saxitoxin level in less than a 1 hour (Bricelj et al. 1990). Butter clams can be highly toxic partially because their nerve cells appear to have a special resistance to STX saxitoxin, one of the two most potent forms of the saxitoxins (Beitler and Liston 1990, Twarog et al. 1972).

In addition, the butter clam has a distinctive ability to chemically bind the highly toxic STX saxitoxin in their siphon tissue (Beitler and Liston 1990), and they can retain PSP toxins for up to two years after initial ingestion (Hall 1982).

The Alaska steamer or littleneck clam, *Protothaca staminea*, becomes toxic but is generally less toxic than the butter clam. The lower toxicity of the littleneck clam is due partially to their ability to perform unique transformations that change highly toxic saxitoxins to the moderately toxic forms (Sullivan et al. 1983).

The combined effect of the littleneck clam's capability to transform saxitoxins to less toxic forms, and the ability of butter clams to concentrate and retain highly toxic forms can result in a wide difference in toxicity between these two species. This toxicity difference is particularly significant since butter and littleneck clams can coexist on the same beach, and, to the unskilled harvester, are similar in appearance. To exemplify the difference, one study testing for toxicity of a mixed butter/littleneck clam population found that littleneck clams were about 11-25% as toxic as butter clams (Kvitek and Beitler, 1991). The lesson here is that if you cannot distinguish the difference between a butter and littleneck clam, you should take the time to learn and return your harvested butter clams back to the clam bed.

The Pacific oyster, *Crassostrea gigas*, though not native to Alaska is an important species for aquatic farming. The Pacific oyster tends to consume toxic algae readily during initial contact but decreases and eventually stops feeding when tissue toxin levels become high (Bardouil et al. 1993).

Saxitoxin concentrations also differ among various shellfish tissues. For example, in the Pacific giant scallop, *Patinopectin caurinus*, the adductor muscle seldom accumulates saxitoxins above the FDA limit, but other tissues regularly have high levels (Table 1). It is these high saxitoxin concentrations in other tissues that have prevented development of a highly valued gonad/adductor muscle product.

Another endeavor to diversify the line of scallop products through aquaculture development in the Kodiak area was attempted on two bay scallop species; the pink scallop, *Chlamys rubida*; and spiny scallop, *Chlamys hastata*. This time the scallop were to be sold as a whole in-the-shell product. The effort ceased when persistent high saxitoxin concentrations, at times exceeding 11,000 mg, were encountered. While most of the PSP records for whole scallop has been confined to the Kodiak area, consumers should be cautious of eating whole scallop harvested anywhere in the state since toxin levels can be very high and scallop retain toxins for an extended time.

The purple hinge rock scallop, *Crassadoma gigantea*, is another popular scallop species found attached to subtidal rocky substrate, predominantly in Southeast Alaska. Peculiar to this scallop is its tendency to have a toxic adductor muscle (Beitler 1991). Although testing for saxitoxins in purple hinge rock scallop has not been done in Alaska, data from British Columbia and the West Coast of the U.S. provides us a warning (Table 2).

The razor clam recreational fishery in Cook Inlet brings thousands of harvesters to the beach during extreme low summer tides. A question often asked is “Are these clams safe to eat?” The answer to this question is, “Most likely, yes.” Data collected by the ADEC from the Cook Inlet commercial fishery has consistently shown that PSP is not a problem in these razor clams. Other locations around the state, however, have recorded saxitoxin concentrations in razor clams that are above the FDA regulatory limit. Relying on a commercial fishery for PSP monitoring does have a major shortcoming because you, as a recreational harvester, do not have immediate access to the test results. Thus, you would have no idea if a sample submitted by a commercial harvester failed the PSP test.

Saxitoxins also migrate to different tissues and may undergo further transformation in the process. In the butter clam, for example, high saxitoxin concentrations begin to accumulate in the digestive system after initial consumption of toxic algae. Within one month, however, saxitoxins migrate to the siphon and undergo transformation from the relatively less toxic GTX saxitoxins to the highly toxic STX form (Beitler and Liston 1990).

Shellfish eventually clean themselves of saxitoxins through a process termed depuration. The time required for saxitoxin depuration is greatly

Table 1: PSP values for selected giant scallop tissues (in μg saxitoxin/100 grams of shellfish tissue).

Location	Date	Adductor	Viscera	Gills	Gonads	Mantel
Akhiok	June 1987	35	2,298	221	301	340
Izhut Bay	July 1987	58	4,945	504	1,361	243
Swikshak	Sept. 1987	<32	2,862	-	446	41

Data from Alaska Department of Environmental Conservation.
Note: All the locations in this table are in the Kodiak Island area.

influenced by environmental conditions and is extremely variable and unpredictable for wild grown shellfish. As an example, blue mussels can reduce saxitoxins from 700 mg to below the FDA 80 mg limit within 20 days, but the process may take over 50 days (Desbins et al. 1990). In the Skagway area, blue mussels required 40 days to reduce saxitoxins from 1,098 mg to below the 80 mg FDA requirement (ADEC data). Any attempt to estimate the depuration time for a shellfish population following a PSP event is dangerous; primarily because there is no way of knowing the size and duration of the toxic dinoflagellate bloom, and recurrent blooms can recontaminate shellfish.

The PSP problem in not isolated to just the bivalve shellfish. In recent years the Alaska crab fishery was drastically impacted when PSP was found in crab viscera. Although crab viscera is consumed in small portions, the discovery of PSP caused a flurry of regulations meant to assure consumer safety. A major concern that differs from bivalve shellfish is the fact that crab are opportunistic feeders, not filter feeders, and toxicity may vary significantly for each crab based upon the toxins contained in the food they choose to eat. Since initial concerns of PSP in crabs, regulations developed by the ADEC and cooperative agreements with the commercial crab fishery, now assure the safety of crab viscera. Since saxitoxins are water soluble, boiling live crab with the viscera in tack may spread the toxins from the viscera to other tissues. To prevent spreading of toxins, the ADEC recommends cleaning crabs of viscera before boiling.

The Food Web

How does PSP effect the marine environment? The answer to that question is difficult and extensive research reveals few conclusions.

Zooplankton, microscopic animals drifting in water, feed on toxic dinoflagellates and concentrate the saxitoxins, but these tiny animals are generally more sensitive to the effects of saxitoxins than adult bivalve shellfish (Hwang and Chueh, 1990). Although lethal to many zooplankton, saxitoxins can be passed along the food chain by zooplankton that limit toxin accumulation by reducing their feeding. High saxitoxin levels also impaired zooplankton; swimming ability causing them to become easy prey for fish, mammals, and birds (Buskey and Stockwell, 1993). Saxitoxin containing zooplankton have been implicated in fish kills (White 1981, Smayda 1992) and deaths of marine mammals after eating toxic fish (Geraci et al. 1989).

Some marine mammals and birds have adapted to living in an environment of marine toxins. For example, sea otters can detect harmful concentrations of saxitoxins and avoid eating toxic shellfish (Kvitek et al. 1991). The glaucous-winged gull has evolved an aversion to PSP and even young chicks regurgitate contaminated shellfish (Kvitek 1991). Marine biotoxins play a significant role in our marine environment and future efforts to measure the sublethal effects of toxic algae on marine organisms and the consequences for the marine ecosystems will be an elusive endeavor.

The Alaska Problem

Episodes of PSP in Alaska are centuries old, but on a global scale, toxic algae blooms are becoming an increasing menace. Attributed to man-caused nutrient enrichment of coastal waters (Anderson 1989, Smayda 1992), uncontrolled ballast water discharge from international shipping (Jones 1991), and possibly climatic changes, an international effort is now underway to explore solutions to the problem. Of practical significance is recognition that unpredictable changes in the ocean environment invalidates use of historical information as a sole source in forecasting toxic algal blooms and provides no guarantee that shellfish, historically free of PSP toxins, will remain in that condition.

Table 2: PSP toxin concentrations in the purple hinge rock scallop (μg saxitoxin/100 grams of tissue).

Location	Adductor	Viscera	Whole Body
British Columbia[1]	130	2,500	1,200
Washington[1]	229	2,036	295
California[2]	2,000	26,000	13,593

Data from: [1]Department of Fisheries and Oceans 1989
[2]Sharpe 1981

The economic consequences of the PSP problem has drastically impacted development of a clam fishery in Alaska where an estimated 50 million pounds are available for harvest (U.S. Department of Interior 1968). With harvest of 5 million pounds annually, a wholesale value of over $5 million could be realized.

In Alaska, widespread indifference of recreational and subsistence harvesters to PSP warnings causes considerable concern for the Alaska Division of Public Health and the Alaska Department of Environmental Conservation, agencies responsible for ensuring public health.

Paralytic Shellfish Poisoning: The Alaska Problem

continued

A recent survey of Kodiak Island conducted by the Alaska Division of Public Health found that the level of risk of contracting PSP is not equally shared among all shellfish consumers. Survey results found that:

- Long-term residents (at least 23 years) are 11.8 times more likely to report symptoms of PSP than short terms residents.
- Alaska Natives are 11.6 time more likely to report symptoms of PSP than non-Natives.
- If you have eaten shellfish for longer than 20 years, you are 5.4 times more likely to report symptoms of PSP.
- Residents of the Alaska Native village of Old Harbor are 3 times more likely to report symptoms of PSP than residents of Kodiak.

One of the most disturbing findings of the study showed that people who knew nothing about the lethal potential of PSP had the same frequency of reporting symptoms of PSP as those who knew PSP could cause death (Gessner and Schloss 1996).

Non-English speaking residents may have greater risk of exposure to PSP because the communication barrier hampers alerting them of PSP warnings. One of the latest victims in Kodiak was a Laotian resident.

Many myths about PSP have lead to practices alleged to improve your chances of avoiding illness. The Kodiak study found two-thirds of the residents that consumed shellfish from untested beaches believed it was possible to collect, prepare, or test shellfish in such a way that PSP could be prevented. Rather than reducing the risk of PSP, these unproven practices may give the consumer a false sense of security that may actually increase their risk of a PSP incident.

PSP is a complex problem, but you can still reduce your risk of encountering PSP. Obviously, the most acceptable decision is not to consume untested shellfish but purchase shellfish from a seafood retailer or shellfish farm that is required to sell only tested product. However, many people will continue to consume shellfish despite the warnings, and willingly accept an unknown risk with each meal.

Some shellfish consumers take absurdly high risks. For example, eating whole blue mussels from the Kodiak area during the summer is an invitation for PSP. When considering harvesting shellfish the potential consumer must at a minimum consider:

- The recent history of PSP for the area.
- The species harvested and their ability to concentrate and retain toxin.
- The season of the year.
- The method of cleaning and preparing the shellfish (i.e., whole scallop vs. adductor muscle).

As a harvester of wild shellfish, you cannot have enough information to absolutely guarantee that untested shellfish are free of dangerous levels of PSP toxins.

Avoid myths surrounding PSP prevention. The mere fact that in all five outbreaks in Kodiak in 1993, none showed any evidence of a red tide should be ample evidence that water color is not a reliable indicator of PSP.

A major problem in Alaska is under-reporting of PSP by persons experiencing minor symptoms. In some instances, if victims had reported their PSP symptoms to a medical facility, more serious consequences could have been averted.

It is your obligation to report even minor symptoms of PSP to your local medical care unit. Your action may save someone's life.

An obvious problem in Alaska is the lack of data on toxic algae blooms, shellfish testing, and reporting of PSP outbreaks. The Alaska Division of Public Health and the ADEC are very interested in recruiting public assistance in PSP monitoring. The more information we collect about the frequency and distribution of red tides, toxic algae blooms, and PSP episodes the more likely we are to understand the environmental impacts of PSP and develop strategies to prevent illness.

References

Anderson, D.M. 1989. Toxic algal blooms and red tides: a global perspective. Pages 11-16. *in* R. T. Okaicki, D.M. Anderson and T. Nemto, editors. Red Tides: Biology Environmental Science and Toxicology. Elsevier Science Publications.

Anderson, D.M. 1990. Toxin variability in *Alexandrium* species. Pages 41-51. *in* E. Graneli, B. Sundstrom, L. Edler, and D.M. Anderson, editors. Toxic Marine Phytoplankton. Elsevier Science Publications

Anderson, D.M., D.M. Kulis, J.J. Sullivan, S. Hall, and C. Lee. 1990. Dynamics and physiology of saxitoxin production by the dinoflagellates *Alexandrium* spp. Marine Biology 104:511-524.

Bardouil, M., M. Bohec, M. Cormerais, S. Bougrier, and P. Lassus. 1993. Experimental study of the effects of toxic microalgal diet on feeding of the oyster *Crassostrea gigas* Thunberg. Journal of Shellfish Research. 12(2):417-422.

Beitler, M.K. and J. Liston. 1990. Uptake and tissue distribution of PSP toxin in butter clams. Pages 257-263 *in* E. Graneli, B. Sundstrom, L. Edler, and D.M. Anderson, editors. Toxic Marine Phytoplankton. Elsevier Science Publications.

Beitler, M. 1991. Toxicity of adductor muscles from the purple hinge rock scallop (*Crassodoma gigantea*) along the Pacific coast of North America. Toxicon 29(7):889-894.

Bricelj, V.M., J.H. Lee, A.D. Cembella, and D.M. Anderson. 1990. Uptake of *Alexandrium fundyense* by *Mytilus edulis* and *Mercenaria mercenaria* under controlled conditions. Pages 269-275 51 *in* E. Graneli, B. Sundstrom, L. Edler, and D.M. Anderson, editors. Toxic Marine Phytoplankton. Elsevier Science Publications.

Buskey, E.J. and D.A. Stockwell. 1993. Effects of a persistent "brown tide" on zooplankton populations in the Laguna Madre of South Texas. Pages 659-666 *in* T.J. Smayda and Y. Shimizu, editors. Toxic Phytoplankton Blooms in the Sea. Elsevier Science Publications. B.V. Amsterdam.

Department of Fisheries and Oceans. 1989. Summary of paralytic shellfish toxicity records in the Pacific region. Department of Fisheries and Oceans. Burnaby, British Columbia. Canada.

Desbins, M., F. Coulombe, J. Gaudreault, A.D. Cembella, and R. Larocque. 1990. PSP toxicity of wild and cultured blue mussels induced by *Alexandrium excavatus* in Gaspe Bay (Canada): Implication for aquaculture. Pages 459-463 *in* E. Graneli, B. Sundstrom, L. Edler, and D.M. Anderson, editors. Toxic Marine Phytoplankton. Elsevier Science Publications.

Geraci, J.R,. D.M. Anderson, R.J. Timperi, D.J. St. Aubin, G.A. Early, J.H. Prescott, and C.A. Mayo. 1989. Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. Canadian Journal of Fisheries and Aquatic Sciences. 46:1895-1898.

Gessner, B.D. and M.S. Schloss. 1996. A population-based study of paralytic shellfish poisoning in Alaska. Alaska Medicine. 38(2):54-58.

Hall, S. 1982. Toxins and toxicity of *Protogonyaulax* from the northeast Pacific. Ph.D. Thesis. University of Alaska Fairbanks. 196 pp.

Hall, S., G. Strichartz, E. Moczydolowski, A. Ravindran. and P. Reichardt. 1990. The saxitoxins: sources, chemistry, and pharmacology. Pages 29-65 *in* S. Hall and G. Strichartz, editors. Marine Toxins: Origin, Structure, and Molecular Pharmacology. American Chemical Society Symposium Series. Washington, DC.

Hwang, D, and C. Chueh. 1990. Susceptibility of fish, crustacean and mollusk to tetrodotoxin and paralytic shellfish poison. Nippon Suisan Gakkaishi. 56(2):337-343.

Jones, M. 1991. Discharge ballast introduces unwanted organisms to Australian waters. Australian Fisheries. August edition. Bureau of Rural Resources. Canerra, Australia.

Kao, D.Y. 1993. Paralytic Shellfish Poisoning. Pages 75-86 *in* I.R. Falconer, editor. Algal Toxins in Seafood and Drinking Water. Academic Press, New York.

Kvitek, R.G. 1991. Sequestered paralytic shellfish poisoning toxins mediate glaucous-winged gull predation on bivalve prey. Auk 108(2):381-392.

Kvitek, R.G. and M.K. Beitler. 1991. Relative insensitivity of butter clam neurons to saxitoxin: a pre-adaptation for sequestering paralytic shellfish poisoning toxins as a chemical defense. Marine Ecology Progress Series. 69:47-54.

Kvitek, R.G., A.R. DeGange, and M.K. Beitler. 1991. Paralytic shellfish poisoning toxins mediated feeding behavior of sea otters. Limnology and Oceanography. 36(3):393-404.

Mosher, H.S., F.A. Fuhrman, H.S. Buchwald, and H.G. Fischer. 1964. Tarichatoxin-Tetrodotoxin: A potent neurotoxin. Science. 144:1100.

Oshima, T., K. Sugino, H. Itakura, M. Hirota, and T. Yasumoto. 1990. Comparative studies on paralytic shellfish toxin profile of dinoflagellates and bivalves. Pages 479-485 *in* E. Graneli, B. Sundstrom, L. Edler, and D.M. Anderson, editors. Toxic Marine Phytoplankton. Elsevier Science Publications.

Sharpe, C.A. 1981. Paralytic shellfish poison, California - Summer 1980. State of California Department of Health Services - Sanitary Engineering Section

Smayda, T.J. 1992. Global epidemic of noxious phytoplankton blooms in the sea: evidence for a global epidemic. Pages 275-307 *in* K. Sherman, L.M. Alexander, and B.D. Gold, editors. Food Chains: Models and Management of Large Marine Ecosystems. Westview Press. San Francisco.

Sullivan, J. and W.T. Iwaka, and J. Liston. 1983. Enzyme transformations of PSP toxins in the littleneck clams, *Protothеca staminea*. Biochemical and Biophysical Research Communications. 114(2):465-472.

Sullivan, J. and M. Wekell. 1988. Detection of paralytic shellfish toxins. Pages 87-106 *in* T. Tu. Anthony, editor. Handbook of Natural Toxins, Volume 3. Marcel Dekker. Inc., New York.

Twarog. B.M., T. Hidaka, and H. Yamaguchi. 1972. Resistance of tetrodotoxin and saxitoxin in nerves of bivalve molluscs. Toxicon. 10:273-278.

United States Department of the Interior. 1968. The potential of Alaska's fishery resources. Newsletter to Alaska Fishermen and Processors. Number 9, September 13, Juneau, Alaska.

White A.W. 1981. Marine zooplankton can accumulate and retain dinoflagellate toxins and cause fish kills. Limnology and Oceanography. 26:103-109.

White, A.W., S.E. Shumway, J. Nassif, and D. Whittaker. 1993. Variation in levels of paralytic shellfish toxins among individual shellfish. Pages 441-445 *in* T.J. Smayda and T. Shimizu, editors. Toxic Phytoplankton Blooms in the Sea. Elsevier Science Publications.

Alexandrium, the Dinoflagellate that Produces Shellfish Poisoning Toxins

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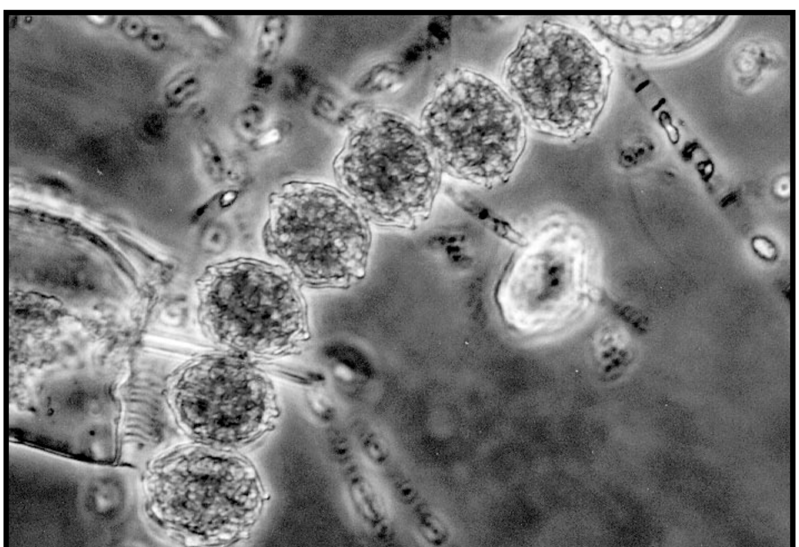
In Alaska, and elsewhere in the Pacific Northwest, paralytic shellfish poisoning (PSP) is caused by dinoflagellates in the genus *Alexandrium* (Figure 1). First described as a species in the genus *Gonyaulax* (Whedon and Kofoid 1936), the toxin-producing species were later transferred to *Protogonyaulax* (Taylor 1979), and recently to *Alexandrium* (Balech 1985, Steidinger 1990).

Much of the confusion has been resolved by a closer examination of cellular morphology of the toxin-producing species. In addition, the *Alexandrium* show much variation in morphology caused by natural variation, sexual reproduction that increases genetic variation, the discovery of the cyst stage that is structurally different from the vegetative cell stage, and environmental conditions. Currently, there are 22 species in this genus (Balech 1985).

The vegetative stage of *Alexandrium* is motile and have a theca (an outer covering or cell wall) made of cellulose plates. The arrangement of these plates, though there may be some variability, is a characteristic used for identification (Balech 1985). The plates are most easily seen if the cells are gently squashed to remove the cell contents. The cells are divided into upper and lower parts by a central groove (girdle) with the ends displaced about one girdle width. A longitudinal groove (sulcus) runs from the girdle to the posterior end of the cell (Figure 2). Two flagella, whip-like structures used for swimming, are present, one encircling the cell in the girdle, the other, lying along the sulcus and trailing behind the cell. Cells are round to oval in shape and range in size from about 20-50 mm in diameter. They may be single or occur in chains. Identification is difficult unless chains are present and single cells may easily be mistaken for other small, brown-pigmented dinoflagellates including *Scrippsiella trochoidea*.

Figure 1: Alexandrium catenella 7-celled chain



General features of the genus include the characteristic shape and arrangement of surface plates, girdle displacement about one girdle width, no spines or horns, thin cell walls, a characteristic apical pore plate, the presence or absence of a ventral pore, and smooth-walled cysts. Species are distinguished by the size and shape of the cells, size and shape of some of the thecal plates, presence or absence of a ventral pore, size and shape of some of the girdle plates, and the relationship between the apical pore plate and the more-or-less diamond-shaped plate ventral to it. A key to the species is found in Balech (1985).

Based on analysis of small-subunit ribosomal RNA genes, three species of *Alexandrium* occur on the North American west coast (Scholin and Anderson 1994). *A. catenella* (Whedon and Kofoid) Balech occurs from southern California to southeast Alaska, forms chains, blooms when the water temperature is about 20°C, and occurs in both estuarine and open coast environments; it lacks a ventral pore. *A. tamarense* (Lebour) Balech, prefers cooler temperatures and less saline water than *A. catenella* and has a ventral pore. It has been found at Unimak Island in the Gulf of Alaska. *A. fundyense* Balech, originally described from the Bay of Fundy, is small, lacks a ventral pore, and has been found at Porpoise Island, Alaska. Other species identified using standard morphological characteristics include *A. acatenella* (Whedon and Kofoid) Balech, *A. ostenfeldi* (Paulsen) Balech, *A. hiranoi* Kita and Fukuyo (Taylor and Horner 1994). *A. catenella, A. acatenella*, and *A. tamarense* are part of the same species complex, but in British Columbia, at least, they tend to have different distributions (Taylor and Horner 1994). Elsewhere in the Pacific Northwest, their distribution is not well-known.

Two kinds of cysts may occur in the life cycle, both with smooth cell walls (Figure 2). Pellicle cysts are vegetative and are produced from motile, vegetative cells in response to environmental stress, including temperature changes and nutrient depletion. These cysts have limited durability and do not overwinter. They are smooth-walled, deeply pigmented, and have a required dormancy period. They are resistant to environmental extremes and may provide seed populations for future blooms if conditions for germination are right. These resting cysts may be transported in the same manner as sediment particles, including by normal water currents or catastrophic events such as hurricanes. As a result, they may germinate far from their place of origin and initiate blooms in new areas. Cyst formation may be a factor in the decline of blooms. Cysts are also toxic and are thus a source of toxicity to the food chain.

The distribution of *Alexandrium* in Alaskan waters is not well-known and historical records are sparse. Reasons for this include the long coastline and the lack of samples from many sites. Moreover, much of what is known or suspected about the distribution of toxic cells comes from records of toxicity in shellfish, not from knowledge of the biology of the dinoflagellates. *Alexandrium*-like cells have been found at a number of places in southeast and southcentral Alaska, but the problem has been to correlate the abundance of a causative organism, presumably *Alexandrium* spp., with the timing, levels, and geographic distribution of toxin in the shellfish (Hall 1982). Consequently, Hall (1982) sampled the water column and sediments from Dutch Harbor to Ketchikan for motile cells or cysts and isolated about 50 strains from 11 sites. In culture studies he found that toxin content per cell varied substantially within a strain, but toxin composition of a strain changed little with culture conditions or stage of growth. However, regional patterns of toxin composition were found where strains from one region had the same toxin composition, while strains from other regions had different compositions. Shellfish toxicity should vary in a similar manner according to Hall (1982).

Thus, it is apparent that there are no easy answers to the problem of shellfish toxicity and causative species in Alaska. Without comprehensive phytoplankton and/or shellfish monitoring programs, there is currently no way to ensure that shellfish are safe for human consumption.

References

Anderson, D.M. and D. Wall. 1978. Potential importance of benthic cysts of *Gonyaulax tamarensis* and G. *excavata* in initiating toxic dinoflagellate blooms. Journal of Phycology. 14:224-234.

Balech, E. 1985. The genus *Alexandrium* or *Gonyaulax* of the tamarensis group. Pages 33-38, *in* D.M. Anderson, A.W. White, and D.G. Baden, editors. Toxic dinoflagellates. Elsevier, New York.

Hall, S. 1982. Toxins and toxicity of *Protogonyaulax* from the northeast Pacific. Ph.D. Thesis, University of Alaska, Fairbanks. 196 pp.

Scholin, C. A. and D.M. Anderson. 1994. Identification of group and strain-specific genetic markers for globally distributed *Alexandrium* (Dinophyceae). I. RFLP analysis of SSU rRNA genes. Journal of Phycology 30:744-745.

Streidinger, K.A. 1990. Species of the *tamarensis/catanella* group of *Gonyaulax* and the fucoxanthin derivative-containing Gymnodinioids. Pages 11-16, *in* E. Graneli, B. Sundstrom, L. Edler, and D.M. Anderson, editors. Toxic dinoflagellate blooms. Elsevier, North Holland, New York.

Taylor, F.J.R. and R.A. Horner. 1994. Red tides and other problems with harmful algal bloom in Pacific Northwest coastal waters. Pages 175-186, *in* R.C.H. Wilson, R.J. Beamish, F. Aitkens, and J. Bell, editors. Review of the marine environment and biota of Strait of Georgia, Puget Sound and Juan de Fuca Strait: Proceedings of the BC/ Washington Symposium on the Marine Environment, Jan 13 & 14, 1994. Can. Tech. Rep. Fish. Aquat Sci. 1948.

Whedon, W.F. and C.A. Kofoid. 1936. Dinoflagellata of the San Francisco region. I. On the skeletal morphology of two new species, *Gonyaulax cantenella* and *G. acatenella*, University of California Publication. Zoology 41(4):25-34.

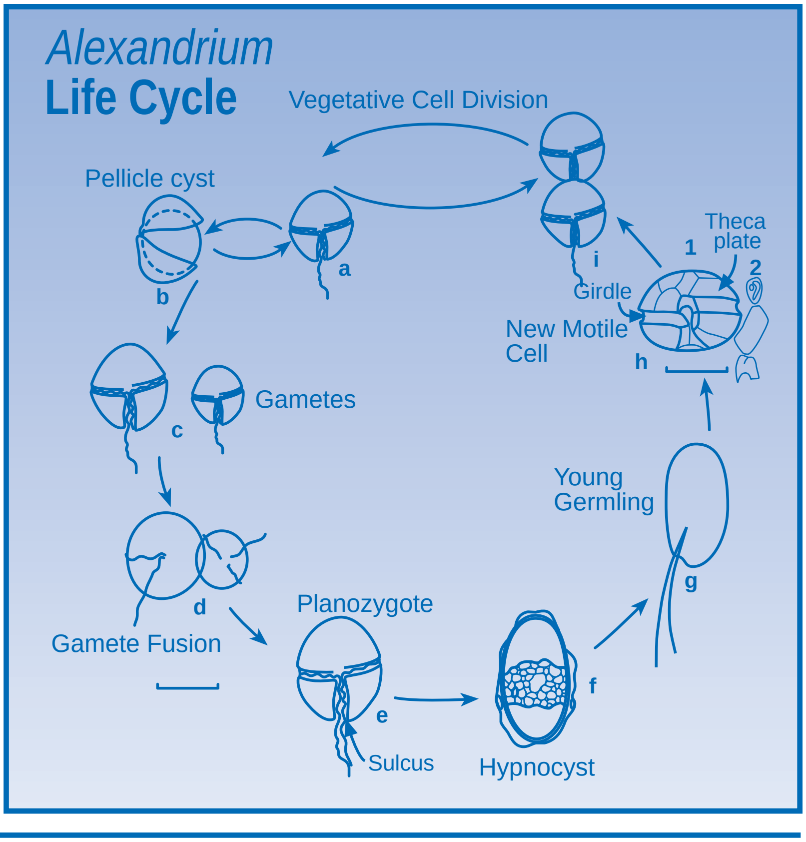
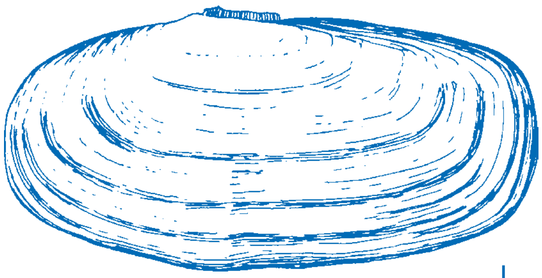


Figure 2: Generalized life cycle of Alexandrium. Figure h shows characteristic thecal plates for A. catenella; 1 is the ventral view, 2 is the apical pore plate, the thecal plate closest to the port plate, and a sulcal plate. Figures a-g, and i modified from D.M. Anderson; Figure h modified from Balech (1985).

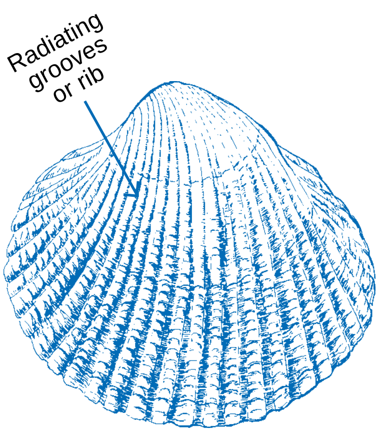
How Toxic Are Alaska's

Toxicity levels shown are the highest recorded in Alaska. The FDA



Pacific Razor Clam

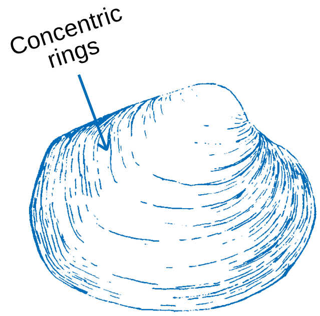
Siliqua patula
Distribution: Alaska to mid California
Habitat: Intertidal zone, open coasts in sand
Size: up to 8"
Identification: Long narrow shell, thin and brittle, olive green to brown color
Toxicity: 3,294 µg toxin



Cockle

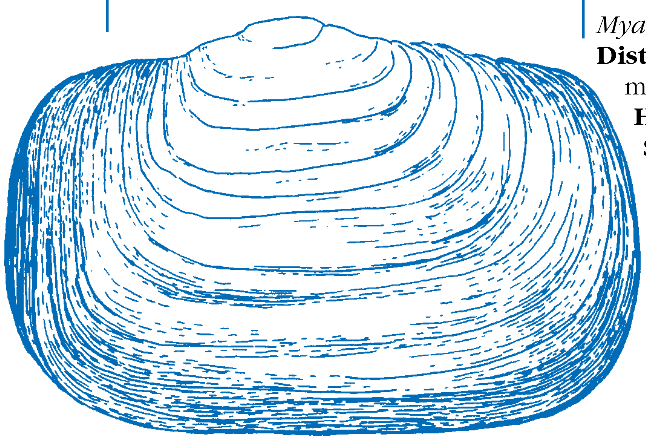
Clinocardium nuttalli
Distribution: Bering Sea to Southern California
Habitat: Interidal zone to 90 feet, mud to sand beaches
Size: Up to 6"
Identification: Thick cupped shells, up to 35 strong ribs spreading from the hinge to shell margin
Toxicity: 2,252 µg toxin

Shellfish drawings from "Intertidal Bivalves: A Guide to Common Marine Bivalves of Alaska", Nora R. Foster. 1991. University of Alaska Press



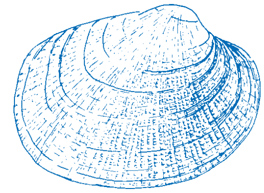
Butter Clam

Saxidomus giganteus
Distribution: Aleutian Islands to mid California
Habitat: Intertidal zone to 120 feet depth, on protected gravel, sandy beaches
Size: up to 5"
Identification: Dense shell, external surface with concentric rings, prominent growth rings
Toxicity: 7,750 µg toxin



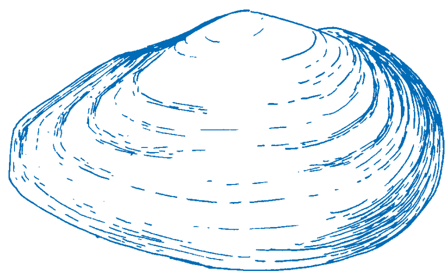
Geoduck

Panopea abrupta
Distribution: Sitka, Alaska to Gulf of California
Habitat: Intertidal to deep water, buried deeply in sand and mud bottom
Size: Shell up to 8"
Identification: Shells heavy, one end of shell rounded the other end flat, rough concentric grooves on shell surface.
Toxicity of viscera: 1,526 µg toxin



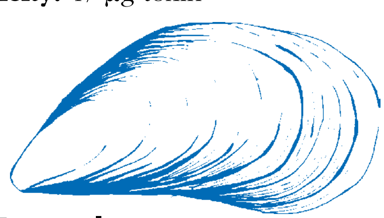
Pacific Littleneck Clam

Protothaca staminea
Distribution: Aleutian Islands to mid California
Habitat: Midtidal to subtidal zone, mud to coarse gravel beaches
Size: Up to 2 1/2"
Identification: External surface of shell with radiating and concentric grooves
Toxicity: 580 µg toxin



Softshell Clam

Mya arenaria
Distribution: World-wide north of mid California
Habitat: Upper tidal level mud flats
Size: Up to 6"
Identification: Shell soft, easily broken, one end of shell rounded, other end pointed, concentric rings only
Toxicity: 47 µg toxin

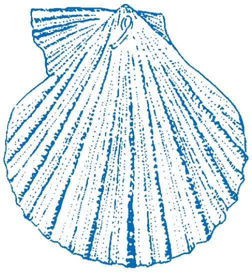


Blue Mussel

Mytilus edulis
Distribution: Northern Hemisphere
Habitat: Rocky intertidal areas of exposed and protected coastline
Size: Up to 4"
Identification: Blue/black to brownish shell, shell pointed at one end and round at the other, has a threadlike structure to attach to substrate
Toxicity: 20,000 µg toxin

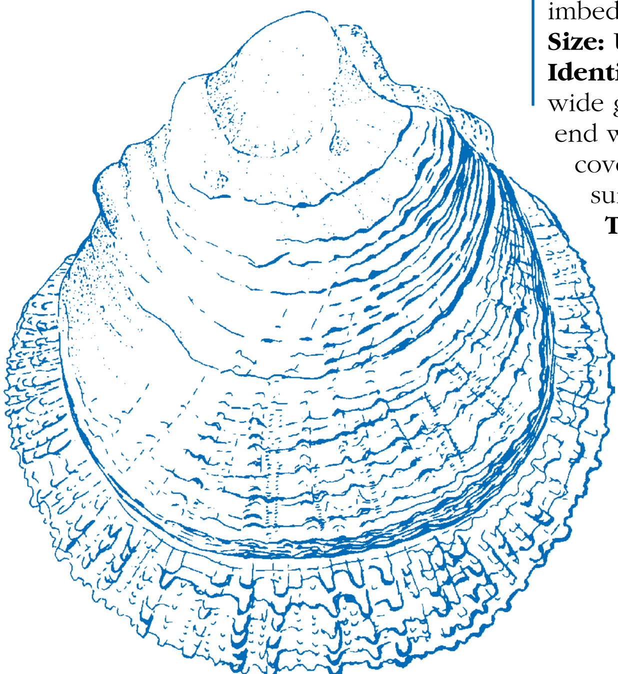
Most Common Shellfish ?

considers anything above 80 µg (micrograms) of toxin not safe to consume.



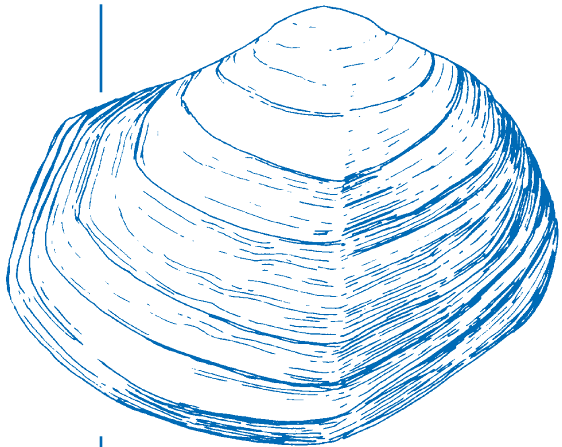
Spiny Scallop

Chlamys hastata
Distribution: Gulf of Alaska to California
Habitat: Low intertidal area to 400 feet depth
Size: Up to 3 1/2"
Identification: Shell thin and flattened, auricles uneven size, 20-30 ribs on each shell, ribs spiny textured
Toxicity: 11,945 µg toxin (whole)



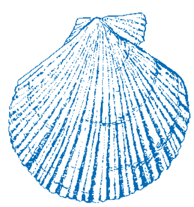
Purple Hinge Rock Scallop

Crassadoma gigantea
Distribution: Aleutian Islands to Southern California
Habitat: Low tidal area to 200 feet depth, attached to rocks and in crevices.
Size: Up to 10"
Identification: Very heavy rough shell, purple color hinge area when shell open
Toxicity: 2,000 µg toxin (whole)



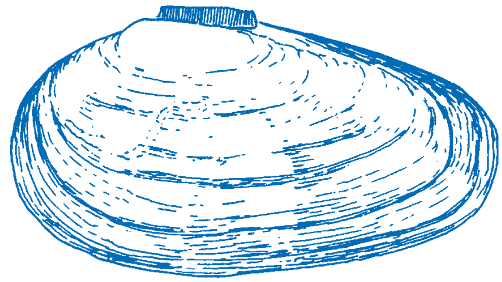
Horse (Gaper) Clam

Tresus capax
Distribution: Shumagin Islands, Alaska to California
Habitat: Intertidal zone imbedded deeply
Size: Up to 8"
Identification: Shell large and thick, wide gape between shells at posterior end when held together, dark covering (periostracum) on shell surface often partially worn off
Toxicity: 281 µg toxin



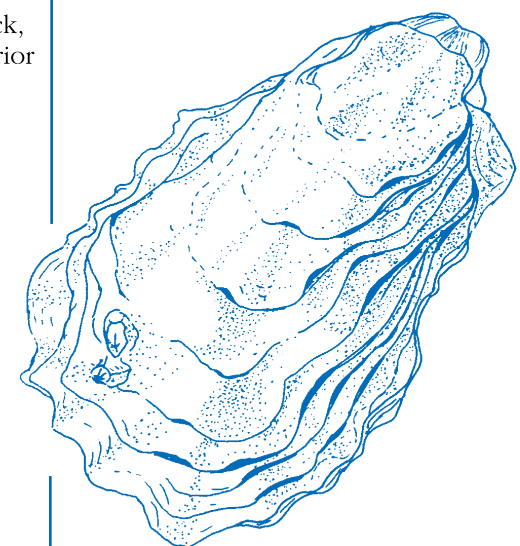
Pink Scallop

Chlamys rubida
Distribution: Bering Sea to mid California
Habitat: Low tidal area to 900 feet depth, rocky shoreline
Size: Up to 2 1/2"
Identification: Shell thin and flattened, 20-30 ribs on each shell, auricles uneven size, red/pink on one shell, opposite shell, color pale
Toxicity: 11,945 µg toxin (whole)



Alaska Razor Clam

Siliqua alta
Distribution: Bering Sea to Cook Inlet
Habitat: Intertidal zone to 30 feet on open sandy beaches
Size: Up to 6"
Identification: Long narrow shaped shell, shell thin and brittle, brown to olive green color
Toxicity: 3,294 µg toxin



Pacific Oyster

Crassostrea gigas
Distribution: Kachemak Bay to California
Habitat: Intertidal in mud to rocky beaches. In Alaska only on aquatic farms, but may be a few small populations in southern southeastern Alaska. Does not reproduce in Alaska waters
Size: Up to 8"
Identification: Shell irregular shape, rough surface, upper shell cupped while lower shell flat
Toxicity: 910 µg toxin

PSP: The Bacterial Connection

F.G. Plumley, Associate Professor, UAF Institute of Marine Science,
and Z. Wei, Ph.D. graduate student

Paralytic shellfish poisoning (PSP) is a persistent problem in Alaska and along the West Coast of the United States. PSP is caused by a neurologically damaging saxitoxin that is assumed to be produced by a planktonic dinoflagellate, *Alexandrium cantenella* (Read: *Alexandrium*, the Dinoflagellate that Produces Shellfish Poisoning Toxins). This may very well be true, but recent data questions this assumption and surfaces suspicions that bacteria, not dinoflagellates, produce saxitoxins.

Questions about the role of dinoflagellates in Alaska producing saxitoxins began in the mid-1960s when a study by the University of Alaska in southeastern Alaska failed to find a relationship between the abundance of *A. cantenella* in the water and the occurrence of PSP (Chang 1971). Other studies found a correlation between the presences of *A. cantenella* and PSP, however, the very small number of *A. cantenella* collected in the water samples could not account for the high level of toxin (Sparks 1966, Neal 1967). In 1973, the first direct link between *A. cantenella* and PSP was recorded by Simmerman and McMahon (1976) when several families ate butter clams collected near the boat harbor in Tenakee. The case was proven when two unsuspecting victims developed PSP from eating clams harvested from a beach whereas others, having recently eaten clams from the same beach, had no toxic reaction. An analysis of the uneaten portions of clams, which included the gills and digestive gland, showed high levels of saxitoxin. Saxitoxin in these particular tissues indicated that the toxic conditions were recent since toxin in butter clams moves into the siphon after a period of time. Fortuitously, only five days before the toxin problem, the Alaska Department of Environmental Conservation RV Maybeso had been in the area and had observed unusual bioluminescence in Tenakee Harbor prompting the scientists to collect water samples. Later examination of the samples found high numbers of *A. cantenella*. Later, Hall (1982) confirmed the "dinoflagellate connection" when he induced resting cysts of *A. cantenella* to germinate and then subsequently produced saxitoxin.

During the same time period the PSP story was also unfolding in laboratories around the world. The general scenario emerging was similar to Alaska, in some locations and at certain times there were inconsistencies between toxin production and algae abundance, whereas in other locations there was consistent agreement. Adding to the confusion were findings that some geographical strains of dinoflagellates produce more toxin while others produced little or no toxin. Silva and Sousa (1981) made a remarkable discovery when they transformed a non-toxic dinoflagellate strain to a toxin producer by simply inoculating the non-toxic strain with a bacterium, *Pseudomonas sp.*, isolated from a toxin-producing dinoflagellate. This observation, though exciting, could not confirm which organism, the bacterium or the dinoflagellate, produced the toxin. Nonetheless, this observation, linked with the fact that dinoflagellates routinely harbor intra cellular bacteria (Bold and Wynn, 1979), prompted the question "are bacteria the real source of saxitoxins?" Since most scientists studying saxitoxins were phycologists (algae specialists), they emphatically responded: "no way!"

The implication that bacteria produce the saxitoxins has met with some resistance from phycologists. This resistance is due in part to the complex associations that occur between algae and bacteria, but there is clear implication that phycologists could say with a clear conscience: "bacteria are not producing saxitoxins, they are only inducing the alga to synthesize the toxins."

Most phycologists accepted the idea that bacteria may have a direct role in saxitoxin production by inducing the algae to produce toxin rather than directly producing saxitoxin. Many investigators started examining their algal cultures more closely and using the electron microscope to look for bacteria within the dinoflagellate cell. Kodama and colleagues, attempting to prove the hypothesis that bacteria can produce saxitoxin took a more risky approach (Kodama et al. 1988, 1990) by isolating bacteria from cultured dinoflagellates and even removing bacteria individually from inside the dinoflagellate cells. They found that under certain precise growing conditions bacterium could indeed synthesize saxitoxins. This finding was a shock to everyone, especially the phycologist, many of whom had spent a lot of time confirming that bacteria were NOT present in their toxic dinoflagellate cultures.

The race was on. Who makes saxitoxins? Could Kodama's work be repeated? For more than five years several labs attempted to culture saxitoxin producing bacteria, some labs even used Kodama's original strain, but without success. Was the toxin producing bacteria an artifact or a hoax? Could the toxin detected in the original experiment have been a residual amount accumulated and retained by the bacteria from toxin producing dinoflagellates?

Then, to everyone's surprise, a second lab demonstrated bacterial production of toxin (Doucette and Trick 1995, Doucette 1995). The amount of toxin was very small, but the experimental methodology was performed with extreme care and the results were conclusive. This time the results were more acceptable to phycologists because more recent studies also showed that freshwater cyanobacteria (formerly known as blue-green algae) also produced saxitoxins (reviewed in Carmichael et al. 1990; Carmichael and Falconer 1993). The importance of this event is apparent in that the saxitoxin producing cyanobacteria are more closely aligned taxonomically to bacteria than algae. The fact that this process occurs in freshwater rather than marine systems was then, and still is, a matter of concern.

There remains, however, several unanswered questions. First, are dinoflagellates able to synthesize saxitoxins in the absence of bacteria? Second, if bacteria contained within the dinoflagellate cell are responsible for saxitoxin synthesis, how in nature, can they produce the large amount detected when in laboratory culture only minute quantities are produced? Third, if both the bacteria and the dinoflagellate have necessary roles in toxin production, how did such an evolutionarily separated pair of organisms develop such a capability?

The answers to the first two questions are now being investigated by a number of laboratories around the world. For the first problem, laboratories are again checking their toxin producing dinoflagellate cultures for bacteria.

A problem with this type of investigation is that theoretically you cannot prove that something does not exist, you can only demonstrate that you have been unable to find it. By the same logic, the absence of data cannot be taken as an absence of the event. Bacteria may indeed be in a dinoflagellate culture, but scientists have not been able to find them or detect their influence on toxin production. For the second question, several labs are growing bacteria under a variety of conditions to determine if saxitoxin production can be increased.

The answer to the third question is the area of research being conducted in the laboratory of these authors. We are attempting to clone one or more genes that encode the enzymes required to make saxitoxins. Once this task is completed, the cloned DNA fragments can then be used as "probes" to determine who else produces saxitoxins. To date our results have been less than encouraging, primarily because the bacteria that produce saxitoxin are difficult to analyze at the molecular level.

One hypothesis we are pursuing is that the toxin producing genes evolved only once, originating in the bacteria, then later were transferred to dinoflagellates by a recently discovered process called trans-kingdom sex (Amabile-Cuevas and Chicurel 1993). That bacteria may be able to transfer genetic information across kingdom boundaries from bacteria to algae cells. This has profound evolutionary implications for several controversial issues in biology, possibly including a better understanding of the PSP problem.

References

Amabile-Cuevas, C.F. and M.E. Chicurel. 1993. Horizontal gene transfer. American Scientist. 81:332-341.

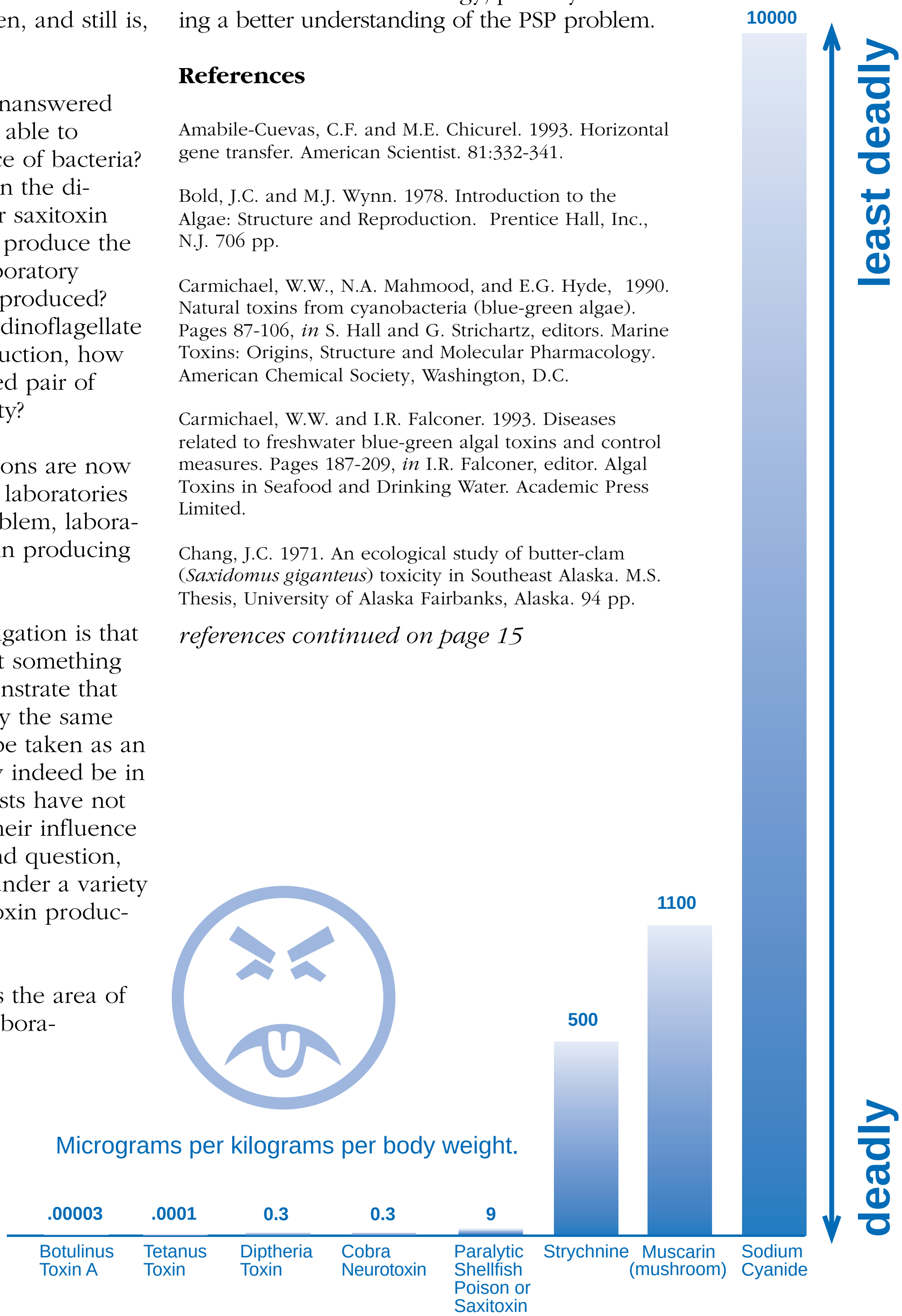
Bold, J.C. and M.J. Wynn. 1978. Introduction to the Algae: Structure and Reproduction. Prentice Hall, Inc., N.J. 706 pp.

Carmichael, W.W., N.A. Mahmood, and E.G. Hyde, 1990. Natural toxins from cyanobacteria (blue-green algae). Pages 87-106, *in* S. Hall and G. Strichartz, editors. Marine Toxins: Origins, Structure and Molecular Pharmacology. American Chemical Society, Washington, D.C.

Carmichael, W.W. and I.R. Falconer. 1993. Diseases related to freshwater blue-green algal toxins and control measures. Pages 187-209, *in* I.R. Falconer, editor. Algal Toxins in Seafood and Drinking Water. Academic Press Limited.

Chang, J.C. 1971. An ecological study of butter-clam (*Saxidomus giganteus*) toxicity in Southeast Alaska. M.S. Thesis, University of Alaska Fairbanks, Alaska. 94 pp.

references continued on page 15



How Much Will Kill Me?

Truths and Myths about PSP

Are months with an "r" are safe for eating shellfish?

No. Months without an "r" occur during the summer when toxic dinoflagellate blooms that cause PSP most often occur. With the unlikely possibility that shellfish will become toxic outside the summer season, consumers assume shellfish are safe to eat. This answer is wrong in three ways.

1. In some locations in Alaska shellfish remain highly toxic in the spring and fall. PSP outbreaks have occurred in all seasons.

2. Toxic dinoflagellate algae can form cysts that reside in the sediment during the non-bloom seasons. These cysts are as toxic as the suspended vegetative form that are present during a toxic bloom. Shellfish, being bottom dwelling filter feeders, can continue to consume cysts during non-bloom periods and accumulate PSP toxin.

3. Some shellfish can retain the PSP toxin for a long period. Blue mussels in the Skagway area took 28 days before they were safe to eat. Such a long retention time could extend into the fall season. Other shellfish like the butter clams can chemically bind PSP toxin and retain it for as long as two years.

Is there an antidote for PSP?

No. PSP is a neurotoxin that blocks movement of sodium through membranes of nerve cells. Without sodium transmission, nerve cells cannot function. This leads ultimately to the symptoms of PSP: numbness, paralysis, respiratory failure, and coma. There is no specific antidote to stop the effect of PSP toxicity.

Is there a treatment for PSP?

Yes. Induce vomiting by sticking a finger down the throat, drinking warm saltwater, or taking Syrup of Ipecac to expel shellfish from the victim's stomach. Treat the victim for shock and transport to a medical facility. Application of life support services at the medical care facility may be necessary to sustain the life of the victim. Reduction of symptoms normally occurs within 9 hours and complete recovery usually within 24 hours. You must not underestimate the seriousness of PSP. Once the symptoms begin to appear, the victim must be transported immediately to a medical care facility.

Is a toxic algae bloom the same thing as a red tide?

Not always. A number of marine organisms in Alaska cause red tides, including non-toxic dinoflagellates of the genera *Noctacula* and *Mesodinium*. During bloom conditions, single celled organisms can cause the surface water to become red. Toxic dinoflagellate blooms turn red only when a certain density is reached. Individual toxic dinoflagellate cells may actually be most dangerous during the early part of bloom when the red color is less likely to appear. Red coloration often occurs in patches created by winds and water currents passing through the area. Shellfish left in the wake of these moving poisonous patches may remain toxic long after evidence of the algae bloom has passed. Thus, water color alone is not a consistent indicator of PSP toxicity. To emphasize this point, none of the five PSP outbreaks in Kodiak in 1993 were preceded by a red tide. However, if a red tide is in progress, do not eat the shellfish! You may not know what is causing the red coloration.

Is shellfish purchased at a seafood retailer safe to eat?

Yes. Shellfish sold for human consumption must meet the Food and Drug Administration standard of less than 80 ug of PSP toxin per 100 grams of shellfish tissue. Alaska regulations require regular monitoring of commercially harvested shellfish or batch certification that requires each commercially harvested or farm grown batch of shellfish to pass the PSP test prior to market.

Are there some clam beaches in Alaska certified to be free from PSP toxin?

No. Unlike other west coast states, Alaska does not certify recreational beaches for evidence of PSP toxin. The term "certified beach" is used in Alaska, but a certified beach is one that has passed a fecal coliform test. This test certifies a beach free from sewage caused pollution and indicates the shellfish are free of human pathogens like cholera or hepatitis.

Can I test for PSP in shellfish by chewing a small piece of shellfish tissue and see if I feel tingling in my lips? If no tingling or numbness occurs, is the shellfish OK to eat?

No. Only a mouse bioassay is approved by the U.S. Food and Drug Administration for detection of PSP toxins. The test procedure first extracts PSP toxins from 150 grams of shellfish tissues. The extract is injected into 3 Swiss Webster strain white mice 18-23 grams in weight. The amount of time required for the mice to die is recorded then converted to micrograms (ug) of toxin by substitution into a prescribed mathematical formula.

Chewing on a small piece of shellfish gives you no clue as to the PSP dosage in the tissue. In addition, PSP toxins in an acid pH environment undergo chemical transformations that may produce more potent toxins than originally found in the shellfish. Since your mouth has a nearly neutral pH, the toxins in your mouth may not have the potency as the toxins that are formed in acidic conditions of your stomach. With data collected during recent outbreaks, the Alaska Department of Epidemiology found evidence of toxin transformations in the digestive tract of humans. The amount of change in PSP toxicity caused by these transformations has not been confirmed and requires additional research.

Is my risk of getting PSP reduced if I dig clams in an area where there is an ongoing commercial fishery?

It depends. In the Cook Inlet region, PSP has not been a problem with razor clam harvesting. During the razor clam fishery for example, commercial harvesters submit a sample for PSP analysis at every other tidal change. The Alaska Department of Environmental Conservation then fills in the remainder of the sampling schedule. This massive testing program has not found PSP levels that exceed the FDA standard. The same is true for the littleneck clam fishery in Kachemak Bay. However, reliance on commercial fishery sampling has a major drawback since you do not have immediate knowledge of the commercial fishery PSP test results.

Shellfish from other locations around the state—Southeast Alaska, Prince William Sound, Kodiak, and the Aleutians; have PSP toxin problems. Commercial harvest of shellfish in these areas requires certification of the harvested batch before marketing. Again, as a personal use harvester, you do not have access to the PSP test results.

Does cleaning the intestinal contents of the shellfish make them safer to eat?

Sometimes. The digestive tract of the shellfish is the first tissue to accumulate PSP toxin from the food they consume, and cleaning the intestinal contents can reduce your risk if done during the early part of the toxic bloom. The problem, however, is that you have no indication of how long the shellfish have been consuming the toxic algae. After initial consumption by the shellfish, the toxin distributes to other tissues, and the level of toxicity these other tissues achieve depends on a number of factors. Butter clams store highly toxic forms of toxins in their siphon, the part most often eaten. Along with the intestinal contents the most toxic tissues tend to be gonad, siphon, foot, mantle, and gills. Several articles in this publication provide additional information of tissue accumulation.

Does cooking eliminate PSP from shellfish?

No. PSP toxins are heat stable. Even when pressure cooked at a temperature of 250°F for 15 minutes, PSP remains toxic.

PSP: The Bacterial Connection

references continued from p. 13

Doucette, G.J. and C.G. Trick. 1995. Characterization of bacteria associated with different isolates of *Alexandrium tamarense*. Pages 33-38, *in* P. Lassus, G. Arzul, E. Erard, P. Gentien, and C. Marcaillou, editors. Harmful Algal Blooms. Technique et Documentation - Lavoisier, Intercept Limited.

Doucette, G.J. 1995. Interactions between bacteria and harmful algae: a review. Natural Toxins 3:65-74.

Kodama, M., T. Ogata, and S. Sato. 1988. Bacterial production of saxitoxin. Agriculture and Biological Chemistry. 52:1075-1077.

Kodama, M., T. Ogata, S. Sakamota, S. Sato, T. Honda, and T. Miwatani. 1990. Production of paralytic shellfish toxins by a bacterium *Moraxella* sp. isolated from Protogonyaulax tamarensis. Toxicon 28:707:14.

Neal, R.A. 1967. Fluctuations in the levels of paralytic shellfish toxin in four species of lamellibranch molluscs near Ketchikan, Alaska, 1963-1965. Ph.D. Dissertation, University of Washington, Seattle, WA. pp. 1964

Schantz, E.J. and H.W. Magnussen. 1964. Observations of the origin of paralytic poison in Alaska butter clams. Journal of Protozoology 11:239-242.

Silva, E.S. and I. Sousa. 1981. Experimental work on the dinoflagellate toxin production. Arq. Inst. Nac. Sau´de 6:381-387.

Sparks A.D. 1966. Physiological ecology of the causative organisms including mechanisms of toxin accumulation in shellfish. pages 10-11, *in* W. Felsing (ed) Proceedings of Joint Sanitation Seminar on North Pacific Clams. Alaska Department of Health and Welfare and U.S. Dept. of Health, Education, Welfare and Public Health Service.

Zimmerman, S.T. and R.S. McMahon. 1976. Paralytic shellfish poisoning in Tenakee, Southeastern Alaska: a possible cause. Fisheries Bull. (U.S.) 74:679-680.

Epidemiology of Paralytic Shellfish Poisoning Outbreaks in Alaska

Dr. Brad Gessner, Section of Epidemiology, Alaska Department of Health and Social Services

The information presented below represents an update of information presented in a previously published article (Gessner and Middaugh, Am J Epidemiol 1995;141:766-70). Persons interested in further detail, including methodology, should consult this article.

Between 1973 and 1994, 66 outbreaks of paralytic shellfish poisoning occurred in Alaska, involving 143 ill persons. Of the 143 ill persons, the most common symptom was paresthesias including perioral or extremity numbness or tingling (n=137). Other common symptoms included nausea or vomiting in 57 persons, trouble with balance in 39, dizziness in 37, shortness of breath in 35, a floating sensation in 33, dry mouth in 23, difficulty seeing in 19, difficulty talking in 17, diarrhea in 10, and difficulty swallowing in 10. Eight persons had paralysis of a limb, eight required mechanical ventilator support, and two died. The time from ingestion of shellfish to illness onset ranged from 5 minutes to 11 hours (most commonly, 1 hour). The time from illness onset until resolution of symptoms ranged from 30 minutes to 8 hours (most commonly, 8 hours). The majority of persons had cooked their shellfish before eating it (76%).

Most outbreaks occurred during May and June with a smaller number during July (79%) (Figure 1). However, outbreaks occurred during every month except November and December. Among 61 outbreaks where the shellfish species was known, 57% involved butter clams (*Saxidomus giganteus*); 30% involved mussels (*Mytilis edulis* or *californianus*); 13% involved cockles (*Clinocardium nuttalli*); and 5% each involved razor clams (*Siliqua patula*) or littleneck clams (*Protothaca staminea*); some outbreaks involved more than one species.

Symptoms of 143 people with paralytic shellfish poisoning, Alaska, 1973-94

Symptom	Number
Paresthesias (tingling on skin)	113
Perioral (lip) numbness	64
Perioral (lip) tingling	61
Nausea	45
Extremity numbness	43
Extremity tingling	39
Vomiting	34
Weakness	33
Ataxia (immobility)	32
Shortness of breath	29
Dizziness	28
Floating sensation	24
Dry mouth	23
Diplopia (double vision)	19
Dysarthria (difficulty speaking)	16
Diarrhea	10
Dysphagia (difficulty swallowing)	6
Limb paralysis	4

For 1979-92, we determined the location of outbreaks (Figure 2). No outbreaks occurred north of the Aleutian Chain. Most outbreaks occurred on Kodiak Island, the southern edge of the eastern half of the Aleutian Islands, and in Southeastern Alaska. Interestingly, no outbreaks have resulted from eating shellfish collected from Cook Inlet, including Clam Gulch, and only one outbreak has resulted from eating clams collected from Prince William Sound, on Montague Island.

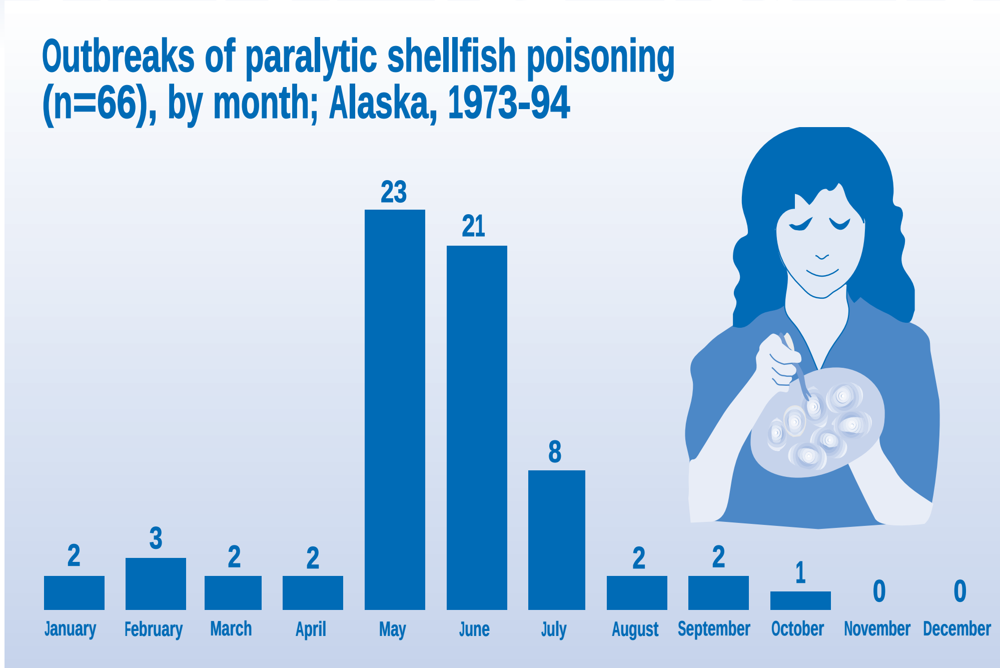
To evaluate the historical trends of paralytic shellfish poison levels in Alaska shellfish, we analyzed records from the Alaska Department of Environmental Conservation for all shellfish tested which had detectable paralytic shellfish poison (>39 ug/100 gm tissue) during July 1982-February 1992. These records roughly corresponded with data from outbreaks and showed that the mean paralytic shellfish poison level varied by month and shellfish type and that the highest toxin levels occurred among mussels and butter clams during May and June. All types of shellfish tested, except razor clams, had at least one sample with detectable levels during the winter (December-February).

Comment

Although suspected previously, a recent investigation provides evidence that most cases of paralytic shellfish poisoning go unreported (Alaska Division of Public Health, unpublished data). Cases of paralytic shellfish poisoning are sentinel events, signaling public health providers to warn local residents about the increased danger from eating shellfish. For this reason, persons who experience symptoms of paralytic shellfish poisoning, even if they only experience numbness or tingling, should immediately report their symptoms to a medical provider. Medical providers, in turn, should immediately report all suspected cases of paralytic shellfish poisoning to the Alaska Section of Epidemiology.

The data presented above indicates that the most dangerous shellfish consumption involves eating mussels or butter clams collected from south of the Aleutian chain during May, June, or July. Although less dangerous, outbreaks have also occurred with razor clams, cockles, and littleneck clams. Additionally, outbreaks have occurred during all months of the year except November and December. It is also important to recognize that saxitoxin and its analogues are heat stable toxins. Thus, unlike many other shellfish-borne illnesses, paralytic shellfish poisoning may occur even when eating cooked shellfish. While some persons believe siphon removal prevents illness, evidence indicates that sufficient toxin exists in the remainder of the shellfish to cause symptoms. Persons who harvest shellfish, including recreational and subsistence users, should familiarize themselves with the epidemiology of paralytic shellfish poisoning to minimize their risk of illness.

Case Histories: Paralytic Shellfish Poisoning



Case 1

Within one hour after eating 50 roasted mussels, a 28-year-old male Kodiak resident developed perioral paresthesias, nausea, and vomiting followed by headache, and difficulty talking, swallowing, and walking. Shortly after presenting to the Kodiak Island Hospital he had a respiratory arrest. The patient was rapidly incubated and placed on mechanical ventilation. A neurologic examination shortly after the respiratory arrest suggested the patient did not have cortical functioning and consideration was given to pronouncing him dead. The clinicians caring for the patient, however, recognized that the symptoms were consistent with paralytic shellfish poisoning and maintained supportive therapy. Several hours later the patient regained consciousness and within 24 hours had complete symptom resolution.

Case 2

Within 1 hour of eating at least 12 raw and cooked mussels, a 61-year-old female Old Harbor resident developed paresthesias, vomiting, weakness, and difficulty walking. Soon after presentation at the local health clinic she suffered a respiratory arrest. Because no trained personnel or equipment for endotracheal intubation were available, community health workers supported the patient with bag and mask ventilation. When emergency medical technicians arrived for air transport to Kodiak, the patient had no pulse or voluntary respirations. At the Kodiak Island Hospital, a cardiac examination suggested her heart had stopped working. Despite vigorous resuscitative efforts, she was pronounced dead approximately six hours after she had consumed mussels.

Comment

These two cases illustrate the potential severity of paralytic shellfish poisoning. Patient 1

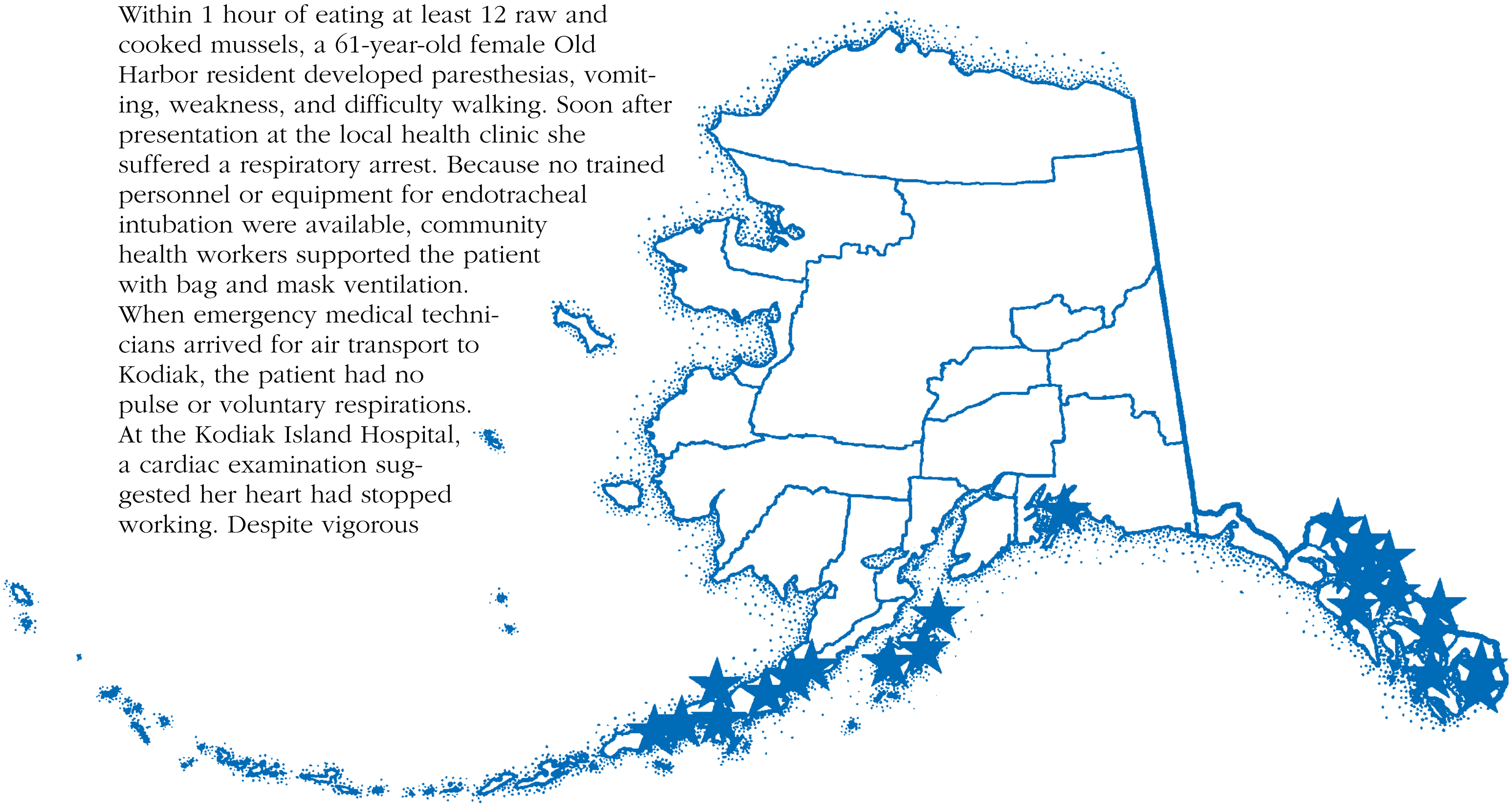


Figure 2: Location of paralytic shellfish poisoning outbreaks; Alaska, 1973-92
★ indicates ≥ 1 outbreak

Paralytic Shellfish Poisoning In The North Pacific: Two Historical Accounts and Implications for Today

Robert Fortuine, M.D.

Excerpt from "Chills and Fever", published by University of Alaska Press

The Natives of Alaska were exposed to several types of poisonous substances in their natural environment. Although general experience and cultural taboos protected them from frequent encounters with these hazards, illness and death could result from accidental (or sometimes intentional) exposure.

Paralytic shellfish poisoning, or PSP, is caused by the ingestion of a powerful toxin that is produced by severe species of plankton called dinoflagellates. These plankton sometimes "bloom" and are ingested by certain bivalve mollusks, such as mussels and razor clams. When the latter in turn are eaten by humans, a severe illness may result. The disease is characterized by numbness and tingling around the mouth, vomiting, diarrhea, and double vision, followed in severe cases by respiratory paralysis that may lead to death. This problem was first identified in the north Pacific nearly two hundred years ago and still claims periodic victims (Fortuine 1975b.)

What was undoubtedly an episode of severe PSP occurred in southeastern Alaska in July 1799, although early accounts differ on the date. Aleksandr Baranov himself, the chief manager of the newly formed Russian-American Company, has left a description of this tragic event, even though he was not personally a witness. A large party of Aleut hunters under his command had left the new fort on Sitka Island and were on their way back to Kodiak in their skin boats, when they stopped for the night at a place called Khutznov Strait, later called Peril Strait to commemorate the event. Although well supplied with provisions, the Natives could not resist eating some of the small, black mussels that were abundant in the area. Two minutes later about half the party experienced nausea and felt a dryness in the throat. By the end of two hours, says the account, about a hundred hunters had died. Some were saved, according to Baranov, by taking a mixture of gunpowder, tobacco, and spirits to induce vomiting. So far so good, but the chief manager goes on to describe how the illness then became infectious and others died without having eaten the mussels at all (Baranov *in* Tikhmenev 1979, 110-11; Khlebnikov 1973, 26-27).

The unique account of a Native witness—a Koniag named Arsenti—was preserved by Heinrich Johan Holmberg many years later (1985, 43):

> "When we found ourselves in Pogibshii proliv (Peril Strait), we turned to eating mussels (Mytilis) because of a shortage of fresh fish. They must have been poisonous at this time of year for a few hours later more than half of our men died. Even I was near death, but remembering my father's advice, to eat smelt (korushki) at such times, I vomited and recovered my health."

Arsenti's version is interesting because it shows that he knew mussels were poisonous in certain seasons of the year, and also knew of a traditional remedy, both of which point to previous experience with the disease.

The account of the same episode by Davydov (1977, 177) a few years later sheds some further light. According to him the Koniag were well acquainted with shellfish poisoning and knew that the mollusks could be harmless at some times and poisonous at others. In describing the events at Peril Strait (which he incorrectly dates in 1797), he recalled that the party camped at the mouth of a stream where there were many shellfish on both banks. Only those from the bank where there was no seaweed covering them caused illness. Within a half hour of eating the mussels a Chugach Eskimo had died, followed shortly by the death of five Koniag. According to Davydov, some eighty persons died that day. All who immediately ate sulfur, rotting fish, tobacco, or gunpowder survived, although some still had tingling sensations in the skin several years later. Davydov heard that pepper boiled in water was also an effective remedy, although no one seems to have tried it at the time. He also asserted that those who were affected felt some relief with the ebb tide.

The disaster at Peril Strait was an unforgettable one but certainly not unique. Veniaminov (1984, 364) mentioned that the Aleuts knew that clams and mussels were sometimes poisonous from May to September, while Holmberg (1985, 42-43) indicated that shellfish poisoning was well known in Kodiak in earlier times.

References

Davydov, G.I. 1977. Two voyages to Russian America, 1802-1807. Translated by C. Berne. Ed. R.A. Pierce. Kingston, Ontario: Limestone Press.

Fortuine, R. 1975b. Paralytic shellfish poisoning in the North Pacific: Two historical accounts and implications today. Alaska Medicine 17(5):71-76.

Holmberg, H. 1985. Holmberg's ethnographic sketches. Ed. Marvin W. Falk. Translated by F. Jaensch. The Rasmuson Library Historical Translation Series. Vol. 1. Fairbanks: University of Alaska Press.

Khlebnikov, K.T. 1973. Baranov: Chief Manager of the Russian colonies in American. Translated by C. Bearne. Ed. R.A. Pierce. Kingston, Ontario: Limestone Press.

Tikhmenev, P.A. 1979. A history of the Russian American Company. Volume 2 documents. Pertiod 1783-1807. Translated by D. Krenov. Ed. R.A. Pierce and A.S. Donnelly. Kingston, Ontario: Limestone Press.

Veniaminov, I. 1984. Notes on the islands of the Unalaska District. Translated by L.T. Black and R.H. Geoghegan. Ed. R.A. Pierce. Kingston, Ontario: Limestone Press.

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survived only because he was able to find medical assistance before he had a respiratory arrest and because of the clinical acuteness of the health care providers caring for him. This case emphasizes the need for health care providers to recognize the symptoms of paralytic shellfish poisoning and, when it is suspected, to maintain respiratory support regardless of adverse neurologic findings. Case 2 died despite receiving appropriate medical care before her respiratory arrest. It is possible that she died of a cardiac arrhythmia rather than respiratory arrest, a recognized complication when exceptionally high amounts of toxin have been ingested. Both of these patients ate mussels, the shellfish traditionally associated with the highest toxin levels; collecting during May, the month which usually has the highest toxin levels; from Kodiak Island, a location which has been the site of several previous outbreaks. This raises the possibility that culturally appropriate education could have prevented these outcomes.

Sea Watch

Have you seen:

- discolored ocean, bay or estuary waters?
- unusual behavior or illness displayed by a group of fish, birds, or mammals?
- an extensive bird, mammal, or fish kill?

If your answer is yes, call Sea Watch at 1-800-731-1312 and report your observations.

The Department of Environmental Conservation's (DEC) Division of Environmental Health is urging you to call this information so that it can be used with marine toxin data to help forecast toxic events. These forecasts could help with public health notices regarding the possibility of toxic shellfish or crab, and assist the department in monitoring commercial crab harvests for possible PSP.

Marine toxins, such as PSP and domoic acid, are produced under certain environmental conditions by marine phytoplankton—the source of "red tides" sometimes observed. The toxins may be concentrated in the bodies of filter-feeding shellfish and in the viscera or guts, of crab and can thus become a public health hazard.

When you call, the department needs to know the exact location of your sighting, in detail if possible, especially latitude/longitude, loran, or by landmark. They would also like you to collect a quart or more of the water in a clean container and refrigerate it. When you call they will give you instructions on what to do with it.

Contact any of the following offices for information on:

- **Fisheries Business Management**
- **Seafood Technology**
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- **Processing**
- **Legislation**
- **Workshops**
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The Business of Farming

Economic Model for Optimum Alaska Shellfish Oyster Farm –

Review of Assumptions and Conclusions

Glenn Haight
Anchorage Alaska
November 2007

Alaska Sea Grant Marine Advisory Program

Optimum Farm Model – Review of Assumptions and Calculations

Profit and Loss Statement

										Year
Item	1	2	3	4	5	6	7	8	9	10
A. Cost										
Farm Equipment	$ 694	$ 1,388	$ 5,550	$ 7,632	$ 12,488	$ 16,651	$ 19,426	$ 19,426	$ 19,426	$ 19,426
Boat (30')	$ 3,750	$ 3,750	$ 3,750	$ 3,750	$ 3,750	$ 3,750	$ 3,750	$ 3,750	$ 3,750	$ 3,750
Work Platform	$ 144	$ 144	$ 144	$ 144	$ 144	$ 144	$ 144	$ 144	$ 144	$ 144
Packing Facility	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000	$ 1,000
Refrigeration Unit	$ 275	$ 275	$ 275	$ 275	$ 275	$ 275	$ 275	$ 275	$ 275	$ 275
Truck	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750	$ 750
Owner/Operator Opportunity Cost	$ 42,000	$ 42,000	$ 42,000	$ 42,000	$ 42,000	$ 42,000	$ 42,000	$ 42,000	$ 42,000	$ 42,000
Half-Time Employee	$ -	$ 23,780	$ 23,780	$ 23,780	$ 23,780	$ 23,780	$ 23,780	$ 23,780	$ 23,780	$ 23,780
Supply/Maintenance/Telecommunications	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000
Fuel	$ 6,000	$ 6,000	$ 6,000	$ 6,000	$ 6,000	$ 6,000	$ 6,000	$ 6,000	$ 6,000	$ 6,000
Seed Cost	$ 3,094	$ 6,188	$ 12,375	$ 18,563	$ 24,750	$ 24,750	$ 24,750	$ 24,750	$ 24,750	$ 24,750
Packing Supplies	$ -	$ -	$ 1,004	$ 2,007	$ 4,015	$ 6,022	$ 8,029	$ 8,029	$ 8,029	$ 8,029
Application and Bond Fee	$ 2,600	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Lease	$ 1,575	$ 1,575	$ 1,575	$ 1,575	$ 1,575	$ 1,575	$ 1,575	$ 1,575	$ 1,575	$ 1,575
PSP Testing Fees	$ -	$ -	$ 5,124	$ 5,124	$ 5,124	$ 5,124	$ 5,124	$ 5,124	$ 5,124	$ 5,124
Freight	$ -	$ -	$ 5,451	$ 10,901	$ 21,803	$ 32,704	$ 43,605	$ 43,605	$ 43,605	$ 43,605
Total Cost Per Year	$ 71,882	$ 96,849	$ 118,778	$ 133,501	$ 157,454	$ 174,525	$ 190,209	$ 190,209	$ 190,209	$ 190,209
B. Gross Revenue										
1. Oyster Sales	$ -	$ -	$ 32,174	$ 64,348	$ 128,695	$ 193,043	$ 257,391	$ 257,391	$ 257,391	$ 257,391
2. Salvage Value	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Gross Revenue	$ -	$ -	$ 32,174	$ 64,348	$ 128,695	$ 193,043	$ 257,391	$ 257,391	$ 257,391	$ 257,391
Profit/Loss	$ (71,882)	$ (96,849)	$ (86,604)	$ (69,153)	$ (28,758)	$ 18,518	$ 67,182	$ 67,182	$ 67,182	$ 67,182

Baseline Model

Item/Year	**$ 1**	**$ 2**	**$ 3**	**$ 4**	**$ 5**	**$ 6**	**$ 7**	**$ 8**	**$ 9**	**$ 10**
Total Gross Revenue	$ -	$ -	$ 32,174	$ 64,348	$ 128,695	$ 193,043	$ 257,391	$ 257,391	$ 257,391	$ 257,391
Total Cost Per Year	$ 71,882	$ 96,849	$ 118,778	$ 133,501	$ 157,454	$ 174,525	$ 190,209	$ 190,209	$ 190,209	$ 190,209
Profit/Loss	$ (71,882)	$ (96,849)	$ (86,604)	$ (69,153)	$ (28,758)	$ 18,518	$ 67,182	$ 67,182	$ 67,182	$ 67,182

Optimum Farm Model – Review of Assumptions and Calculations

Development plan for a 10 acre bottom lease 4.48 acre surface production 10 tiered lantern net

	Operational year								
Cohort	Number of longlines with full longline having 75 10-tiered lantern nets intially stock with 250 spat per net chamber for three year growout to market size								
Cycle	1	2	3	4	5	6	7	8	9
0	**0.5**							**Carrying**	
		1					**Year**	**Capasity/net**	red = seed p
1		**1**	**2**				Seed	2500	Other cc
			2				1	1500	Blue i
2			**2**	**4**			2	750	
				4			3	750	
3				**3**	**8**				
					6				
4					**4**	**12**			
						8			
5						**4**	**16**		
		Survival rates	**85%**	**year 0-1**			**8**		
6			**95%**	Year 1 0 harvest			**4**	**16**	
		Even years	Time of seed stocking					**8**	
7			Beginning in year 2 harvest beginns						**16**
8									
9									
Longlines required	1	2	8	11	18	24	28	28	28

Production cycle (seed, growout, and sales)								
1	2	3	4	5	6	7	8	9
93,750								
	79,688							
	187,500	**75,703**				**Seed**		
		159,375				**Growout year**		
		375,000	**151,406**			**Harvest**		
			318,750					
			562,500	**302,813**				
				478,125				
				750,000	**454,219**			
					637,500			
					750,000	**605,625**		
						637,500		
							605,625	

Assumptions

Main:

***** Farm is 4.8 acres surface area, thus 10 acre bottom lease

* Designed to be owner/operater, plus one half time employee.

*Oyster growth between 18 to 24 months. If planted year 1 on April 1, then oysters are ready to market summer/fall of year 2; thus 2 year rotation

* Did not start up with full capacity. Farmers recommend to go slow, thus lines are put in step wise

* seed purchased 20 to 25mm at $33.0 per 1000; $0.033 per seed

Optimum Farm Model – Review of Assumptions and Calculations

Seed Cost and Value Production

Harvest value of $5.10 FOB at city

Finished product			75,703	**151,406**	**302,813**	**454,219**	**605,625**	**605,625**	**605,625**	**605,625**
		Income	**$ 32,173.83**	**$ 64,348**	**$ 128,695**	**$ 193,043**	**$ 257,391**	**257,391**		
Initial seed planted	**93,750**	**187,500**	**375,000**	**562,500**	**750,000**	**750,000**	**750,000**			
1 year seed	**0**	**79,688**	**159,375**	**318,750**	**478,125**	**637,500**	**637,500**			
2 year seed	**0**	**0**	**75,703**	**151,406**	**302,813**	**454,219**	**605,625**			
	93,750	267,188	610,078	1,032,656	1,530,938	1,841,719	1,993,125			
PSP testing			**15.14**	**30.28**	**27.00**	**27.00**	**27.00**			
			$ 1,892.58	**3,785.16**	**$ 3,375.00**	**3,375.00**	**3,375.00**			
Farm help	0.43	1.24	2.82	4.78	7.09	8.53	9.23			

Assumptions

Regulations require batch havesting until the beginning of three years of operation
The shellfish passes all of the PSP tests
The farmer will provide PSP samples during the times required
The start time for the operational years is 1
Number of longlines with 75 lantern nets for each longline (initial seed stock 250 seed per tier, final density after two years 75 oysters per tier)
2 year growout cycle and into full production of 605,525 after 7 years
Operator and one part time person from March through September
The model assumes that an owner/operator can manage a farm size of 28 longlines with 75 nets per line
Starts with 0.5 longlines of seed purchase , progressing to one line after one year, then adding one seed line every year

	1	2	3	4	5	6	7	8	9	10
Yearly seed cost	**$ 3,094**	**$ 6,188**	**$ 12,375**	**$ 18,563**	**$ 24,750**	**$ 24,750**	**$ 24,750**	**$ 24,750**	**$ 24,750**	**$ 24,750**
Yearly longline cost	**$ 6,941**	**$ 6,941**	**$ 41,646**	**$ 20,823**	**$ 48,587**	**$ 41,646**	**$ 27,764**	**$ -**	**$ -**	**$ -**
Total annual cost	**$ 10,035**	**$ 13,129**	**$ 54,021**	**$ 39,386**	**$ 73,337**	**$ 66,396**	**$ 52,514**	**$ 24,750**	**$ 24,750**	**$ 24,750**
Sales income	0	0	$ 32,173.83	$ 64,347.66	$ 128,695.31	$ 193,042.97	$ 257,390.63	$ 257,390.63	$ 257,390.63	$ 257,390.63

Assumptions	
Seed cost/1000	$ 33.00
Longline cost	$6,941
Price per doz.	$ 5.10

	Square feet	Acres
Surface acres needed	128,000	3
Bottom lease should be double	256,000	6

Optimum Farm Model – Review of Assumptions and Calculations

Individual Long Line cohort Cycle and Years of Operation

Note: This is used to determine in 20 years of operation, when is the last harvest for a line that is put in from year 1 to 8. The objective is to help determine salvage values

Line/Year	1	2	3	4	5	6	7	8	9	10
1	Line Installed		H1		H2		H3		H4	
2		Line Installed		H1		H2		H3		H4
3			Line Installed		H1		H2		H3	
4				Line Installed		H1		H2		H3
3					Line Installed		H1		H2	
4						Line Installed		H1		H2
5							Line Installed		H1	
6								Line Installed		H1
7										

10	11	12	13	14	15	16	17	18	19	20	Years in Operation	
	H5		H6		H7		H8		H9		19	$ 1,318.80
H4		H5		H6		H7		H8		H9	19	$ 1,318.80
	H4		H5		H6		H7		H8		17	$ 2,706.40
H3		H4		H5		H6		H7		H8	17	$ 2,706.40
	H3		H4		H5		H6		H7		15	$ 2,824.00
H2		H3		H4		H5		H6		H7	15	$ 2,824.00
	H2		H3		H4		H5		H6		13	$ 4,211.60
H1		H2		H3		H4		H5		H6	13	$ 4,211.60

Equipment Costs

Item	Useful Life (Years)	Unit Cost (US$)		Quantity	Cost (US$)		Annual Cost	
A. Farm Equipment List								
1" Polyethylene Rope	20	$	1.60	620	$	992.00	$	49.60
Concrete Anchors (1800lb.)	20	$	165.00	2	$	330.00	$	16.50
Scope line weights	20	$	12.00	2	$	24.00	$	1.20
Anchor chain for each end	20	$	200.00	2	$	400.00	$	20.00
Lantern Nets	20	$	23.00	75	$	1,725.00	$	86.25
Buoys	12	$	25.00	75	$	1,875.00	$	156.25
Shackles	10	$	11.00	75	$	825.00	$	82.50
Droplines (75x6')	5	$	1.60	450	$	720.00	$	144.00
Water Pump	4	$	550.00	1	$	550.00	$	137.50
Total					$	7,441.00	$	693.80

B. Longline System

*items, costs, and useful life for a 300 foot longline of lantern nets

*to be deployed on a 10 acre square bottom lease with side length of 660ft. And 60ft. Depth

Item	Cost		Unit	No. of Units	Total Cost		Useful Life
1" Polyethylene Rope	$	1.60	feet	620	$	992.00	20
Concrete Anchors (1800lb.)	$	165.00	1800lb.	2	$	330.00	20
Scope line weights	$	12.00	50lb.	2	$	24.00	20
Droplines (75x6')	$	1.60	feet	450	$	720.00	5
Anchor chain for each end	$	200.00	per chain	2	$	400.00	20
Shackles (attach lantern nets tc	$	11.00	per shackle	75	$	825.00	10
Buoys	$	25.00	each	75	$	1,875.00	12
Lantern Nets	$	23.00	each	75	$	1,725.00	20
					$	6,891.00	

Optimum Farm Model – Review of Assumptions and Calculations

Annual Long Line Costs and Salvage Values

Line/Year	1	2	3	4	5	6	7	8	9	10
1	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
2		$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
3			$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
4			$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
5			$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
6			$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
7			$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
8			$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
9				$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
10				$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
11				$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
12					$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
13					$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
14					$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
15					$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
16					$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
17					$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
18					$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
19						$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
20						$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
21						$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
22						$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
23						$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
24						$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80
25							$ 693.80	$ 693.80	$ 693.80	$ 693.80
26							$ 693.80	$ 693.80	$ 693.80	$ 693.80
27							$ 693.80	$ 693.80	$ 693.80	$ 693.80
28							$ 693.80	$ 693.80	$ 693.80	$ 693.80
Yearly Cost	$ 693.80	$ 1,387.60	$ 5,550.40	$ 7,631.80	$ 12,488.40	$ 16,651.20	$ 19,426.40	$ 19,426.40	$ 19,426.40	$ 19,426.40
Salvage Values	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Line/Year	11	12	13	14	15	16	17	18	19	20	Years in Operation	
1	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		19	$ 1,318.80
2	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	19	$ 1,318.80
3	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		17	$ 2,706.40
4	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		17	$ 2,706.40
5	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		17	$ 2,706.40
6	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		17	$ 2,706.40
7	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		17	$ 2,706.40
8	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		17	$ 2,706.40
9	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	17	$ 2,706.40
10	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	17	$ 2,706.40
11	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	17	$ 2,706.40
12	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		15	$ 2,824.00
13	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		15	$ 2,824.00
14	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		15	$ 2,824.00
15	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		15	$ 2,824.00
16	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		15	$ 2,824.00
17	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		15	$ 2,824.00
18	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		15	$ 2,824.00
19	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	15	$ 2,824.00
20	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	15	$ 2,824.00
21	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	15	$ 2,824.00
22	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	15	$ 2,824.00
23	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	15	$ 2,824.00
24	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	15	$ 2,824.00
25	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		13	$ 4,211.60
26	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		13	$ 4,211.60
27	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		13	$ 4,211.60
28	693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80	$ 693.80		13	$ 4,211.60
Yearly Cost	19,426.40	$ 19,426.40	$ 19,426.40	$ 19,426.40	$ 19,426.40	$ 19,426.40	$ 19,426.40	$ 19,426.40	$ 19,426.40	$ 6,938.00		
Salvage Values	-	$ -	$ 16,846.40	$ -	$ 36,712.00	$ -	$ 24,357.60	$ -	$ 2,637.60	$ -		

Optimum Farm Model – Review of Assumptions and Calculations

Year One Capital Outlay and Annualized Depreciation

Item	Useful Life (Years)	Unit Cost (US$)	Quantity	Cost (US$)	Annual Cost	% of Annual Cost
A. Farm Equipment List						
1" Polyethylene Rope	20	$ 1.60	620	$ 992.00	$ 49.60	
Concrete Anchors (1800lb.)	20	$ 165.00	2	$ 330.00	$ 16.50	
Scope line weights	20	$ 12.00	2	$ 24.00	$ 1.20	
Droplines (75x6')	5	$ 1.60	450	$ 720.00	$ 144.00	
Anchor chain for each end	20	$ 200.00	2	$ 400.00	$ 20.00	
Shackles	10	$ 11.00	75	$ 825.00	$ 82.50	
Buoys	12	$ 25.00	75	$ 1,875.00	$ 156.25	
Lantern Nets	20	$ 23.00	75	$ 1,725.00	$ 86.25	
Water Pump	4	$ 550.00	1	$ 550.00	$ 137.50	
Total Farm Equipment		$ 989.20		$ 7,441.00	$ 693.80	
B. Water Support Equipment						
Boat (30')	20	$ 75,000.00	1	$ 75,000.00	$ 3,750.00	
Work Platform	10	$ 1,940.00	1	$ 1,940.00	$ 194.00	
Total Water Support		$ 76,940.00		$ 76,940.00	$ 3,944.00	
C. Land Infrastructure						
Packing Facility	20	$ 20,000.00	1	$ 20,000.00	$ 1,000.00	
Refrigeration Unit	20	$ 5,500.00	1	$ 5,500.00	$ 275.00	
Total Land Infrastructure		$ 25,500.00		$ 25,500.00	$ 1,275.00	
D. Logistics Support						
Pick-up Truck	10	$ 7,500.00	1	$ 7,500.00	$ 750.00	

Optimum Farm Model – Review of Assumptions and Calculations

Fuel

Assumption: **$6000 fuel consumption per year**

Regulatory Costs

One-Time Fees

*ADNR application fee -- $100 included with application

*ADNR bond -- $2500 per farm site (may increase with facilities)

Assumption: **$2,600 one time charge**

Annual Fees

*** Lease Fees**

$450 up to 1 acre plus $125 each additional acre -- in our model, we noted a 10 acre bottom lease = $1575 per year

Assumption: **$1575 per year lease**

***PSP Sampling**

First 2 years no. Then weekly for 26 weeks, then monthly for 6 months. Plus 3 extra for re-test

Item	Frequency	Cost	Subtotal
Testing	35	$ 125.00	$4,375.00
Freight	35	$ 21.40	$ 749.00
Total			$ 5,124.00

Assumption: **$5124 per year for PSP testing starting year 3**

Optimum Farm Model – Review of Assumptions and Calculations

Packing Supplies

*each 50 lb. wet lock box can hold 20 dozen mediums and 25 dozen smalls

Assumption:

•each box cost $2.30 for 22 dozen i.e. 264 oysters

•*$2.3 per box and liner, average 3 gel packs. Total = $2.3 + $1.2 = $3.5

***$3.5 X (no. of oysters produced per year/264)=annual total cost for packing supplies**

Annual Cost for Packing Supplies

Item/Year	1	2	3	4	5	6	7	8	9
Marketable Oysters	0	0	75,703	151,406	302,813	454,219	605,625	605,625	605,625
No. of Boxes	0	0	287	574	1,147	1,721	2,294	2,294	2,294
Annual Cost	0	0	$1,003	$2,007	$4,014	$6,021	$8,029	$8,029	$8,029

Packing Facility

a. 20x20 shed with concrete floor -- shed has small storage space with boxes on site - sink, stainless table

b. Refrigeration unit, walk in cooler -- $5500   20 years use including refrigeration unit

Assumption: **$20,000 for structure, $5500 for refrigeration unit and walk in cooler; useful life 20 years.**

Optimum Farm Model – Review of Assumptions and Calculations

Freight to FOB Point **from farm to city**

1. Freight $/lb.
•use $0.4 per pound

2. Lbs. per year shipped
*the following table shows weight in lbs per dozen and per oyster

2. Lbs. per year shipped

*the following table shows weight in lbs per dozen and per oyster

Oyster Size	Avg Wt./Doz	Avg Wt./Oyster
Small (3-4")	1.8	0.15
Medium (4-5")	2.19	0.18
Large (>5")	2.74	0.23

Assumption: **$0.40 per lb. freight**

Table C1 Freight Cost per Year

Item/Year	1	2	3	4	5	6	7	8	9
Average Weight/Oyster (lb.)	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Marketable Oysters	0	0	75,703	151,406	302,813	454,219	605,625	605,625	605,625
Oyster Produced (lb.)	0	0	13,627	27,253	54,506	81,759	109,013	109,013	109,013
Frieght Cost Per Year	$ -	$ -	$ 5,450.62	$ 10,901.23	$ 21,802.54	$ 32,703.77	$ 43,605.00	$ 43,605.00	$ 43,605.00

Optimum Farm Model – Review of Assumptions and Calculations

Farm Structure

A. Work Platform

* use for storage, washing oysters, and for bad weather workplace

* Cost: $500 for about 16'x32'; a combination of new and old lumber, floatation by using logs on beach; useful life = 10 years

* Labor cost to build platform: 3 x 8 hour days, $20 per person per hour, for 3 persons = $1,440

*washing pump needed to wash oysters. Cost: $575; useful life 4 year

*fuel: use to run washer. Usage: 12 gallons fuel per week for 7 months = 28 weeks x 12 gallons x $4.00 = $1344 per season i.e. per year

Assumptions: **$1440 work platform; useful life 10 years**

$550 Water pump: useful life 4 years -- this is included in *farm equipment* cost category.

Transportation

* commuting to the grounds and stay there to work

*Farmer A options -- • 29ft. landing craft, got it for $50,000 used to run back and forth to the farm, as dwelling, and work platform when low wind. A brand new one would cost $180,000. Useful life for hull, 20 years. Has a diesel engine that rated for 30,000 hours, he does not use the engine much, only 4 hours roundtrip to farm. In 10 years, he put 2500 hours in it.

*Farmer b options -- 40 foot seiner; bought used for USD 90,000 including a seine permit; old boat so no insurance; 20 years useful life fuel use $120 per week

*Farmer C -- lives on houseboat -- but said that if he does it again, he would consider commuting

Note: we assume that the boat costs $75000 used that has a useful life of 20 years, including a diesel engine that also has a useful life of 20 years that rated 30,000 hours.

Assumption: **$75,000 boat cost including engine; useful life 20 years**

Location

•farm is located about 10 to 15 miles from town

•* secure because there are nobody around

•* commute to farm by boat, stay there for 3, 4 days or so.

Optimum Farm Model – Review of Assumptions and Calculations

Labor

***Farm owner opportunity cost -- $42,000

* help for 6 months -- $700 per week x 26 weeks plus $475 per month insurance plus 15% pay roll tax

Annual Labor Cost

Item	**Cost (USD)**
Owner/Manager Opportunity Cost*	$ 42,000.00
Farm Help (6 months)	$ 18,200.00
Farm Help Insurance	$ 2,850.00
Payroll Tax for Help	$ 2,730.00
Total	$ 65,780.00

*Note: include insurance etc.

Assumption: **$65,780 labor cost per year**

Office and Marketing

a. Marketing

*currently, demand exceeds supply, all 3 farmers have very little marketing costs

Maintenance, replacement costs, and other supplies

General Supplies

Assumption: **$10,000 for general supplies and maintenance per year.**

Optimum Farm Model – Review of Assumptions and Calculations

Recast – Pro Forma – Farm Only

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Gross Revenues	$ -	$ -	$ 32,174	$ 64,348	$ 128,695	$ 193,043	$ 257,391	$ 270,260	$ 283,773	$ 297,962	$ 312,860	$ 328,503	$ 344,928	$ 362,174	$ 380,283	$ 399,297	$ 419,262	$ 440,225	$ 462,237	$ 485,348
Returns	$ -	$ -	$ 322	$ 643	$ 1,287	$ 1,930	$ 2,574	$ 2,703	$ 2,838	$ 2,980	$ 3,129	$ 3,285	$ 3,449	$ 3,622	$ 3,803	$ 3,993	$ 4,193	$ 4,402	$ 4,622	$ 4,853
Net Revenues	$ -	$ -	$ 31,852	$ 63,704	$ 127,408	$ 191,113	$ 254,817	$ 267,558	$ 280,935	$ 294,982	$ 309,731	$ 325,218	$ 341,479	$ 358,553	$ 376,480	$ 395,304	$ 415,070	$ 435,823	$ 457,614	$ 480,495
Cost of Production																				
Farm Expense																				
Seed purchases	$ 3,094	$ 6,188	$ 12,375	$ 18,563	$ 24,750	$ 24,008	$ 23,287	$ 22,589	$ 21,911	$ 21,254	$ 20,616	$ 19,998	$ 19,398	$ 18,816	$ 18,251	$ 18,708	$ 19,175	$ 19,655	$ 20,146	$ 20,650
Farm labor	$ 30,000	$ 36,090	$ 42,984	$ 33,809	$ 34,654	$ 35,521	$ 36,409	$ 37,319	$ 38,252	$ 39,208	$ 40,188	$ 41,193	$ 42,223	$ 43,278	$ 44,360	$ 45,469	$ 46,606	$ 47,771	$ 48,965	$ 50,190
Farm insurance	$ 356	$ 365	$ 749	$ 767	$ 786	$ 806	$ 826	$ 847	$ 868	$ 890	$ 912	$ 935	$ 958	$ 982	$ 1,007	$ 1,032	$ 1,058	$ 1,084	$ 1,111	$ 1,139
Farm supplies	$ 50	$ 103	$ 420	$ 592	$ 993	$ 1,358	$ 1,624	$ 1,664	$ 1,706	$ 1,748	$ 1,792	$ 1,837	$ 1,883	$ 1,930	$ 1,978	$ 2,028	$ 2,078	$ 2,130	$ 2,184	$ 2,238
Water support maintence	$ 250	$ 256	$ 263	$ 269	$ 276	$ 283	$ 290	$ 297	$ 305	$ 312	$ 320	$ 328	$ 336	$ 345	$ 353	$ 362	$ 371	$ 380	$ 390	$ 400
Food provisions	$ 1,500	$ 1,538	$ 3,152	$ 3,231	$ 3,311	$ 3,394	$ 3,479	$ 3,566	$ 3,655	$ 3,747	$ 3,840	$ 3,936	$ 4,035	$ 4,136	$ 4,239	$ 4,345	$ 4,454	$ 4,565	$ 4,679	$ 4,796
Fuel cost	$ 4,080	$ 4,788	$ 8,203	$ 10,280	$ 14,878	$ 19,297	$ 22,835	$ 23,977	$ 25,176	$ 26,435	$ 27,756	$ 29,144	$ 30,601	$ 32,131	$ 33,738	$ 35,425	$ 37,196	$ 39,056	$ 41,009	$ 43,059
Total Farm Expense	$ 39,330	$ 49,327	$ 68,145	$ 67,511	$ 79,649	$ 84,666	$ 88,750	$ 90,259	$ 91,872	$ 93,593	$ 95,425	$ 97,371	$ 99,434	$ 101,618	$ 103,927	$ 107,368	$ 110,938	$ 114,641	$ 118,484	$ 122,471
Gross Profit after Farm Production	$ (39,330)	$ (49,327)	$ (36,293)	$ (3,806)	$ 47,759	$ 106,446	$ 166,067	$ 177,299	$ 189,063	$ 201,389	$ 214,306	$ 227,847	$ 242,045	$ 256,935	$ 272,554	$ 287,936	$ 304,131	$ 321,182	$ 339,130	$ 358,024
General and Administrative																				
PSP testing	$ -	$ -	$ 1,940	$ 3,880	$ 3,459	$ 3,546	$ 3,635	$ 3,725	$ 3,819	$ 3,914	$ 4,012	$ 4,112	$ 4,215	$ 4,320	$ 4,428	$ 4,539	$ 4,652	$ 4,769	$ 4,888	$ 5,010
DNR lease costs	$ 1,575	$ 1,614	$ 1,655	$ 1,696	$ 1,739	$ 1,782	$ 1,827	$ 1,872	$ 1,919	$ 1,967	$ 2,016	$ 2,067	$ 2,118	$ 2,171	$ 2,225	$ 2,281	$ 2,338	$ 2,397	$ 2,456	$ 2,518
DNR application and bond	$ 2,600	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Management	$ 10,000	$ 20,000	$ 30,000	$ 40,000	$ 41,000	$ 42,025	$ 43,076	$ 44,153	$ 45,256	$ 46,388	$ 47,547	$ 48,736	$ 49,955	$ 51,203	$ 52,483	$ 53,796	$ 55,140	$ 56,519	$ 57,932	$ 59,380
Office Supplies	$ 500	$ 513	$ 525	$ 538	$ 552	$ 566	$ 580	$ 594	$ 609	$ 624	$ 640	$ 656	$ 672	$ 689	$ 706	$ 724	$ 742	$ 761	$ 780	$ 799
Office Rent	$ 1,000	$ 1,025	$ 1,051	$ 1,077	$ 1,104	$ 1,131	$ 1,160	$ 1,189	$ 1,218	$ 1,249	$ 1,280	$ 1,312	$ 1,345	$ 1,379	$ 1,413	$ 1,448	$ 1,485	$ 1,522	$ 1,560	$ 1,599
Phone/Communications	$ 1,200	$ 1,230	$ 1,261	$ 1,292	$ 1,325	$ 1,358	$ 1,392	$ 1,426	$ 1,462	$ 1,499	$ 1,536	$ 1,575	$ 1,614	$ 1,654	$ 1,696	$ 1,738	$ 1,781	$ 1,826	$ 1,872	$ 1,918
Debt Service																				
Total G&A	$ 16,875	$ 24,382	$ 36,431	$ 48,483	$ 49,178	$ 50,408	$ 51,668	$ 52,960	$ 54,284	$ 55,641	$ 57,032	$ 58,457	$ 59,919	$ 61,417	$ 62,952	$ 64,526	$ 66,139	$ 67,793	$ 69,487	$ 71,225
Net Income Before Taxes	$ (56,205)	$ (73,709)	$ (72,725)	$ (52,290)	$ (1,419)	$ 56,039	$ 114,399	$ 124,339	$ 134,780	$ 145,748	$ 157,275	$ 169,390	$ 182,126	$ 195,518	$ 209,601	$ 223,410	$ 237,992	$ 253,389	$ 269,643	$ 286,799
Investing Activities																				
Longlines	$ 6,891	$ 7,063	$ 43,439	$ 22,263	$ 54,039	$ 47,594	$ 36,976	$ 2,568	$ 6,141	$ 7,325	$ 5,664	$ 14,623	$ 8,755	$ 30,417	$ 22,064	$ 29,002	$ 23,114	$ 14,699	$ 7,861	$ 17,922
Water pump	$ 550	$ -	$ -	$ 592	$ -	$ -	$ -	$ 654	$ -	$ -	$ -	$ 722	$ -	$ -	$ -	$ 797	$ -	$ -	$ -	$ 879
Water support	$ 76,940	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,940	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Truck	$ 7,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 7,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Office Equipment	$ 3,000	$ -	$ -	$ -	$ 1,000	$ -	$ -	$ -	$ 1,000	$ -	$ -	$ -	$ 1,000	$ -	$ -	$ -	$ 1,000	$ -	$ -	$ -
Total Investments	$ 94,881	$ 7,063	$ 43,439	$ 22,855	$ 55,039	$ 47,594	$ 36,976	$ 3,221	$ 7,141	$ 16,765	$ 5,664	$ 15,345	$ 9,755	$ 30,417	$ 22,064	$ 29,799	$ 24,114	$ 14,699	$ 7,861	$ 18,802
Cash Flow After Investments	$(151,086)	$ (80,772)	$ (116,164)	$ (75,145)	$ (56,458)	$ 8,445	$ 77,423	$ 121,118	$ 127,639	$ 128,984	$ 151,610	$ 154,045	$ 172,371	$ 165,101	$ 187,538	$ 193,611	$ 213,879	$ 238,690	$ 261,782	$ 267,997
Financing Activities																				
Equipment	$ 85,393	$ 6,357	$ 39,095	$ 20,569	$ 49,535	$ 42,834														
Operating Loan	$ 50,585	$ 66,338	$ 65,452	$ 47,061	$ 1,277	$ (50,435)														
Net Financing Activity	$ 135,977	$ 72,695	$ 104,547	$ 67,630	$ 50,813	$ (7,600)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Debt service - Interest and Principal	$8,159	$13,721	$32,614	$50,772	$72,137	$84,981	$95,008	$82,999	$67,251	$47,291	$30,103	$20,588	$20,588	$20,588	$20,588	$20,588	$20,588	$20,588	$20,588	$20,588
Cash Surplus (Shortfall)	$ (23,267)	$ (21,799)	$ (44,230)	$ (58,286)	$ (77,782)	$ (84,136)	$ (17,584)	$ 38,119	$ 60,388	$ 81,692	$ 121,507	$ 133,457	$ 151,783	$ 144,513	$ 166,950	$ 173,023	$ 193,290	$ 218,102	$ 241,194	$ 247,409

Optimum Farm Model – Review of Assumptions and Calculations

Recast – Pro Forma – Farm and Processing Facility

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
Gross Revenues	-	-	32,174	64,348	128,695	193,043	257,391	270,260	283,773	297,962	312,860	328,503	344,928	362,174	380,283	399,297	419,262	440,225	462,237	485,348
Returns	-	-	322	643	1,287	1,930	2,574	2,703	2,838	2,980	3,129	3,285	3,449	3,622	3,803	3,993	4,193	4,402	4,622	4,853
Net Revenues	-	-	31,852	63,704	127,408	191,113	254,817	267,558	280,935	294,982	309,731	325,218	341,479	358,553	376,480	395,304	415,070	435,823	457,614	480,495
Cost of Production																				
Farm Expense																				
Seed purchases	3,094	6,188	12,375	18,563	24,750	24,008	23,287	22,589	21,911	21,254	20,616	19,998	19,398	18,816	18,251	18,708	19,175	19,655	20,146	20,650
Farm labor	30,000	36,090	42,984	33,809	34,654	35,521	36,409	37,319	38,252	39,208	40,188	41,193	42,223	43,278	44,360	45,469	46,606	47,771	48,965	50,190
Farm insurance	356	365	749	767	786	806	826	847	868	890	912	935	958	982	1,007	1,032	1,058	1,084	1,111	1,139
Farm supplies	50	103	420	592	993	1,358	1,624	1,664	1,706	1,748	1,792	1,837	1,883	1,930	1,978	2,028	2,078	2,130	2,184	2,238
Water support maintence	250	256	263	269	276	283	290	297	305	312	320	328	336	345	353	362	371	380	390	400
Food provisions	1,500	1,538	3,152	3,231	3,311	3,394	3,479	3,566	3,655	3,747	3,840	3,936	4,035	4,136	4,239	4,345	4,454	4,565	4,679	4,796
Fuel cost	4,080	4,788	8,203	10,280	14,878	19,297	22,835	23,977	25,176	26,435	27,756	29,144	30,601	32,131	33,738	35,425	37,196	39,056	41,009	43,059
Total Farm Expense	39,330	49,327	68,145	67,511	79,649	84,666	88,750	90,259	91,872	93,593	95,425	97,371	99,434	101,618	103,927	107,368	110,938	114,641	118,484	122,471
Gross Profit after Farm Production	(39,330)	(49,327)	(36,293)	(3,806)	47,759	106,446	166,067	177,299	189,063	201,389	214,306	227,847	242,045	256,935	272,554	287,936	304,131	321,182	339,130	358,024
Processing Expense																				
Processing labor	-	-	10,995	11,270	11,551	11,840	12,136	12,440	12,751	13,069	13,396	13,731	14,074	14,426	14,787	15,156	15,535	15,924	16,322	16,730
Processing insurance	-	-	250	256	262	269	275	282	289	297	304	312	319	327	336	344	353	361	370	380
Freight	-	-	5,727	11,739	24,066	37,001	50,568	51,833	53,128	54,457	55,818	57,214	58,644	60,110	61,613	63,153	64,732	66,350	68,009	69,709
Packaging	-	-	1,054	2,162	4,431	6,813	9,311	9,544	9,783	10,027	10,278	10,535	10,798	11,068	11,345	11,629	11,919	12,217	12,523	12,836
Processing supplies	-	-	1,051	1,077	1,104	1,131	1,160	1,189	1,218	1,249	1,280	1,312	1,345	1,379	1,413	1,448	1,485	1,522	1,560	1,599
Processing maintenance	-	-	525	538	552	566	580	594	609	624	640	656	672	689	706	724	742	761	780	799
Processing overhead	-	-	1,091	1,118	1,146	1,175	1,204	1,234	1,265	1,297	1,329	1,363	1,397	1,432	1,467	1,504	1,542	1,580	1,620	1,660
Total Processing Expense	-	-	20,692	28,160	43,113	58,795	75,235	77,116	79,044	81,020	83,046	85,122	87,250	89,431	91,667	93,958	96,307	98,715	101,183	103,713
Gross Profit After Farm and Product	(39,330)	(49,327)	(56,986)	(31,967)	4,646	47,651	90,832	100,183	110,019	120,369	131,261	142,725	154,795	167,504	180,887	193,978	207,824	222,466	237,947	254,311
General and Administrative																				
PSP testing	-	-	1,940	3,880	3,459	3,546	3,635	3,725	3,819	3,914	4,012	4,112	4,215	4,320	4,428	4,539	4,652	4,769	4,888	5,010
DNR lease costs	1,575	1,614	1,655	1,696	1,739	1,782	1,827	1,872	1,919	1,967	2,016	2,067	2,118	2,171	2,225	2,281	2,338	2,397	2,456	2,518
DNR application and bond	2,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Management	10,000	20,000	30,000	40,000	41,000	42,025	43,076	44,153	45,256	46,388	47,547	48,736	49,955	51,203	52,483	53,796	55,140	56,519	57,932	59,380
Office Supplies	500	513	525	538	552	566	580	594	609	624	640	656	672	689	706	724	742	761	780	799
Office Rent	1,000	1,025	1,051	1,077	1,104	1,131	1,160	1,189	1,218	1,249	1,280	1,312	1,345	1,379	1,413	1,448	1,485	1,522	1,560	1,599
Phone/Communications	1,200	1,230	1,261	1,292	1,325	1,358	1,392	1,426	1,462	1,499	1,536	1,575	1,614	1,654	1,696	1,738	1,781	1,826	1,872	1,918
Debt Service																				
Total G&A	16,875	24,382	36,431	48,483	49,178	50,408	51,668	52,960	54,284	55,641	57,032	58,457	59,919	61,417	62,952	64,526	66,139	67,793	69,487	71,225
Net Income Before Taxes	(56,205)	(73,709)	(93,417)	(80,450)	(44,532)	(2,757)	39,164	47,223	55,736	64,728	74,229	84,268	94,876	106,087	117,935	129,452	141,685	154,674	168,460	183,086
Investing Activities																				
Longlines	6,891	7,063	43,439	22,263	54,039	47,594	36,976	2,568	6,141	7,325	5,664	14,623	8,755	30,417	22,064	29,002	23,114	14,699	7,861	17,922
Water pump	550	-	-	592	-	-	-	654	-	-	-	722	-	-	-	797	-	-	-	879
Water support	76,940	-	-	-	-	-	-	-	-	1,940	-	-	-	-	-	-	-	-	-	-
Processing facility	-	25,500	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Truck	7,500	-	-	-	-	-	-	-	-	7,500	-	-	-	-	-	-	-	-	-	-
Office Equipment	3,000	-	-	-	1,000	-	-	-	1,000	-	-	-	1,000	-	-	-	1,000	-	-	-
Total Investments	94,881	32,563	43,439	22,855	55,039	47,594	36,976	3,221	7,141	16,765	5,664	15,345	9,755	30,417	22,064	29,799	24,114	14,699	7,861	18,802
Cash Flow After Investments	(151,086)	(106,272)	########	(103,305)	(99,571)	(50,351)	2,188	44,002	48,595	47,964	68,565	68,923	85,121	75,670	95,871	99,653	117,571	139,975	160,599	164,285
Financing Activities																				
Equipment	85,393	29,307	39,095	20,569	49,535	42,834														
Operating Loan	50,585	66,338	84,075	72,405	40,079	2,481														
Net Financing Activity	135,977	95,645	123,170	92,974	89,614	45,316	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Debt service - Interest and Principal	$8,159	$13,721	$32,614	$50,772	$72,137	$84,981	$95,008	$82,999	$67,251	$47,291	$30,103	$20,588	$20,588	$20,588	$20,588	$20,588	$20,588	$20,588	$20,588	$20,588
Cash Surplus (Shortfall)	(23,267)	(24,349)	(46,299)	(61,102)	(82,094)	(90,016)	(92,819)	(38,997)	(18,656)	672	38,462	48,335	64,533	55,082	75,283	79,065	96,983	119,387	140,011	143,697

Optimum Farm Model – Review of Assumptions and Calculations

Recast – Pro Forma – Farm Only

Assumptions	Measure		
Work begins January 1 of Year 1 to have gear and seed ready for initial planting in April			
Returns & allowances set at 1% of total gross. Assumes recalls and loss from delays from PSP testing.			
Gross revenues calculated at $5.10/doz.	$ 5.10	Value per dozen	
Gross revenues calculated to move at projected growth rate through Year 7 to account for inflation and gains through branding/marketing.	5%	Increase in gross revenues	
Seed costs projected at $0.33/1000	$ 33.00	Cost for 1000 seed	
Seed costs projected to decline at 3% annually from declining cost of seed production after year 5 through year 15. Cost reduction comes from greater volumes produced statewide thereby lowering costs and general reduction for single farm based on larger purchases and improving relations.	3%	price reduction on seed cost	
Projected rate of inflation.	2.5%		
Most expenses increase annually based on the projected rate of inflation.			
Fuel usage on farm site is 4 gallons of fuel per longline per week for washing oysters and estimated at 30 gallons for transportation.		Year 2	Year 3
Fuel costs will increase at a greater rate than inflation.	5%	1.05	1.1025
Gas price is set at $4 for Year 1.	$ 4.00		
Weeks of activity in a season.	30		
Gallons of gas per longline per week	4		
Cost of gasoline for transport back and forth to farm for each trip	$120		
Farm help labor begins in year 2. Production increments in excess of 500,000 brings another employee up to 3.	500,000		
Employees	1	1	2
75% of employee help is farm, 25% is production	0.75	% of labor allocated to farm	
Insurance per person	$ 475		
Inflation	1	1.025	1.050625
Water support maintenance, including engine repair, is estimated at $250 annually for the life of the vessel	$ 250	water support maintenance	
Food provisions for the farm site set at $50/week/per person.	50		
Farm supplies listed at $50 per longline	$50	per longline	
Office supply at $500 a year	$500	Annual office supply	
Office rent and overhead at $1000 annually	$1,000	annual office rent	
Communications at $100 a month	$1,200	communications	
Processing supplies at $1000 annually	$1,000		
Processing maintenance at $500 annually	$500		
Processing overhead, utilities, water, etc at $150/month, running for 6 months	$150		
Loan assumes payment on interest for three years and then begin principal for five years.			
Present value of investments through Year 7	$234,217		
Present value of working capital through Year 7	($177,053)	($411,270)	
Loan to Value percentage	90%	for equipment loan	
Loan to Value percentage	90%	for operating loan	

Chapter 30. Business Planning for the Alaska Seafood Industry

Glenn Haight

Introduction to the Business Plan

So you want to start a business? 600,000 new businesses are started each year in the U.S. According to the U.S. Small Business Administration, 56% of them fail within four years. What can you do to determine if your business idea will succeed or fail before you invest lots of money?

You need to do a business plan to understand what you are doing. What is a business plan? A business plan clearly identifies all aspects of a business venture including:

- Organizational structure
- Description of business
- Goals
- Management experience
- Competitive review
- Regulatory constraints and requirements
- Marketing plan including overall strategy, products, pricing, promotion, and placement
- Production/operation considerations—how the business will operate
    - ✓ Inventory
    - ✓ Quality control
    - ✓ Raw materials
    - ✓ Fixed assets
- Financial information
    - ✓ Income statement
    - ✓ Cash flow statement
    - ✓ Balance sheet
    - ✓ Breakeven analysis

Do It Yourself

That's a lot of stuff—can this be easier? No. You're doing yourself a favor to do the work yourself. Understanding all the ups and downs, lefts and rights of your business idea before you invest money will help determine if it will be profitable or what will need to change to make it profitable.

Don't hire someone to write a business plan for you. Do it yourself. The person who is going into business needs to know it better than anyone else.

Business plans are written to get money—investors of all kinds require them. The formality of your business plan is a function of how much money you need, what experience you bring into the business, and how large the venture will be.

Writing a business plan depends on what you are doing. Often a new business venture is a small departure from what you currently do. For example, what if a popcorn seller wants to start selling snow cones? Selling snow cones is not a great departure from selling popcorn.

What changes are needed?

- Signage for a new menu item
- A new pricing consideration
- Some new equipment for a modest cost

What stays the same?

- Location
- Suppliers, probably
- Customers and their preferences
- Legal requirements, likely
- Labor considerations

This is a "new venture" that could be planned with some quick number crunching and a scoop of common sense. But what happens when the popcorn seller wants to start a movie theatre? Selling popcorn is not the same as running a movie theatre.

What changes?

- Location
- Suppliers, including large distributors
- Customers
- Legal requirements
- Labor
- Management responsibilities
- Products and other marketing considerations
- Financial needs

What stays the same?

- You will still sell popcorn

With a change of business like this, developing a comprehensive business plan will help determine if the project is possible.

Seafood Business Examples

Seafood ventures that likely do not require a business plan

- Switching processors you sell to
- Changing your operation to improve quality
- Buying a new permit
- New boat and new species

Seafood ventures that likely do require a business plan

- Moving into processing/marketing
- New boat and new species
- Buying expensive IFQ

Getting Started on the Business Plan

Four steps to complete prior to creating a full-blown business plan

1. Self evaluation
2. SWOT analysis
3. Back of the envelope pro forma
4. Pre-business environment review

Self Evaluation

An entrepreneur is a person who organizes and manages any enterprise, especially a business, usually with considerable initiative and risk. Are you an entrepreneur? Are you entrepreneurial?

Everyone has a little entrepreneur in them. People are made to believe starting a business is some mystical thing. Not true. You need vision, an ability to take risk and some initiative, and managerial and technical skills. Succeeding in business is often about building the best team possible. Honestly understand your strengths and weaknesses and build the right team to fit around you.

SWOT Analysis

SWOT stands for Strengths, Weaknesses, Opportunities, and Threats.

A SWOT analysis is a brainstorming exercise where you determine what is good and bad about your business, and how your business is positioned compared to things beyond your control. Strengths and weaknesses are internal to your company. You have control over these items. Opportunities and threats are external to your company. You may not be able to control these items, but you can alter your business to take advantage of or mitigate the risk from them. Seeking help in this exercise is good because we are often blind to aspects of ourselves.

Strengths
Strength assessment is an internal measure. You are looking at particular aspects of your idea/operation that are superior to or on par with other businesses. Consider production levels, location, machinery, facilities, financial condition, alliances, partnerships, employees, management, family, operational efficiencies, and your strategic plan.

Weaknesses
Weakness assessment is also an internal measure. You are measuring particular aspects of your idea/operation that are inferior to other businesses. Again, look at production levels, location, machinery, facilities, financial condition, alliances, partnerships, employees, management, family, operational efficiencies, and your strategic plan.

Opportunities
Opportunity assessment is an external measure. Opportunities are circumstances beyond your business that present a potential to improve your position, such as the marketplace or changing regulations. Examples are technology, legislation and political changes, regulations, globalization, cultural and demographic trends, and changes to your input suppliers.

Threats
Threat consideration is an external measure. Threats include circumstances beyond your business that may be a detriment to your position, such as changing consumer preferences or regulations. Examples are technology, legislation and political changes, regulations, globalization, cultural and demographic trends, or changes to your input suppliers.

Potential Profitability
Prior to initiating an in-depth review of your business idea, it is useful to determine the potential range of profitability the business idea may have. Based on your current knowledge, determine initial investment costs and potential returns. This calculation is not intended to be completely accurate, but should give you an idea whether the project has any potential to be successful. The numbers will undoubtedly change after a more thorough review.

Initial Investment
Estimate all your initial start-up costs including:

- Building, land, remodeling
- Inventory
- Raw materials
- Production equipment
- Office equipment
- Regulatory fees—prepaid taxes, permits
- Marketing costs

- Overhead—rent, utilities, insurance
- Patents, trademarks, acquisitions

Determine initial working capital needs. How much money will you need until your revenues start coming in? These expenses include some of the items above—overhead, marketing, inventory—and also include labor, accounting, sales, and taxes.

Determine a Timeline

- Regulatory requirements
- Build/remodel
- Production equipment purchase and installation
- Production cycle
- Obtain adequate financing
- Source materials
- Hiring personnel
- Obtain markets

Calculate a Breakeven Analysis

Estimate a sales price for goods, including fixed and variable expenses. Arrive at a breakeven production number. Ask: will the market purchase more than your breakeven volume, i.e., will there be enough to survive?

Fixed Costs = (Revenue per unit – Variable costs per unit)
Example: $50,000/($3.50 – $2.80) = $50,000/($0.70) = 71,429 units

In this example you will need to sell at least 71,429 units to break even. Your plan is to sell many more to cover your initial investment costs and make a living!

Business Environment Review

Take a longer look at the business environment.

- Markets and competition
- Government regulations
- Availability of raw material
- Places to operate
- Available funding sources

Talk with trusted counselors and partners in the industry. Does your review change your SWOT, timeline, and financial projections?

Marketing Plan
A marketing plan consists of marketing strategy, market research, and marketing mix and product differentiation.

Marketing Strategy
- Define how you identify your market segment
- Determine your target market
- Design your marketing mix
- Differentiate your product from others

Market Segmentation
Grouping customers into similar categories will allow you to target your marketing effort more efficiently. For example, a perfume company may select a market segment of women between the ages of 25 and 40 who are in households with incomes of $70K or higher.

Market Research
Market research is critical to determining your marketing strategy. Types of market research include:
- Data gathering
- Surveys
- Interviews

Marketing Mix and Product Differentiation, the Four P's
Marketing mix is a blend of price, product, promotion, and placement that coordinates to market your product to your target.

Promotion includes:
- Sales promotion
- Advertising
- Sales force
- Public relations

Product (consumer vs. industrial) includes:
- Quality, warranty
- Design/label
- Packaging
- Physical characteristics

Branding

- More than creating a name
- Identify what's most important to the market/barriers to sales
- Differentiate where there is the most value to the buyer or consumer
- Move purchasing decisions beyond price

Price includes:

- List price
- Discounts
- Allowances
- Payment period
- Credit terms

Placement includes:

- Channels
- Coverage
- Assortments
- Locations
- Inventory
- Transport

The Seafood Marketing Chain

Grower and Harvester → Primary Processor → Further Processor and Manufacturer → Wholesaler (using Brokers) → Retailers and Food Service → Consumer

Chapter 31. So Where Do I Get All This Money?

Rodger Painter

Make no mistake about it, getting into the oyster farming business in Alaska will require quite a few dollars on the front end and revenues will be slow in coming.

Before a grower generates enough oysters to sell to even begin to cover operating costs there will be many expenses to cover. These include infrastructure, culture systems, sorter/tumbler, vessel, generators, pumps and other small engines, several years of spat and tideland lease fees, and literally dozens of other costs. Certainly some of these expenses can be reduced by working as part of a cooperative, but entry costs are still likely to exceed $100,000. In addition, there will be no significant revenues generated by the new business for at least four years, although much labor will be required during those early years.

If you have a couple hundred thousand in the bank and are willing to invest it in your new business, great, skip reading this chapter. If you are like most new Alaska shellfish farmers you are going to want to take a hard look at the government loan programs designed to help family-size farms.

Commercial Banks

During more than two decades of oyster farming, consulting, and representing the Alaskan Shellfish Growers Association, I had the opportunity to talk to several commercial banks about business loans for my farming ventures and those of other Alaskans. Anyone can get a loan from a commercial bank to finance an oyster farm **IF** you have a sterling credit rating and enough assets acceptable to your banker to cover the amount of the loan. Otherwise, you might as well forget it.

Oyster farms simply don't fit the traditional model for small business loans, and your banker won't be able to bend established lending practices or bank rules enough to structure a financing plan that fits your business.

First of all, only a few of the capital items you need to purchase will be acceptable collateral to a commercial banker. Gear such as trays, lantern nets, tumbler/sorters, rafts, longlines, pumps, generators, boom arms, davits, and other more specialized equipment simply does not have a broad enough market appeal to work as collateral. The only real exception is a boat.

Then there's the problem of not having a positive cash flow for four to five years. Here's what happened to me during my first interaction with a commercial bank.

My partner and I had outside income and good credit ratings and the National Bank of Alaska was eager to finance a new sector of the seafood industry. The bank offered a three-year loan with interest and principal payments beginning immediately. Naturally, those terms did not fit our business model.

We eventually got a seven-year loan with interest-only payments during the first two years because the state was willing to carry two-thirds of a $50,000 note. Interest on the state-covered portion of the loan was fixed at 1% above prime at the time of closing compared to the bank's floating rate. The fixed interest turned out to be an important provision, as interest rates were very low when the loan was made but rose several percentage points during the term of the loan. That particular loan program was designed to help finance rural businesses, but it no longer exists.

Commercial lenders are very reluctant to finance ventures that are slow in turning over the lent capital, and bankers are reluctant to gamble on businesses in developing industries. That's why venture capital is so important.

Government Loan Programs

That leaves Alaska shellfish farmers with only one place to turn for financing: government loan programs. Fortunately, the U.S. Department of Agriculture's Farm Service Agency has a number of loan programs specifically designed to help small scale farmers.

At the time of the writing of this manual, the State of Alaska appeared poised to enact a new mariculture loan program offering some very attractive terms. The proposed loan program was designed to help startup businesses and established growers, and would allow borrowers to postpone principal payments up to five years. The revolving loan fund would be capitalized with $5 million from the state treasury. The measure passed the House by a 35-0 margin in 2011 and appeared likely to be approved during the 2012 legislative session.

Farm Service Agency

The Farm Service Agency (FSA) was developed to help the family farm survive in the face of competition from agribusiness and urbanization pressures, and the agency practically bends over backwards to help its clientele.

FSA's Direct Farm Ownership loan program offers loans up to $300,000 to purchase a farm or make improvements to an existing operation, but it appears to have limited applicability to shellfish farming. Interest rates are fixed at the time of closing and loan terms can be up to 40 years. This loan would be limited to purchasing farm real estate and possibly building a processing facility on the property. It could not be used to finance the other farm infrastructure.

By 2011, FSA had made only one Alaska mariculture loan under this program, for the construction of a land-based shellfish processing facility.

Another FSA program, Guaranteed Farm Ownership, is designed to guarantee a portion of loans from commercial lending institutions, and can be used as leverage for obtaining more favorable terms from reluctant bankers. This program offers guarantees up to $1.1 million for up to 40 years and can be used to help refinance debt. Applicants also are eligible to borrow up to $1.1 million under FSA's operating loan guarantee program. This loan program is unlikely to be of much help to most Alaska shellfish farmers except for established and profitable operations.

The program that would be most applicable for startup farms, and most established businesses as well, is FSA's operating loans. Up to $300,000 may be borrowed on an annual basis for operating capital, although FSA is willing to extend the terms for another six months if required. These loans commonly are used for purchasing seed and fuel, and for other operating expenses. A seven-year operating loan is available to be used for purchasing equipment and even refinancing farm-related debt. Unlike commercial banks, FSA will accept farm assets, including crops in the water, as collateral.

A portion of FSA loan funds is set aside each year for socially disadvantaged and beginning farmers. These vary annually; contact FSA for additional information.

Borrowers must have at least one year of experience operating or managing a farm within the past five years, or have sufficient education or training. FSA loan programs are available to farmers only when credit from other sources is not available. Since each borrower's financial circumstances differ, FSA will assist each individual to determine whether financing can be obtained from other sources.

FSA loan officers are very helpful and will provide plenty of assistance in completing the paperwork necessary for a loan application. This assistance is part of the agency's mission. In fact, you can expect your FSA loan officer to follow your business operations throughout the life of your loan. If you appear to be doing all right, the oversight is minimal. Here's how FSA describes the agency role for those receiving direct loans:

> "FSA has the responsibility of providing credit counseling and supervision to its direct borrowers by making a thorough assessment of the farming operation. The Agency helps applicants evaluate the adequacy of the real estate and facilities, machinery and equipment, financial and production management, and the farmer's goals.
>
> FSA assists the applicant in identifying and prioritizing areas needing improvement in all phases of the operation. An FSA official then works one-on-one with the farmer to

> develop and to help strengthen the identified areas that ultimately result in the farmer's graduation to commercial credit."

The agency goes the extra distance to help troubled borrowers and can defer payments, refinance loans, and write down the debt. If those fail, FSA can enter into a debt settlement process that focuses on the borrower's ability to repay the outstanding balance of defaulted loans.

Alaska State Loans

Governor Sean Parnell introduced legislation to establish a $2.5 million mariculture revolving loan fund in 2011. The state loans would be designed to help start-ups, but established farms also are eligible. With 20-year terms, interest rates of about 5% and the ability to defer principal payments for five years, the loan fund would be a significant addition to the FSA loans.

The proposed loan fund passed the Alaska House unanimously, but got stalled in the Senate Finance Committee. ASGA and other supporters were optimistic the measure would pass during the 2012 legislative session. The Senate appeared prepared to double capitalization to $5 million.

Check with the Alaska Department of Commerce, Communities and Economic Development on the status and terms of the loan program.

Before You Go to the Lender

Regardless of where you go to get financing, a government loan program, bank, or private investors, you'd better expect to produce a business plan. You'll also need tax returns, list of assets and liabilities, resume or bio, referrals, and other personal financial data.

A business plan might seem to be intimidating, but it is easier to pull together than you'd initially think and there are plenty of people and agencies out there to help. The University of Alaska has small business centers and many regional economic development entities that will provide hands-on assistance in developing a business plan and preparing a loan application.

One bit of advice is to start out modestly and expand the operation once an oyster inventory is established. Even if it is possible to borrow large sums of money to start out with a larger operation, the lack of cash flow during early years will prevent you from servicing a large amount of debt.

Programs such as Naukati's "Weekend Warrior" project provide a significant jump-start for new farmers. By going through two growing seasons working with 100,000 spat per year and getting hands-on advice from experienced farmers, the apprentice farmers were able to have crops ready to sell when they moved to their own sites and the experience necessary to operate a farm and qualify for financing.

ASGA and the Alaska Sea Grant Marine Advisory Program also are very good contacts in trying to figure out how to proceed.

The Application Process

Chapter 32. Developing a 10-Year Operation Plan for an Oyster Farm

Raymond RaLonde

Introduction

Planning your farm is a fundamental activity requiring you to forecast the future of the farming enterprise for production capacity, cost of construction and operation, scheduling farm activities, and determining labor requirements. In Alaska, a permit application for aquatic farming requires a 10-year production plan, compelling you to labor through the process. The production plan is a basic description of the farming production cycle and does not contain details included in a business plan.

The first question that arises when developing a 10-year plan is, "How can I possibly forecast production and expenses in a farming venture when I have no idea what environmental, operational, and financial conditions I will face over such a long period?" Keep in mind that forecasting is not intended to be precise, but prompts you to think through the farming process on paper to formulate a detailed plan using the best available information. Plans will always require modification.

In Alaska, every farm is different and a model plan does not exist. However, farming practices are becoming more standardized, expected production outcomes more predictable, and cost and income information more readily available via local knowledge and the Internet. Every farm plan must include a clearly described set of assumptions needed for computing numerical details. For example, projection of oyster survival from seed to market size over a two-year period requires an assumed level of annual mortality. In the model used for this publication, mortality is assumed as 15% for year 1 and an additional 5% for year 2 of growout.
Developing reasonable assumptions requires homework and asking questions. While this publication will guide you through the process using realistic information, nearly every assumption used to illustrate the planning process will vary based on many factors. Therefore, calculation results in the model cannot be taken as completely reliable for all circumstances.

The basic components of a 10-year oyster farm are:

1. A general description that includes projected production and gross income by year 10 and an estimate of rate production increase through time (e.g., addition of 50,000 more oyster seed every year for five years until reaching a maximum of about 250,000 annually).
2. Set of assumptions
3. Computation of production
4. Computation of growout gear required.

5. Costs
    a. Total growout gear
    b. Oyster seed
    c. Farm equipment
    d. Total cost and income over five years.

The five components are addressed in this publication for a fictional farm site. Labor and operational supply costs are not included, as these are very difficult to project without details of the farm site and availability of goods and services. Of course, operational costs are required to develop a fully descriptive business plan at a later date.

Farm Description

The proposed oyster farm will utilize a raft and tray culture growout method (Table 1). The raft is 16 feet wide and 20 feet long, has seven hangers, and is capable of holding 42 racks with eight growout trays in each rack (see photos). Oyster stocking density will be 300 oyster seed (25 mm plus) per tray for the first year, then thinned to 150 oysters (approximately 50 mm) after one year of growout (Table 2).

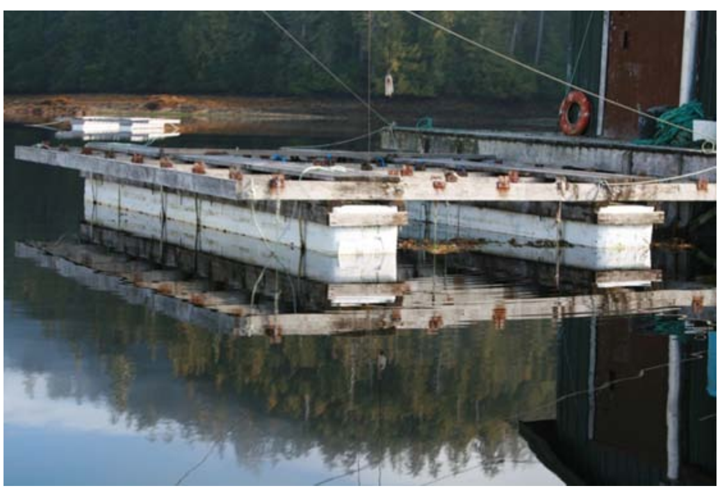
The farm will start production with 50,000 seed, adding an additional 50,000 seed per year. A little extra is added to reach a total seed planting of 253,100 per year starting in year 4. The total maximum harvest projection is 202,480 beginning in year 6 (Table 1).

The farm includesa work raft/processing facility equipped with a lifting boom and tumbler sorter (see photo). Additional equipment is listed in Table 2.

Table 1. Ten year production plan for a raft and tray oyster farm with a maximum harvest of 200,000 oysters.

Start	Growout year										
0	1	2	3	4	5	6	7	8	9	10	11
50,000											
	42,500										
	100,000	40,000									
		85,000	32,000								
		150,000	80,000	0							
			127,500	64,000							
			200,000	120,000	0						
				170,000	94,500						
				253,100	160,000	0					
					215,135	128,000					
		Seed plant			253,100	202,480	0				
						215,135	161,984				
		Final harvest				253,100	202,480	0			
							215,135	161,984			
							253,100	202,480	0		
								215,135	161,984		
								253,100	202,480	-	
									215,135	161,984	
									253,100	202,480	
										215,135	
										253,100	202,480
	Harvests										
	2 year olds(Note)	8,000	16,000	25,500	32,000	40,496	40,496	40,496	40,496	40,496	
	Final harvest		32,000	64,000	94,500	128,000	161,984	161,984	161,984	161,984	
	Total	8,000	48,000	89,500	126,500	168,496	202,480	202,480	202,480	202,480	

Note: Two year old harvest component is 20% of two year olds. Example 6,400 oyster harvest in year 3 is 20% of 80,000 two year old oysters from a plant of 100,000 two years earlier. Add 32,000 three year olds for a total harvest of 48,000.



Raft suspension system supporting 42 stacks of trays.

Eight stack tray growout system.

Table 2. Farm description, production goals, assumptions, and total construction cost estimate. Labor and expendable supplies are not included.

Annual gross income	Harvest goal	Maximum seed planting	
$100,000	200,000	253,100	
Goal at end of production year 5 is to scale up to over 100,000; at end of year 7 scale up to 200,000			
Assumptions:			
* Mortalities: 15% first year growout, 5% more second year, 0% third year			
* Annual harvest composed of 20% at end of year 2 growout, remainder by end of year 3			
* Exceed harvest of 200,000 in estimates to account for unexpected underproduction			
* Seed cost $25.00/1,000 for 25 mm plus size			
* Seed stocking density: Initial tray density = 300/tray. After year 1 growout = 150/tray.			
Cost of maximum gear required by year 10:			
Tray density	Trays	Stacks (8 trays/stack)	Rafts (42 stacks/raft)
300 seed/tray to age class 1	844	105	3
150 seed/tray age class 1-2	1,434	179	4
150 seed/tray to age class 2-3	1,080	135	3
Total	3,358	420	10
$20.00/tray	**$67,156**	**$916.00/raft**	**$9,154**
Seed cost for 10 years:			
Seed number	Cost		
2,018,600	$50,465		
Farm equipment cost:			
Item	Cost	Item	Cost
Boom arm	$16,000	Vessel	$15,000
Tumbler/sorter	$7,000	Generators (2)	$7,000
Pumps (2)	$2,000	Work raft	$5,000
Processor	$20,000		
Total cost	**$72,000**		
Total cost of construction, equipment, and seed for 10 years:		**Total income over 10 years (assuming 50¢/oyster)**	**$625,208**
Raft and culture gear construction	$76,310		
Seed cost	$50,465		
Farm equipment	$72,000		
Grand total cost	**$198,775**		

Assumptions

Table 2 explains the assumptions used in forecasting production and costs. Oyster growth is estimated for southeastern Alaska where water temperatures and productivity allow some harvest after 2 years of growout. Twenty percent of the oysters are projected to reach a minimum market size of 75 mm and weight of 2 ounces (57 gm) for each oyster. The remainder are left in the water to continue growing and will be harvested in the third year.

The tumbler sorter, for maintaining quality and sorting, is not included in the production plan. It is a necessary piece of equipment to reduce your labor effort and cost.

Mortality estimates are 15% after one year and an additional 5% after the second year of growout. An important consideration when estimating mortality is the size of the seed initially planted on the farm. Oyster seed less than 25 mm generally have a higher and less predictable mortality rate. With the development of nurseries to produce large seed, farmers generally stock large seed to shorten the growout time to harvest, improve survival, and enable more accurate forecasting of harvest yield.

Oysters sell for $6.00 per dozen ex-farm price. Cost of marketing and shipping is not included in the model. Total seed cost is included for the entire growth period. Expenses include farm equipment costs (Table 2).

Computation of Production

To compute oyster production over a 10-year period, you must first determine the rate at which farm production increases. A farmer may develop to maximum production as soon as possible if capital is available, or scale up production gradually with capital gained from harvest sales. In the example production plan (Table 3), growth increases by starting with 50,000 and adding an additional 50,000 seed for 3 years, then maximizes with 53,100 in the fifth year of production. Harvest value exceeds the 200,000 goal in year 7 and continues at that level.

Table 1 shows each cohort (age class) as a color coded set of numbers. Red shows 50,000 oysters initially planted, 42,500 oysters after year 1 experiencing 15% loss to mortality, and 40,000 at the end of year 2 with an additional 5% loss. The underlined number is the amount of seed stocking and the blocked-in number is the final harvest number of each production lot at year 3. From production year 3 on, each harvest includes 2 year olds and 3 year olds.

Harvest of the original stocking occurs for the first time at the end of year 2, where 20% of the oysters are assumed to be market size allowing a harvest of 8,000. In year 3, with removal of the 8,000 oysters the previous year and assuming negligible mortality during the year, the remaining harvest is 32,000.

Computation of harvest becomes more complicated when an additional year is planted and market size oysters are harvested and sold. This complication occurs when the first year plant (in red) has its final harvest at year 3, and the harvest also contains oysters from the second stocking (in blue) of 100,000 oysters when they reach 2 years old (80,000).

The year 3 computation goes like this: The final harvest of 32,000 oysters from the first planting is supplemented by a 20% harvest of 2 year old oysters from the second planting (0.20 x 80,000 = 16,000). Adding the 32,000 3 year olds to 16,000 2 year old oysters gives a total harvest in the third year of 48,000 oysters. The final harvest of the second year plant at year 3 is reduced by 16,000 from 80,000 to produce a harvest of 64,000 in the fourth year plus 20% of the 2 year olds from the third planting year, and so on for each subsequent harvest.

Gear Requirement

The number of oysters in each age class will determine the amount of gear needed for each year of growout. The general rule is that 25 mm oysters at first planting can be stocked at 300 oysters per tray, and the density is reduced to 150 oysters per tray for age classes 2 and 3. These stocking densities are not uniform throughout the industry; some farmers stock at 200. Year 7 in the production model, when the production level maximizes at 202,480, is used to explain the calculation. Year 7 appears as in Table 3 below.

Table 3. Number of seed, trays, stacks, and rafts for the farm.

Age class	Seed number	Trays	Stacks	Rafts
To age 1	253,100	844	105	3
Age 1 to 2	215,135	1,434	179	4
Age 2 to 3	161,984	1,080	135	3
Total	630,219	3,358	419	10

Note that age class 2 to 3 is 161,984 and not 202,480 shown in Table 1. The latter number is the total number of 2 year olds possible, while the former is 2 year olds less 20% harvested as market size, so the actual number of 3 year olds remaining is 161,984.

Tray numbers are calculated by dividing the number of seed to 1 year by 300 seed per tray. For subsequent years the number of seed is divided by 150 seed per tray. The number of stacks is the number of trays divided by 8 trays in a stack. The raft is assumed to support 42 stacks of trays, for a total of 10 rafts.

Costs

Costs are presented for growout gear (trays and rafts), seed, and farm equipment. All costs are calculated and displayed in Table 2. Total cost to construct the farm and purchase seed is $198,775 over 10 years and assuming 50 cents per oyster the total income of $625,208 is realized. Keep in mind that the cost is for the construction system only. Infrastructure, maintenance, storage, housing, transportation, labor, etc., are not included.

ALASKA'S AQUATIC FARM PROGRAM
January 1st through April 30th

PART I
APPLICATION PROCESS, GUIDELINES, AUTHORIZATIONS AND CONTACTS

The joint-agency application package is presented in two parts: Part 1 (this section) - Application Process, Guidelines, Authorizations, and Contacts and Part II – Instructions and Application. Part I of the packet provides you with information about the Alaska Aquatic Farm Program application process, requirements, and guidance for aquatic farm site development. It will help you understand how to obtain the authorizations required by the Alaska Departments of Natural Resources (ADNR), Fish and Game (ADF&G), and Environmental Conservation (ADEC) to site, develop, and operate your aquatic farm. Part II of the package contains the joint-agency application and instructions for completing it. The joint-agency application consolidates all applications for each state agency into one to help minimize the paperwork applicants have to complete to obtain authorizations for an aquatic farm.

If you have questions or would like any assistance with the application (Part II), please contact John Thiede, ADNR at (907) 269-8543 and/or Cynthia Pring-Ham, ADF&G at (907) 465-6150.

A. APPLICATION PROCESS – 9 STEPS

An aquatic farm application opening is offered every year from **January 1st through April 30th.** The Aquatic Farm Program is administered through a batch processing method wherein all applications received during the opening period are processed on the same schedule. It is highly recommended that applicants request a pre-application meeting prior to submitting an application. Additionally, applicants should allow time to discuss their proposal with any federal agencies such as U.S. Army Corps of Engineers (USACE) to obtain information on their requirements and authorization. The time to complete the application review process for a lease and operation permit can vary, but typically, it takes approximately, nine months for a proposed aquatic farm operation project using suspended culture methods and approximately, fifteen months for a proposed aquatic farm project using near-bottom or on-bottom culture methods. The following information outlines the application process. Refer to Page 5 for a flow chart of the application review process.

1. **Pre-Application Meeting.** Applicants are encouraged to request a pre-application meeting through the Departments of Natural Resources and Fish and Game. State agency personnel will be happy to help all potential farmers with site selection, developing maps, and completing the application.

2. **The Application and the Fees.** Complete applications need to be submitted to the Department of Natural Resources/Anchorage office along with required fees. ADNR will then make copies and distribute them to other state agencies for review. A summary of all State of Alaska fees for aquatic farm authorizations, operations, and renewals is included.

3. **ADNR Preliminary Decision, Public Review, and Comment.** Preliminary decisions are written by taking information from the application, input from state agencies, and by following statutory and regulatory requirements. They include the proposed action and a recommended decision. Public comment is then taken on the preliminary decision. Public meetings or public hearings can be requested by contacting ADNR.

4. **ADF&G Site Survey and Review.** For on-bottom (clam culture) aquatic farm projects, a site biomass survey to determine the existing population of shellfish to be cultured is required by ADF&G. Applicants will be contacted by ADF&G to schedule the biomass survey.

5. **ADNR Final Finding and Decision.** The ADNR will prepare a final findings and decision document, which will include participating agency stipulations that the applicant will be required to adhere to throughout the 10-year lease. The final decision will be sent to the applicant and all interested parties.

6. **ADF&G Review and Determination.** The ADF&G will review and make a determination regarding the operation permit. A preliminary decision will be sent to DNR and to the applicant. If a survey is required, the applicant will be sent the results.

7. **ADNR Lease.** The ADNR will issue the lease for signature. The applicant then returns the signed and notarized lease along with the first annual lease fee and proof of bond security requirement. The ADNR will sign the final lease and send it to the new lease holder.

8. **ADF&G Operation Permit.** If approved and a final signed ADNR lease is issued (for state lands only), ADF&G will issue the operation permit to construct and operate an aquatic farm once a final lease has been executed. The operation permit will include conditions that the applicant will be required to adhere to throughout the 10-year operation permit.

9. **ADEC Pre-Harvest and Sale Requirements.** A farmer will need to obtain a growing area classification, a shellfish shipper permit, a harvest permit, and have a shellfish sampling plan prior to harvest. The ADEC fee is $500 for the initial water classification, $162 for a Shellfish Harvest permit, $162 for the Shellfish Shipper permit, $649 for a Shellfish Shucker Packer permit, and $325 for a Shellfish Repacker permit. A farmer will be expected to collect water samples and pay for shipping to the ADEC laboratory in Anchorage.

Special Area Permit: For proposed farm projects in the Kachemak Bay Critical Habitat Area, ADF&G also requires an additional permit review and approval of the project proposal. A Special Area Permit to proceed with the project will be issued and include permit conditions that the applicant will be required to adhere to throughout the 5-year permit. An operation permit has to be approved prior to obtaining this special area permit.

Federal Authorizations: A number of federal authorizations may also be required for aquatic farm operations. Applicants should confer with the following agencies to determine which federal authorizations are necessary:

- United States Army Corps of Engineers (USACE) for uses within navigable waterways. USACE Permits are required for any structures to be used at the proposed farm site in navigable waters.
- United States Forest Service (USFS) for associated upland use within national forests.
- United States Fish and Wildlife Service (USFWS) for proposals within wildlife refuges.

B. SITING YOUR AQUATIC FARM

In general, a suitable site for your shellfish farm should have:

- Good oxygen exchange/flushing and water circulation
- Adequate salinity, temperature, and phytoplankton in the water
- Low probability of severe storms or winter icing
- Acceptable water quality and no history of pollution sources
- Sufficient water depth to at least 40 ft., at MLW (mean low water), to allow clearance under suspended gear at low tides
    - Depths equal to or greater than 60 ft. are recommended to enable farmers to drop gear if water temperatures go higher than 60˚ F to help minimize Vibrio sp. bacterial growth
- Accessibility to site
- No history of disease organisms or harmful plankton blooms

- no nearby seal/sea lion haul outs or pupping areas, seabird colonies, eagle nests or anadromous fish streams. The Catalog of Waters Important to the Spawning, Rearing or Migration of Anadromous Fishes (Anadromous Waters Catalog) can be viewed at the following website: http://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=main.overview
- no nearby fish hatcheries

The Alaska Sea Grant Program has useful information on the Alaska shellfish aquaculture industry that can be accessed on their Program web page at: http://seagrant.uaf.edu/map/aquaculture/shellfish/index.html

C. SENSITIVE AREAS AS SET FORTH BY THE ADNR, ADF&G and ADEC

The following areas are considered sensitive and should be avoided when choosing an aquatic farm site. Applicants who apply in or near a sensitive area should contact the responsible state agency to determine how a farm site might be situated to avoid significant impacts.

- Herring Spawning Areas or Kelp and Eelgrass Beds (ADF&G)
- Shorebird, Waterfowl or Sea Otter Concentration Areas (ADF&G)
- Black and Brown Bear Concentration Areas and Travel Corridors (ADF&G)
- Shallow Areas - Less Than 40 Feet at MLW (mean low water) utilizing suspended culture - certain shallow areas serve as nursery areas for fish, shellfish or aquatic plants (ADF&G)
- Commercial, Subsistence or Personal Use Harvest Areas (ADF&G)
- Poor Current Circulation Areas **-** currents should be sufficient to disperse biological wastes (ADEC)
- Heavily Used Anchorages (ADF&G, Sport Fisheries Division; ADNR, Mining, Land and Water Division – management plans, and/or the applicable U.S. Coast Pilot)
- Floatplane Access Areas (ADEC; ADNR)
- Hatchery Harvest Areas**:** Aquatic farms or facilities sited within Special Harvest Areas (SHA) or Terminal Harvest Areas (THA) must have approval of the hatchery operator/manager. (ADF&G)
- Oiled areas from the 1989 Exxon Valdez oil spill. For questions regarding specific areas, contact the Pipeline Corridor Regional Office at (907) 271-4336. (ADEC)

Some areas in the state that have been legislatively designated for purposes other than aquatic shellfish farms. The following areas are not compatible with aquatic farm development projects:

- State Game Refuges and Sanctuaries, State Parks and Marine Parks, State Critical Habitat areas and commercial Pacific geoduck harvest areas. The Fox River Flats and Kachemak Bay Critical Habitat Areas allow aquatic farms, but farms are limited to suspended culture only.
- Some coastal communities have designated areas for subsistence, natural hazards, recreation and important habitat. Development in these areas may be subject to separate local permit reviews and require stipulations under the community authorizations.

D. GROWING AREA CLASSIFICATION CRITERIA (ADEC)

Prior to developing an aquatic farm site, the water surrounding a proposed growing area must be safe for the harvest and sale of shellfish. The Alaska Department of Environmental Conservation (ADEC) is charged with seafood safety and has a program for classifying waters for aquatic farms. Farmers should consider the following items when searching for a suitable aquatic farm site:

- Areas used by boats for recreation, moorage and anchorage, or in close proximity to a proposed growing area may cause conditions that could prevent classification of the growing area.
- Farms should be sited in areas free of waste discharge. Caretaker housing facilities are allowed, but must be a minimum of 300 feet from the boundary of a growing area if sewage is discharged. ADEC can approve a sewage disposal system adequate to protect shellfish from contamination for any caretaker facilities associated with an aquatic farm operation.

- Areas used by commercial fishing or personal use fishing/hunting within the immediate area or in close proximity to the growing area could cause conditions that could prevent classification of the growing area.
- Large wildlife populations in the area and/or the presence of anadromous streams may cause conditions that will affect water quality and thus food safety. This may be resolved in a classification area by limiting harvest times.
- An upland area where cabins and homes exist may cause conditions that could cause food safety issues and thus prevent classification of the growing area. Previously existing facilities may have septic tanks that have been permitted by ADEC with in-water discharge of sewage which may prevent classification of the growing area.

Always contact ADEC-Environmental Health for consultation prior to completing your application. For additional information and assistance regarding these health classification guidelines, please contact the ADEC Shellfish Program Coordinator, Division of Environmental Health, at (907) 269-7638.

Figure 1: Aquatic Farm Application Review Flow Chart

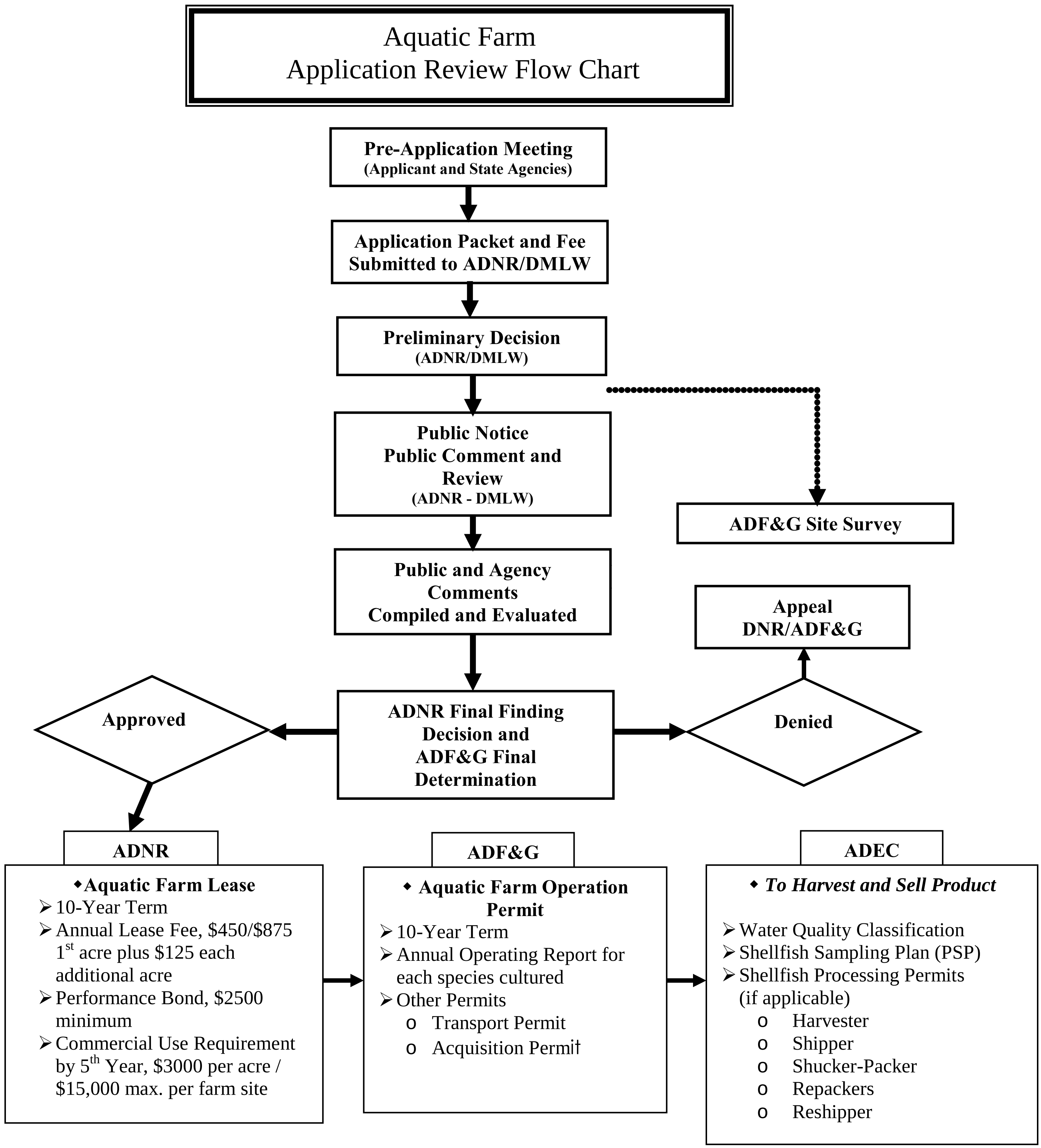


Figure 2: State of Alaska Fees for Shellfish Aquatic Farm Authorization and Operations (Initial Year and Years 2-10)

State of Alaska Fees for Shellfish Aquatic Farm Authorizations and Operations[1]

		Year 1								Years 2-10						Years 1-10	
		DNR	DNR	DNR	DNR	DNR	ADF&G	DEC		DNR	DEC	DEC	DEC	DEC	DEC		
Type of Farm Culture Methods Used	Farm Acreage	Over-the-counter location packet Fee[2]	Application Fee[3,17]	Public Notice[13]	Annual Lease Fee[4]	Security Bond[3,5, 18]	Wild Stock Survey Fee[6,7]	Sanitary Survey Initial Fee, Water Classification[8,9,12]	Total Fees Each Year[11,15] (Min/Max)	Annual Lease Fee[4, 17]	Sanitary Survey, Water Reclassification Annual Reapproval Fee[12]	Shellfish Harvester Permit Annual Fee[12]	Shellfish Shipper (SS) Annual Permit Fee[12]	Shellfish Reshipper (RS) Permit Annual Fee[12,14]	Shellfish Shucker-Packer (SP) Permit Annual Fee[12,14]	Total Cost Each Year[15, 16] (Min/Max)	Total Fees for All 10 Years[15, 16] (Min/Max)
Suspended	1 acre	$25	$100	$1,000	$450/$875	$2,500	$0	$500	$4,575/$5,000	$450	$150	$162	$162	$162	$649	$1,259/$1,521	$18,424/$21,731
Suspended	3 acre	$25	$100	$1,000	$700/$1,125	$2,500	$0	$500	$4,825/$5,250	$450	$150	$162	$162	$162	$649	$1,259/$1,771	$18,674/$24,731
Suspended	5 or more	$25	$100	$1,000	$950/$1,375	$2,500	$0	$500	$5,075/$5,500	$450	$150	$162	$162	$162	$649	$1,259/$2,021	$18,924/$27,731
On Bottom, Intertidal	1 acre	$25	$100	$1,000	$450/$875	$2,500	$2,000	$500	$6,575/$7,000	$450	$150	$162	$162	$162	$649	$1,259/$1,521	$20,424/$23,731
On Bottom, Subtidal	1 acre	$25	$100	$1,000	$450/$875	$2,500	$5,000	$500	$9,575/$10,000	$450	$150	$162	$162	$162	$649	$1,259/$1,521	$23,424/$26,731
Fees Required		When over-the-counter location packet requested.	When application submitted.	Paid to statewide or local paper after public notice.	When signed lease submitted to DNR.	When signed lease submitted to DNR.	When application submitted.	When water classification requested.		In January of each year.	When follow-up completed and before you sell product.	When you act as a harvester shellfish.	When you act as a shipper shellfish dealer.	When you act as a reshipper shellfish dealer.	When you act as a shucker-packer, shellstock shipper (or shellfish shipper), reshipper or a repacker dealer		

Note: DNR - Department of Natural Resources; ADF&G - Alaska Department of Fish and Game; DEC - Department of Environmental Conservation.

1 Based on fee structures in Regulations: DNR AS 38.05.083 (Report No. 2522-9), ADF&G 5 AAC 41.280, and DEC 18 AAC 34.900(a) Seafood Permit Fee Schedule 2010 and 34.900(c)(1) and (2). If any discrepancies is found between this spreadsheet and the Alaska Administrative Code, The Code should be considered the final authority, unless the discrepancy is a result of a manifest error in the Code.
2 Only required to obtain Over-the-Counter location packets and is onetime fee.
3 Onetime fee.
4 For an aquatic farm only, $450 for the first acre plus an additional $125 per acre. For an aquatic farm with housing facilities associated with the aquatic farm, $875 for the first acre plus $125 for each additional acre. Note: The fee schedule is adjusted every five years. If applicant does not want to use the lease fee schedule, applicant can pay for an appraisal to be done.
5 Reduced fees if lessee can find three or more lessees to bond together for an Association bond (11 AAC63.080). The bond would be 50% of the amount individually calculated for each lease.
6 Reduced fees if applicant can work with ADF&G to reduce travel costs and when there is more than one farmer so costs of survey can be split.
7 Survey fee is per day per site and dependent on size of the site.
8 Reduced fees if more than one applicant is in an area.
9 The fee is for water sample testing at $17 a sample, and for the evaluation of results. One year's worth of dry and wet samples is required. Permittee pays for shipping costs for samples to DEC Lab in Anchorage (Approx. costs range -$2,300 - $7,000 dependent on sample plan numbers and location).
10 Operators are required to pay for DEC staff travel and accommodations.
11 Shoreline survey has not been included in the total.
12 DEC permits are good for one calendar year.
13 Applicant are required to pay up to $1,000 for public notice (required as of January 1, 2010).
14 One permit can be used for all three types of shellfish dealers.
15 Does not include DNR's Shucker-Packer annual fee.
16 Does not include Department of Revenues 3% Fisheries Business Export Tax, for any business that exports product out of Alaska.
17 $100 for individual and $200 for corporations
18 Minimum security fee for typical aquatic farm lease, but is dependent on structures used at the site and location of the site and possible cleanup costs.

AUTHORIZATIONS AND CONTACTS

Multiple agency authorizations are required to site, construct, and operate an aquatic farm site in the state of Alaska. ADNR Division of Mining, Land, and Water (DMLW) will review the proposed site to determine if it is in the best interest of the state to grant a 10-year aquatic farm site lease. Once an aquatic farm site lease agreement is granted, Alaska Department of Fish & Game (ADF&G) will review the application, and other site-specific information, before issuing an Aquatic Farm Operation Permit and, if needed, a Special Area Permit to locate a farm in a critical habitat area. Once all State agency authorizations are received, a person can make a request to the U.S. Army Corps of Engineers (USACE) for authorization under the Regional General Permit (GP) POA-2006-1035 for Aquatic Farm Structures within the State of Alaska or Individual permit, if the GP evaluation requirements don't apply to the project.

The following sections provide a summary of the authorizations routinely required by the State of Alaska Departments of Natural Resources (ADNR), Fish and Game (ADF&G), and Environmental Conservation (ADEC), and US Army Corps of Engineers (USACE) to site and operate an aquatic farm in the state of Alaska. Table 1 and 2 provide a list of the state and federal contacts, respectively.

ALASKA DEPARTMENT OF NATURAL RESOURCES, DIVISION OF MINING, LAND, AND WATER
► Aquatic Farm 10-Year Lease Requirements

Activities Covered: Leasing of the state's tidal and submerged land in marine waters
Purpose: To provide for development of the states lands for the purpose of commercial shellfish and sea plant farms
Process: Joint-agency aquatic farm site application packet and agency review for a ten-year lease of state lands, annual reporting, and site inspections
Fees:

- Application filing fee (all applications): $100
- Lease fees: $450 for the first acre plus an additional $125 per acre, or portion thereof. If you have associated housing facilities for the aquatic farm site the fee schedule is $850 for the first acre or portion thereof plus $125 for each additional acre, or portion thereof
- Bond requirement: $2,500 (minimum) for individual or 50 percent of the amount calculated for an association.
- Lease amendment fee: $100 for individual, $200 for corporation
- Lease renewal fee: $100 for individual, $200 for a corporation.
- Cost of public notice of proposed renewal: up to $500 (split by the number of applicants during the opening period)

More Information: http://www.dnr.state.ak.us/mlw/aquatic/index.htm

Lease fees are based on a fair market value, appraisal, or the current fee schedule. The fee schedule is adjusted every 5 years. As with any lease, if you do not want to use the fee schedule, you may pay to have an appraisal done.

The applicant must pay for all costs associated with the required public notice. The cost may be shared if two or more applications are being noticed simultaneously Under 38.05.945 (a)(2)(A) publication of a legal notice in newspapers of statewide circulation and in newspapers of general circulation in the vicinity of the proposed action at least once a week for two consecutive weeks.

Once a favorable final best interest finding is complete and no appeals are submitted and/or upheld by the commissioner, the ADNR sends the applicant a 10-year property lease to operate an aquatic farm for signature. Before the lease is issued a performance bond along with the first year's annual lease fee must be submitted to the ADNR.

A bond is required before issuance of the lease and is determined by such factors as projected site cleanup and restoration should the lessee fail to do so at lease expiration, termination, or abandonment. The minimum bond amount is $2,500. However, if three or more lessees post an association bond to cover all of their leases, the minimum-security amount is 50 percent of the amount individually calculated for each lease. Bonds are subject to periodic review and adjustment, if necessary.

A boundary survey is not required for 10-year leases. However, the department reserves the right to require one should boundary conflicts or disputes over acreage arise.

The definition of aquatic farm in the enabling legislation states that aquatic farms must produce a product that is "sold or offered for sale". The ADNR regulations require that the aquatic farm meet commercial use of the site beginning no later than the fifth year of the lease. This requirement must be reflected in the required development plan, which is incorporated as a provision of the lease. The commercial use requirement was implemented in an effort to prevent "hobbyists" from speculating and not using an area for the commercial purposes intended. If the commercial use requirement is not met by year five of the lease and continued each year for the remaining term, the lease will be terminated. The ADNR currently defines commercial use as: **the minimum annual sales of aquatic farm product (total of all species combined) of at least $3,000 per acre or fraction of an acre, or $15,000 per farm, whichever is less (11 AAC 63.030(b))**.

Personnel housing associated with aquatic farm operations may be approved only if: (1) the level of site development will require personnel be present on a daily basis, 2) personnel cannot reasonably commute to the site by road, boat or aircraft, on a daily basis, and 3) nearby land suitable for housing is not available for sale or lease. This applies to upland facilities as well as floating facilities. **Any housing facility may not be used as a permanent place of abode, must be temporary in nature, and must be designed and constructed so it can be removed and the site completely restored within 30 days if the lease terminates or housing ceases to be necessary. The housing facility may not be placed on a permanent foundation (11 AAC 63.040(b))**.

Please note: The lessee is still responsible for payment of the ADNR's lease fees even though they may not be able to begin operations due to other agencies' authorization requirements.

A lease that is in good standing may be transferred to another entity. "Good standing" as described in 11 AAC 63.900(a)(8) means being in compliance with all provisions of all required authorizations.

Annual inspections are conducted by the ADF&G and the ADNR to the extent possible to monitor compliance with authorized aquatic farm activities.

If a potable water source is to be used in conjunction with an aquatic farm, a Water Right must be obtained. A Water Rights in Alaska Fact Sheet can be found at the DNR/Mining, Land and Water website at http://dnr.alaska.gov/mlw/factsht/wtr_fs/wtr_rght.pdf

If you need additional information, please contact the Water Resources Section with the Division of Mining, Land, and Water at the office listed.

An Alaska Business License is required for any business that operates in Alaska and has to be submitted as part of the application. An Online Alaska Business License Application can be found on the Alaska Dept. of Commerce, Community and Economic Development, Division of Occupational Licensing web site at https://www.commerce.state.ak.us/occ/home_bus_licensing.html

ALASKA DEPARTMENT OF FISH AND GAME, DIVISION OF COMMERCIAL FISHERIES
► Aquatic Farm Operation 10-Year Permit and Transport/Acquisition Permit Requirements

Activities Covered: Aquatic farm, nursery, and hatchery operations.
Purpose: To protect, maintain, and improve the state's fish, game, and aquatic plant resources of the state, and manage their use and development in the best interest of the economy and well-being of the people of the state.
Process: Joint-agency aquatic farm site application packet and agency review for a 10-year aquatic farm operation permit, annual spat transport permits, annual stock acquisition permits, annual reporting, and site inspections.
Fees:

- Survey fee for all on-bottom applications: $5,000 per farm/ per day for a proposed subtidal farm, $2,000 per farm/day for a proposed intertidal farm
- Operation Permit renewal: $100
- Operation Permit transfer: $100

More Information: for permits – http://www.adfg.alaska.gov/index.cfm?adfg=aquaticfarming.main; for program information – and http://www.adfg.alaska.gov/index.cfm?adfg=fishingaquaticfarming.main; for regulations – http://www.adfg.alaska.gov/index.cfm?adfg=fishingaquaticfarming.aquaticregs.

The ADF&G Aquatic Farm Operation Permit is issued after the ADNR lease is granted and all signatures and fees are received by ADNR. The operation permit allows an applicant to construct and operate an aquatic farm, nursery, or hatchery. ADF&G reviews plans to determine the technical and operational feasibility of the venture, physical and biological suitability of an area, and if the proposed area can support the operation without making significant alterations in traditional fisheries or other existing uses of fish and wildlife resources or the habitats that support those resources (AS 16.40.100-105).

Once you obtain an Aquatic Farm Operation Permit for your farm, statute requires the issuance of a Shellfish/Aquatic Plant Stock Transport Permit and/or Acquisition Permit before transferring or acquiring aquatic plants or shellfish seed or broodstock. Applications for transport and/or acquisition permits must be submitted to ADF&G for approval approximately 30 days before your proposed seed transport and/or acquisition. Copies of the permits must accompany the seed or broodstock during transport. Please contact the Statewide Mariculture Program Coordinator in Juneau at (907) 465-6150 for more information. A transport and/or acquisition permit application should NOT be submitted with the aquatic farm application in Part II of this packet.

Please note that currently, ADF&G only allows for the importation of Pacific oyster seed. All other species proposed for culture must be from a certified hatchery or nursery operating within the state of Alaska. A list of certified seed sources is available on the ADF&G website. It is the applicant's responsibility to research the intended species for culture to ensure seed for this species is available for this activity.

The ADF&G regulation 5 AAC 41.240(a) prohibits the permitting of farm sites where significant wild stock populations of the species intended for culture occur. On-bottom aquatic farm proposals for commercial fishery species should be sited where there are minimal numbers of the species intended for culture, which demonstrates the potential of the habitat to support that particular species while at the same time, would not support and attract a commercial fishery. ADF&G has determined that an insignificant population of geoducks is no more than 12,000 pounds of geoducks on a six-acre farm site or an average of no more than 2,000 pounds per acre of an aquatic farm site. Insignificant populations of other shellfish will be determined by ADF&G on a case-by-case basis.

For aquatic farm projects proposing to use on-bottom culture, ADF&G requires that a user fee for a survey of the initial abundance of the species intended for culture be submitted with the 2011 aquatic farm opening application. The user fee for a subtidal on-bottom culture aquatic farm site survey is $5,000 per day per site and for an intertidal on-bottom culture aquatic farm site survey is $2,000 per day per site. The department will work with the applicant to reduce the cost of the user fee for the survey where possible.

Inspections are conducted by ADF&G and ADNR to the extent possible to monitor compliance with authorized aquatic farm activities.

ALASKA DEPARTMENT OF FISH AND GAME, DIVISION OF HABITAT, CRITICAL HABITAT

► Special Area Permit Requirements

Activities Covered: Approval of a project or activity within a State game refuge, game sanctuary, or critical habitat area
Purpose: Regulate water use activities in classified areas, to protect the essential fish and wildlife habitat
Process: Joint-agency application, agency review, special area permit issued for five years and site inspections
Fees: None
More Information: http://www.adfg.alaska.gov/index.cfm?adfg=uselicense.areas
Application: An ADF&G - Special Area Permit Application for Kachemak Bay & Fox River Flats Critical Habitat Management Areas can be found on ADF&G's web site at http://www.adfg.alaska.gov/index.cfm?adfg=kachemakbay.permits

An ADF&G Special Area Permit (5 AAC 95.300 – 990) is required to establish and operate an aquatic farm within a special area. A "special area" is defined as a state game refuge, a state game sanctuary, or a state fish and game critical habitat area, established under AS 16.20. Currently, the only aquatic farming activities allowed within the Kachemak Bay and Fox River Flats Critical Habitat Areas are for suspended culture. Applications will be reviewed for consistency with the goals and policies of the Kachemak Bay and Fox River Flats Critical Habitat Areas Management Plan.

ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION, DIVISION OF ENVIRONMENTAL HEALTH

► Growing Area Classification, Shellstock Shippers, and Shellfish Harvester's Permit Requirements

Activities Covered: Water quality classification; shellfish harvester permit, processing, and shipper permits; paralytic shellfish poisoning (PSP) testing; export certifications, and authorizations for dive boats to be used for shellfish harvesting
Purpose: Sanitary control of regulated food, seafood, and public facilities to protect public health in accordance with the National Shellfish Sanitation Program requirements
Process: Various applications and forms, monitoring programs, testing, and inspections
Fees:

- Water quality classification: Variable, to cover costs of sanitation survey, water sampling, testing, etc.
- Shellfish harvester permit: $162
- Paralytic shellfish poisoning (PSP) testing: Variable, to cover shipment and testing
- Export certifications: $25 for each certificate issued
- Authorizations for dive boats to be used for shellfish harvesting: $162

More Information: contact George Scanlan at www.george.scanlan@alaska.gov or call 907-269-7638

The following ADEC authorizations listed above must be obtained PRIOR to placing your product into commerce. Information can be found at the following ADEC Website: **http://dec.alaska.gov/eh/fss/seafood/Shellfish_Home.html**

A ***Growing Area Classification*** determines that your growing or harvesting water meets the water quality standards set out in the National Shellfish Sanitation Program (NSSP).

A ***Shellstock Shippers Permit*** authorizes individuals/businesses to grow, harvest, buy, or repack and sell shellstock. While this authorization does not allow the shucking of shellfish, it does allow shipping of shucked shellfish.

A ***Shellfish Harvester's Permit*** allows a person to take shellstock from a growing area that has been classified by the ADEC. Please be aware that persons holding a Shellfish Harvester's Permit may only sell product to a processor or shipper who is also permitted by ADEC.

Water quality in the growing area must meet the standards of the NSSP, incorporated by reference in 18 AAC 34.200. The full text of the NSSP is available on the internet at www.issc.org (select "NSSP" from the left-hand column). Once the growing area has been found to meet the NSSP standards, ADEC issues a Growing Area Classification. The Growing Area Classification ensures that the growing or harvesting area(s) is within the acceptable limits for fecal coliform. A shellfish growing area is closed to shellfish harvesting for commercial sales unless classified by the ADEC. Therefore, aquatic farm product may only be sold from sites that have an ADEC water quality classification. In general, the growing area must be free of sewage discharges. Please refer to the Joint-Agency Application in Part II, under the ADEC, Environmental Health Classification Guidelines, for a listing of items that should be considered when selecting a site for aquatic farming operations.

The ADEC charges $500 per growing area classification, which can be pro-rated among two or more farms within the same classified area. Through a Memorandum of Understanding (MOU) between the individual and the ADEC, most of the water quality sampling can be done by the individual under the procedures described in the MOU. Depending on the location of your farm, 15 or 30 water samples will be required from selected sampling sites to initially classify the area. Samples must be collected in both wet and dry weather, during low and high tides, and during the period you intend to harvest. Unless adverse pollution events occur, such as periods of high rainfall or animal activity in the area, it generally takes a minimum of 30 days to collect all the water samples necessary for classification. The operator must pay for shipping sample to the ADEC.

Growing areas must be reclassified annually. Five days of sampling is required for approved areas unless it has a "remote" status, meaning the area has no human habitation and is not impacted by any actual or potential pollution sources. Remote areas require only two days of sampling. The fee for reclassification is $150 per day and also can be pro-rated among two or more farms within the same classification area.

Presently, only the ADEC Environmental Health Lab located at 5251 Hinkle Road, Anchorage, Alaska is authorized to analyze the water samples. Water samples must arrive in Anchorage within 30 hours of being collected, therefore Gold Streak or some other air package service will be required to get the samples to the lab on time. The individual(s) submitting the samples for analyses bears the cost of shipping daily water samples to the lab in Anchorage. If the samples arrive more than 30 hours after being collected, they cannot be tested and more samples must be submitted. This is another important aspect to consider when selecting an aquatic farm site. More details about water quality classification requirements can be found in a fact sheet on ADEC - Classification of Commercial Shellfish Growing & Harvest Areas can be found at **http://dec.alaska.gov/eh/fss/seafood/Docs/shellfishclass.pdfhttp**. It is recommended that applicants obtain this certification before the lease and operation permit is issued. There is no guarantee how long it will take for an area to become ADEC certified.

In addition to water quality classification, testing for Paralytic Shellfish Poison (PSP) is required before any commercial sales are authorized. Currently, the only laboratory approved in the state for PSP testing is the ADEC Lab in Anchorage. Levels cannot exceed the NSSP standard of 80 ug/100 g of tissue. A copy of a Uniform Shellfish Sampling Plan for Paralytic Shellfish Poison can be found at:
http://dec.alaska.gov/eh/fss/seafood/Docs/PSP_Uniform_Shellfish_Sampling_Plan_updated_9-2011.pdf.
The plan describes a four level sampling method used for monitoring PSP at your farm.

Eventually you will be placing the shellfish into commerce as required by the ADNR lease. Therefore, you are also required to have a Hazard Analysis Critical Control Point (HACCP) Plan. A HACCP plan describes the types of hazards that are reasonably likely to occur that could affect the safety of your product and the strategies for controlling those hazards. You must monitor those control strategies and keep written records. The University of Alaska, Marine Advisory Program, periodically offers HACCP training and can be contacted at (907) 274-9691. Additional HACCP training courses are available on the internet at: http://seagrant.uaf.edu/map/haccp/index.html. More information about HACCP plans is available either from the Marine Advisory Program or by contacting George Scanlan, ADEC in Anchorage, at (907) 269-7638.

If you plan to sell your product out of state, you will also need to be placed on the Interstate Certified Shellfish Shippers List. The ADEC must perform an inspection of your facility within the 30 days proceeding the date you are listed. Therefore, if you plan to ship out of state, you will need to contact the department in a timely manner to make those arrangements.

Depending on your aquatic farm operation, there may be other authorizations necessary from the ADEC, Division of Environmental Health. The following is a list of possible authorizations that may be required:

- Shellfish Shucker Packer (allows a person to shuck and pack shellfish or may act as a Shellstock Shipper or a reshipper or may repack shellfish originating from other certified dealers).
- Export Certification (provided as a service by the ADEC, Division of Environmental Health, to assist shellfish shippers). The issuance of export certifications is dependent upon the harvester's and shipper's compliance with 18 AAC 34 and the NSSP requirements.

The ADEC website has all of the information needed to obtain approval from the department as well as links to other important sites. Please visit: http://dec.alaska.gov/eh/fss/seafood/Shellfish_Home.html.

UNITED STATE ARMY CORPS OF ENGINEERS, ALASKA DISTRICT
► Authorization for Placement of Aquatic Farm Structures Within the State of Alaska's Navigable Waters

Activities Covered: Authorizes the placement of aquatic farm structures in navigable waters within the State of Alaska.
Purpose: To prevent unauthorized obstruction or alteration of any navigable water of the United States.
Process: Application process, Dept of Army (DA) Form 4345, and General Permit POA-2006-1035 for Aquatic Farm Structures Within the State of Alaska. Once all state regulatory agencies approve of the development of an aquatic farm site, authorization is given under either the Regional General Permit POA-2006-1035 or an Individual Permit. Site inspections may be conducted.
Fees: None
More Information: http://www.poa.usace.army.mil/reg/gps.htm
Applications: USACE Applicability Certification for GP POA-2006-1035 for Aquatic Farm Structures Within the State of Alaska navigable waters. Structures include associated float houses and mooring buoys. The General Permit and Review Request can be found at http://www.poa.usace.army.mil/reg/gps_scanned/General+Permit+2006-1035.pdf. The DA Form 4345 - Instructions and Application for Department of the Army Permit. The application for this can be found at http://www.lrl.usace.army.mil/orf/article.asp?id=1702&MyCategory=4 (fill-able). Instructions can be found at http://www.lrl.usace.army.mil/orf/article.asp?id=1915&MyCategory=44.

Table 1: AQUATIC FARM STATE AUTHORIZATION AGENCY CONTACTS

State Agency	Permit Type	Contact Information
ADNR: Division of Mining, Land &Water (DMLW)	Aquatic Farm Lease	John S. Thiede, Aquatic Farm Program Manager 550 West 7th Avenue, Suite 900C Anchorage AK 99501 Phone: (907) 269-8543 Fax : (907) 269-8913 Email: john.thiede@alaska.gov www.dnr.alaska.gov/mlw/aquatic/index.htm
ADF&G: Division of Commercial Fisheries	Aquatic Farm, Hatchery, Nursery Operation Permit; Shellfish or Aquatic Plant Transport Permit; Aquatic Stock Acquisition Permit; Surveys	Cynthia Pring-Ham, Statewide Mariculture Program Coordinator 1255 W. 8th Street P.O. Box 115526 Juneau, AK 99811-5526 Phone: (907) 465-6150 Fax: (907) 465-4168 Email: cynthia.pring-ham@alaska.gov www.cf.adfg.state.ak.us/geninfo/enhance/maricult/maricult.htm
ADF&G: Division of Sport Fish	Special Area Permit: (specific to Kachemak Bay& Fox River Flats Critical Habitat Mgt Areas)	Ginny Litchfield, Area Manager 514 Funny River Rd Soldotna, AK 99669 Phone (907) 714-2478 Fax (907) 260-5992 Email:ginny.litchfield@alaska.gov www.sf.adfg.state.ak.us/SARR/SpecialAreas/sapermit.cfm
ADEC: Division of Environmental Health	Water Quality Classification; Shellfish Harvest Permit; Shellfish Shipper Permit; Shellfish Shucker Packer Permit; Shellfish Repacker Permit; Export Certification.	Contact: George Scanlan, Shellfish Coordinator Environmental Health, Food Safety and Sanitation Program 555 Cordova Street Anchorage, AK. 55501. Phone (907) 269-7638 Fax (907) 269-7510 Email: george.scanlan@alaska.gov http://www.dec.state.ak.us/eh/

Table 2: AQUATIC FARM FEDERAL AGENCY CONTACTS

Federal Agency	Permit Type	Contact Information	
U.S. Army Corps of Engineers (USACE)	General Permit POA-2006-1035 for Aquatic Farm Structures Within the State of Alaska or Individual permit	Southeast Region: Juneau Regulatory Field Office U.S. Army Corps of Engineers 8800 Glacier Highway, Suite 106 Juneau, AK 99801-8079 Phone (907) 790-4490 regpagemaster@usace.army.mil http://www.poa.usace.army.mil/hm/default.htm	Southcentral Region (Prince William Sound, Southcentral, And Kachemak Bay): Anchorage Field Office U.S. Army Corps of Engineers P.O. Box 6898 Elmendorf AFB, AK 99506-0898 Phone (907) 753-2712
U.S.D.A. Forest Service	Upland Use Permit	Chugach National Forest: Tongass National Forest:	(907) 743-9500 www.fs.fed.us/r10/chugach (907) 225-3101 www.fs.fed.us/r10/tongass
U.S. Fish & Wildlife Service (USFWS)	Review of Projects within Wildlife Refuges	Ecological Services: Southeast Southcentral Refuge Operations: Subsistence Management:	www.r7.fws.gov (907) 586-7240 (800) 272-4174 (907) 786-3354 http://refuges.fws.gov (800) 478-1456 http://alaska.fws.gov/asm/index.htm
National Marine Fisheries Service (NMFS)	Review of Projects within Essential Fish and Endangered Species Habitat, and Sensitive Sea Mammal Haulouts and Rookery Areas	www.nmfs.noaa.gov	(907) 586-7221

ALASKA'S AQUATIC FARM PROGRAM

Application Opening Period
January 1st through April 30th

PART II
INSTRUCTIONS AND APPLICATION

1. Answer ALL questions using the blanks provided or include additional pages.
2. If additional pages are included, write the corresponding question number from the application on the appropriate page(s).
3. Type or print answers clearly in black ink.
4. An agent cannot sign the application form for the applicant; the applicant must submit the application with an original signature.
5. **STATE AGENCY FEES:** Mail the applicable fees with the completed application packet to either DNR Office:

Department of Natural Resources Aquatic Farm Application 550 W. 7th Avenue, Suite 1260 Anchorage, AK 99501-3557	Department of Natural Resources Aquatic Farm Application 400 Willoughby Ave. Ste 400 Juneau, AK 99801

Application Fee: A non-refundable application fee paid to **Department of Natural Resources** (ADNR) is currently set at **$100** for individuals or **$200** for corporations.

Survey Fee: If your proposed project involves on-bottom clam farming techniques, **Alaska Department of Fish and Game** (ADF&G) will need to conduct a survey to determine the abundance of wild stock shellfish at the proposed site. The fee for the survey is **$2,000**** for an intertidal on-bottom site and **$5,000**** for a subtidal on-bottom site. Mail a separate check for this survey, made out to ADF&G, and submit it along with the completed application packet. **Note: The actual cost may vary by site, please refer to Part I.

Other Fees: A summary of all state fees applicable to aquatic farms sites can be found in Part I.

6. **The original application including attachments and all required fees must be delivered and physically present in either of the Alaska Department of Natural Resources offices listed above by 5:00 p.m., on the last day of April.**

7. If you are applying for more than one site and the boundaries of any additional sites are more than three nautical miles apart, you must submit a separate application for these sites. Alternate sites with a distance of more than three nautical miles apart will not be accepted on the same application.

8. Please Note: The aquatic farm review is for the specific project that you identify in your application. If you decide to change the location or increase the footprint of your operation during the review period, processing of your application will stop, and you will need to re-apply during a subsequent filing period.

For assistance completing the application, please call John S. Thiede (ADNR) at (907) 269-8543 or Cynthia Pring-Ham (ADF&G) at (907) 465-6150.

AQUATIC FARM APPLICATION CHECKLIST

Check off (√) each item after you have completed the task.
By following this checklist you should have a complete application, ready to be processed.

________ Detailed Project Description (Page 2, Section B)

________ General Location Map using USGS topographical map (Page 4, Section C-3a)

________ Detailed Location Map using a NOAA Nautical chart (Page 4, Section C-3b)

________ Site plan map (Pages 4, Section C-3c)

________ Cross-section Diagram(s) of all facilities, equipment, gear, and anchor systems (Page 5, Section C-3d)

________ Detailed Drawing(s) of all facilities equipment, gear, and anchor systems (Page 5, Section C-3e)

________ Signature for the Aquatic Farm Program Application (Page 9, Section J)

________ Aquatic Farm Operation and Development Plan – Part A (Page 10, Section K)

________ Aquatic Farm Operation and Development Plan – Part B (Pages 11 –12, Section K)

________ Check or money order for the ADNR application filing fee ($100 individuals/$200 corporations), made payable to ADNR.

________ <u>If applicable</u>, Ownership Deed or lease document for any upland facility use not on state lands, (Page 7, Section F-3)

________ <u>If applicable</u>, Authorization from City or Borough Planning Departments if site is within a City or Borough Planning area (Page 7 - 8, Section F-4)

________ <u>If applicable and you are proposing to farm clams (geoducks, littleneck clams, etc.) utilizing on-bottom culture methods,</u> a fee of $2,000 for an intertidal survey or $5,000 for a subtidal survey, made payable to ADF&G.

For Office Use Only **ADNR File No:** ____________________ **DATE STAMP:**
ADF&G No: ____________________

AQUATIC FARM PROGRAM APPLICATION

You are encouraged to submit a completed application as early in the filing period as possible. The 2012 application form must be used and properly completed before state agencies can process your project. **An incomplete application will not be processed.** A checklist is included to assist you in meeting this requirement. The best way to facilitate the review of your application is to schedule a pre-application meeting with DNR and ADF&G to discuss your project. The original application including attachments and all required fees must be delivered and physically present in the Alaska Department of Natural Resources office no later than 5:00 p.m. on April 30th.

The project location is in: (Check one) **Southeast Alaska** **Southcentral Alaska**
(Southeast = Projects south of or in the Yakutat area / Southcentral = Projects north of Yakutat

A. APPLICANT INFORMATION

Name

Business Name (If Applicable)

Mailing Address (PO Box or Street Address)

City State Zip

Email Address

Home/Office Phone Cell Phone

If you live in a remote area please provide a contact person (name, phone & email address) who can be easily reached.

Contact Name

Contact Phone Number

Business Partner Name (If applicable)

Business Partner Email Address (If applicable)

Business Partner Phone (If applicable)

`

***Please Answer (√) the following questions:**

This project is: ☐ **First time application** ☐ **Amendment** ☐ **Second time application (years 11-21)**

I plan to farm: ☐ Pacific oyster ☐ Pacific littleneck ☐ geoduck ☐ blue mussel ☐ cockle ☐ sea urchin ☐ aquatic plant (kelp) ☐ other ____________________

I plan to utilize the following area/culture method: ☐ subtidal suspended ☐ subtidal on-bottom ☐ intertidal near-bottom ☐ intertidal on-bottom ☐ other ____________

I plan to utilize the following gear/equipment: ☐ grow-out rafts and ☐ trays (plastic), or ☐ cages (metal) ☐ longlines and lantern nets ☐ flip-flop bags and line ☐ floating shark fin bags ☐ vexar bags ☐ tubes (PVC or vexar) ☐ predator netting ☐ other ________________________________

My support facilities will include: ☐ work raft ☐ enclosed processing facility ☐ processing raft ☐ floating dock(s) ☐ personnel/caretaker housing facility ☐ other ____________________

B. PROJECT DESCRIPTION

<u>On a separate piece of paper,</u> please provide a general description of your proposed aquatic farm site and operations. This should be a narrative of your proposal that includes where your project will be located, overall size including any hardening area, all species you intend to culture, type of farm gear, equipment, support facilities, and associated housing to be used including size, number, and construction materials. Your narrative should match the rest of the application information you provide. **Please label your narrative, "PROJECT DESCRIPTION". The following check-off list can be used to assure all items are covered in your project description.**

- ✓ Site location
- ✓ Site dimensions, acres for each parcel
- ✓ Total acres of all parcels
- ✓ Species you intend to farm
- ✓ Culture Method
- ✓ Gear (type, size, number, configuration, material, mesh size, and anchoring system)
- ✓ Equipment (type, size, number, configuration, material, and anchoring system)
- ✓ Harvest equipment and method
- ✓ Support Facilities (type, size, number, configuration, material, and anchoring)
- ✓ Access to and from site
- ✓ Storage location of equipment and gear when not in use

Note: All floating raft structures should use non-treated wood supported by closed cell (extruded) expanded polystyrene or equivalent material

<u>EXAMPLE OF A PROJECT DESCRIPTION</u>:

The proposed aquatic farm site is composed of three separate parcels located on state-owned tidal and submerged lands, totaling about 4.07 acres. Parcels include:

- *growing area measuring 292 ft x 546 ft (3.66 acres) for subtidal suspended culture of Pacific oysters using grow-out raft and cage system (Parcel 1);*
- *intertidal area measuring 60 ft x 154 ft (0.21 acre) for hardening and defouling (Parcel 2); and*
- *support facility area measuring 46 ft x 190 ft (0.20 acre) for a dock and dock and storage (Parcel 3).*

The proposed aquatic farm is located about 24.7 nautical miles south-southwest of Wrangell near Rocky Bay, a small bay near the mouth of Mosman Inlet on Etolin Island in southeastern Alaska. (Attachments 1-5)

Parcel 1 will hold eight (8) – 16 ft by 20 ft oyster grow-out rafts. Each grow-out raft will use 100 to a maximum of 300 Aquamesh cages stacked 10-high. Each cage will measure 22 inches wide x 22 inches long x 6 inches deep, manufactured of 1- inch by 1-inch PVC coated wire mesh. The 6 ft stacks of cages would hang 8 ft under the water's surface. In addition, in the southwestern portion of the parcel, a 40 ft x 40 ft processing float with one 16 ft x 16 ft work shed, a covered area, and two 20 ft x 4 ft work platforms on each side will be used to accommodate oyster grow-out rafts during processing. The anchor system for all rafts would consist of floating anchor lines from each corner secured using 300 lb concrete anchors in water 60 ft deep. All rafts are constructed of untreated local wood with floatation made of closed cell (extruded) expanded polystyrene. (Attachments 6 – 10)

Parcel 2 will be used for hardening and defouling of Pacific oysters, using Aquamesh trays measuring 22 inches wide by 22 inches long by 6 inches deep (Attachment 11).

Upland facilities and support structures are located on National Forest Service lands adjacent to the farm site. Access to the site is by skiff from the adjacent uplands. Equipment and gear storage will be located on the permitted uplands or in Ketchikan.

C. PROJECT LOCATION

1. Coordinates

Please provide latitude and longitude coordinates for each corner of each parcel at the proposed farm site. Identify each parcel to be used. For example, Parcel 1 - growing area, Parcel 2 - hardening area, etc. Latitude and longitude coordinates must be in **NAD83 datum using degrees and decimal minutes format to the nearest .001 minute (Example: Longitude -133° 17.345)**, obtained using a Global Positioning System (GPS). A handheld GPS unit can be provided with a $100 security fee by contacting the ADF&G at (907) 465-6150.

Parcel 1:	NE Corner No. 1: Latitude ______________________	Longitude ______________________
	SE Corner No. 2: Latitude ______________________	Longitude ______________________
________________	SW Corner No. 3: Latitude ______________________	Longitude ______________________
(e.g. Grow-out Area)	NW Corner No. 4: Latitude ______________________	Longitude ______________________
Parcel 2:	NE Corner No. 1: Latitude ______________________	Longitude ______________________
	SE Corner No. 2: Latitude ______________________	Longitude ______________________
________________	SW Corner No. 3: Latitude ______________________	Longitude ______________________
(e.g. Hardening Area)	NW Corner No. 4: Latitude ______________________	Longitude ______________________
Parcel 3:	NE Corner No. 1: Latitude ______________________	Longitude ______________________
	SE Corner No. 2: Latitude ______________________	Longitude ______________________
________________	SW Corner No. 3: Latitude ______________________	Longitude ______________________
(e.g. Support Facility Area)	NW Corner No. 4: Latitude ______________________	Longitude ______________________

2. Site Size (please use the following formula to compute area)

1. To compute the total area (sq. ft), multiply the width (ft) by the length (ft) of site Parcel 1. The outside length and width of the Parcel **must include your anchors and anchoring system plus any scope**.
2. Divide the area (sq. ft) of Parcel 1 by 43,560, to convert the area from sq. ft to acres.
3. Repeat for each separate Parcel of your proposed farm site.
4. Add the acres of each Parcel to get the total tideland acres for your proposed farm site.
5. Write the amount of Total Acres on the line where indicated.
6. Note that the number of acres must correspond to your farm site maps and drawings.

Parcel 1: _______________ feet (x) _______________ feet = ________________ square feet (÷) 43,560 = _____________
(Width of Parcel 1) (Length of Parcel 1) (Area) (Acres)

Parcel 2: _______________feet (x) _______________ feet = ________________ square feet (÷) 43,560 = _____________
(Width of Parcel 2) (Length of Parcel 2) (Area) (Acres)

Parcel 3: _______________ feet (x) _______________ feet = ________________ square feet (÷) 43,560 = _____________
(Width of Parcel 3) (Length of Parcel 3) (Area) (Acres)

How many total acres of state-owned tidelands are you applying for (add all parcel acres): _____________
(Total Acres)

If you are **also** applying for **state owned uplands for support facilities**, how many total upland acres are you applying for? _______________
(**Total Upland Acres**)

3. Maps and Diagrams

Provide copies of maps and diagrams including general and detailed location maps, site plan map (an over view), cross-sectional diagram and detailed drawings. If the project has multiple parcels, you must provide maps of each location. Copies of the maps and drawings should be no larger than 8½" x 11" (standard letter

size). Examples are provided at the end of the application.
A list of locations to obtain maps is provided below:

USGS Topographic quadrangle maps	State of Alaska Land Records – http://mapper.landrecoreds.info
NOAA nautical charts	NOAA – www.charts.noaa.gov
	Other suppliers – www.naco.faa.gov/agents_acc.asp
Other specialized maps	State of Alaska Land Records – http://tidelands.landrecords.info.
ShoreZone mapping system	http://alaskafisheries.noaa.gov/habitat/shorezone/szintro.htm
Catalog of Anadromous Streams	http://www.sf.adfg.state.ak.us/SARR/AWC/index.cfm/FA/maps.interactive

***Be sure to include a legend box on all maps and diagrams you provide with your application with the following information:**

FORMATTING	**LEGEND BOX EXAMPLE**
Figure No. and Title	FIGURE 1 Detailed Location Map
Applicant Name (Business Name)	Alaska's Best Oysters
Waterbody	Jerryton Bay
Area/Region	East of Prince of Wales Island, Southeast AK
Today's Date	March 30, 2012

a. General Location Map – This map is a larger scaled map showing larger surrounding area with less detail (See Figure 1). Use a USGS Topographic quadrangle map (scale: 1" = one mile (1:63,360)) and label it "Figure 1" and show the following information:

- ☐ USGS Map Name (e.g. Craig B-4) ______________________
- ☐ General location of the farm site
- ☐ Distance (in nautical miles), and direction (arrow) of the site from the nearest community
- ☐ A directional arrow identifying North
- ☐ Scale
- ☐ Legend box (example above)

b. Detailed Location Map – This map is a smaller scaled map showing more detail (See Figure 2). Use a National Oceanic and Atmospheric Administration (NOAA) navigational chart and label it Figure 2 and show the following information:

- ☐ NOAA Chart No. _________________
- ☐ Boundaries of each farm area parcel and clearly label all corners (NE, SE, SW, and NW)
- ☐ Coordinates
- ☐ Directional arrow identifying North
- ☐ Scale on map
- ☐ Legend box (example above)

If uplands area is proposed:
- ☐ location and type of use (e.g. housing, storage shed, etc.)

c. Site Plan Map – Draw an overhead view of the farm area parcel(s) and surrounding area (See Figures 3 and 4). Label it "Figure 3"and show the following information:

- ☐ Boundaries of each farm area parcel and clearly label all corners (NE, SE, SW, and NW)
- ☐ Distance (in feet) between corners of each parcel
- ☐ All in-water structures and anchoring systems (All anchoring systems and anchor scope have to be <u>inside</u> the farm parcel boundary)
- ☐ Acres of each parcel.
- ☐ All equipment and support facilities with dimensions (in feet)
- ☐ Areas of eelgrass beds (intertidal zone)

- ☐ Areas of kelp beds (subtidal zone)
- ☐ Fuel and chemical storage
- ☐ Nearby anadromous streams (salmon)
- ☐ Major natural and man-made features (on site or nearby)
- ☐ Bottom characteristics (sand, mud, silt, clay, bedrock, cobble, shells, rockweed, algae/seaweed)
- ☐ Locations of all known existing uses, as provided in Section E of this application
- ☐ Legend box (example on previous page)

d. Cross-Sectional Diagram(s) - Provide Cross-Sectional Diagram(s) of all support facilities, equipment, and gear showing their placement and anchoring systems (See Figure 5). Note that more than one diagram may be required. Label it "Figure 5" (and so on) and show the following information:

- ☐ Distance between all facilities, gear or equipment on the proposed farm site
- ☐ Distance from bottom of gear to ocean bottom at mean lower low tide
- If suspended or on-bottom culture:
  - ☐ water depth at low tide
  - ☐ major on-bottom physical features (e.g. bottom contours)
- ☐ Dimensions of the anchoring configuration and poundage
- ☐ Dimensions of the marker buoy configuration
- ☐ Scale
- ☐ Legend box (example on previous page)

e. Detailed Drawing(s) - Provide Detailed Drawing(s) of all support facilities, equipment, and gear (See Figure 5). Note that more than one diagram may be required. Label and show the following information:

- ☐ Draw and label the dimensions (length/width/heigh**t**) of all proposed gear and equipment.
- ☐ If suspended, indicate water depth at low tide in relation to structures and gear.
- ☐ Identify the construction materials used for all support facilities, equipment, and gear proposed.
- ☐ Legend box (see below*

D. SITE SUITABILITY - PHYSICAL AND BIOLOGICAL CHARACTERISTICS

1. Is the proposed location protected from severe storms, winter ice, and away from boat traffic?
   Yes ☐ **No** ☐
2. Are the proposed operation support facilities, equipment, gear and anchoring systems built to withstand high strong tidal currents and/or storms? **Yes** ☐ **No** ☐
3. Does your site have good water exchange? **Yes** ☐ **No** ☐
4. Are water temperatures suitable for proposed culture species? **Yes** ☐ **No** ☐
   (Note: temperatures > 60˚ F and < 31˚ F may pose problems such as Vibrio bacteria contamination or icing.)
5. Is there any significant freshwater influence near the farm? **Yes** ☐ **No** ☐
6. (Note: freshwater may impact shellfish growth and/or survival or carry fecal coliform or other pollutants)
7. Is the salinity concentration at your proposed farm site above 28 ppt? **Yes** ☐ **No** ☐
8. Have you monitored the phytoplankton (microalgae) abundance and types during the main grow-out season?
   Yes ☐ **No** ☐ **If yes, findings**: ____
   (Note: shellfish depend on phytoplankton for food, but harmful phytoplankton can prevent harvest/sales.)
9. Have you monitored suspended sediments or turbidity (e.g. water clarity/transparency using a secchi disc) at your proposed farm site? **Yes** ☐ **No** ☐ **If yes, findings**: ______________________________
   (Note: This is used as rough check for microalgae densities, run-off, and glacial silt (milky- grey color).)
10. For on-bottom culture, are the bottom characteristics suitable for the proposed speci**es? Yes** ☐ **No** ☐
    Sand ☐ **Mud** ☐ **Silt** ☐ **Clay** ☐ **Bedrock** ☐ **Cobble** ☐ **Shells** ☐ **Rockweed** ☐ **Other** ________
11. What is the bottom contour like? **Flat** ☐ **Steep** ☐ **or Rough** ☐
12. For suspended culture, is the water depth sufficient to prevent gear from grounding and impacting the benthos under floating structures? **Yes** ☐ **No** ☐ **Depth of Gear** (in ft)**:** ____ **Water depth at low tide** (in ft):____

13. Have you monitored the presence and extent of possible fouling organism within or around your proposed site (barnacle, mussels, algae, etc.)? **Yes** ☐ **No** ☐ **If yes, findings**: ____________________
14. Is your proposed site more than 300 ft from an anadromous fish (e.g. salmon) stream? **Yes** ☐ **No** ☐
15. Are you aware of any eelgrass or kelp beds on or near your proposed farm site? **Yes** ☐ **No** ☐ **If yes**, describe: ____________________
16. For farming using on-bottom culture methods, what is the approximate density of the target species on the proposed farm site? **High** ☐ **Medium** ☐ **Low** ☐
17. What are the shellfish predators and what measures will you take to control, di**s**courage, or eliminate them at your proposed farm site? ____________________
18. Is your proposed farm site in a sensitive area as listed in section C of Part 1 Application Process, Guidelines, Authorizations and Contacts? **Yes** ☐ **No** ☐ **If yes**, describe how your farm site can be sited without significant impact to the area? ____________________

E. KNOWN EXISTING USES

Please check the boxes below, to indicate existing human and/or wildlife uses observed or known to exist at or within three miles of the proposed farm site. Indicate the locations of these existing uses on the Site Plan Map (refer to page 4, Section 3c).

- ☐ mining
- ☐ timber harvest or transfer
- ☐ residential use
- ☐ harbor development
- ☐ sheltered boat anchorage
- ☐ seaplane landing
- ☐ commercial lodges
- ☐ sightseeing
- ☐ recreation
- ☐ tourism
- ☐ historical/cultural/archeological site
- ☐ other aquatic farm projects
- ☐ navigational channels:____________________
- ☐ other; list ____________________
- ☐ commercial fishing
- ☐ sport fishing
- ☐ salmon hatcheries
- ☐ hunting
- ☐ seafood processing plants
- ☐ upland access route(s) areas, bear trails, etc.
- ☐ wildlife uses, (e.g. shorebirds, sea mammal haul-outs)
- ☐ subsistence; list species and frequency ____________________

1. Do any of the existing uses checked above impact your project feasibility? **Yes** ☐ **No** ☐ **If yes**, describe the impact and how you propose to mitigate or eliminate the impacts?____________________

2. Describe how your project may impact any of the existing uses checked above (consider navigational channels, especially in cases where they may be limited).____

F. SUPPORT FACILITIES AND CITY AND BOROUGH CONTACTS

1. Personnel/Caretaker Housing*
   Are you proposing any personnel/caretaker housing? **Yes** ☐ **No** ☐
   If yes, the proposed size will be: _____ (Width) _____ (Length) _____ (Height)
   Please attach diagrams/drawings with labels clearly showing the Personnel/Caretaker housing.

   What would be the maximum number of people housed per day? ________ (Needed for USACE)

   ***Note: a personnel/caretaker facility will add $425.00 to your Department of Natural Resources annual fee.**

   Note: you may stay a maximum of 14 consecutive days at your site on state-owned uplands or tidelands without applying for personnel/caretaker housing.

2. Enclosed Processing Facility
   a. Are you proposing any enclosed processing facility? **Yes** ☐ **No** ☐
   If yes, the proposed size will be: _____ (Width) _____ (Length) _____ (Height)
   Please attach diagrams/drawings with labels clearly showing the processing facility.

3. Upland Property
   Do you currently own or lease upland property adjacent to, or near, the proposed farm site that you plan to use in conjunction with your proposal? **Yes** ☐ **No** ☐ **If yes**, attach a copy of ownership deed or lease.
   If you are the adjacent upland owner, are you applying for a preference right under 11 AAC 63.040(f)? **Yes** ☐ **No** ☐
   a. Please provide the names and addresses of the upland owners within one-half mile on each side of your proposed farm site. **This information may be obtained through borough/city property tax records, state, or federal land records.** Note: all adjacent upland owners within one-half mile on each side of your proposed farm site **must be notified**.

   ____
   UPLAND OWNER(S) ADDRESS

   ____
   UPLAND OWNER(S) ADDRESS

4. City/Borough Authorization
   If you are applying within a recognized first class city or borough, please contact the appropriate Planning Section as additional authorizations may be required from them. Please provide the name, address, and telephone number of the person(s) you contacted and list any required authorizations.

	CITY/BOROUGH	PHONE	CONTACTED?
☐	Ketchikan Gateway Borough – Planning & Community Development….	228-6625	**Yes** ☐ **No** ☐
☐	City of Craig – Planning & Zoning……………………………………….	826-3275	**Yes** ☐ **No** ☐
☐	City and Borough of Juneau – Permit Center…………………………….	586-0770	**Yes** ☐ **No** ☐
☐	City and Borough of Sitka – Planning & Community Development……..	747-1824	**Yes** ☐ **No** ☐
☐	City of Thorne Bay ……………………………………………………….	828-3380	**Yes** ☐ **No** ☐

☐ City and Borough of Yakutat – Planning & Zoning Commission……….. 784-3281 **Yes** ☐ **No** ☐
☐ Kenai Peninsula Borough – Land Management Division………………… 714-2200 **Yes** ☐ **No** ☐

Type of authorization required by City or Borough: ____

G. WATER QUALITY INFORMATION – Department of Environmental Conservation

Do you plan to use a boat on your farm site? **Yes** ☐ **No** ☐ **If yes**, indicate the type of marine sanitation device. ______________________________

1. If you plan to have personnel housing or caretaker facilities:
   Will wastewater be discharged from these facilities? **Yes** ☐ **No** ☐ **If yes,** what are the daily maximum and average discharge volumes? Maximum ____________________Average ______________________
2. Were there any sources of past pollution at the site, such as a shore-based seafood processor, log transfer facility, industrial facility, oil spill contamination, or town or village? **Yes** ☐ **No** ☐ **Unknown** ☐
   If yes, identify:
   a. The type of previous use (e.g. mine, village, seafood processor, oil spill).
   ____
   ____
   b. The last known date of use. ____
   c. The distance from the site previously used to your proposed site. __________________________
   ____
3. Are you aware of any current potential sources of human or industrial pollution in the area? (e.g. sewage outfalls, oil contamination, industrial transfer facilities upland operations, boat harbors, etc.)
   Yes ☐ **No** ☐ **If yes**, describe:
   a. The type of discharge(s). ____
   ____
   b. The location and distance from your site. _____________________________________
   ____
   c. The name of the discharger(s), if known. ______________________________________
   ____
4. Are you aware of any other planned development in the general area of your proposed site?
   Yes ☐ **No** ☐ **If yes**, describe the planned development. ___________________________
   ____
   ____
5. The DEC may request that you provide a map for certain projects to show the following information:
   a. areas of wastewater disposal systems, including both sewage and grey water discharge points (grey water means domestic wastewater from laundry, kitchen, etc., which does not contain human waste)
   b. location of drinking water, including drinking water wells or other drinking water system sources (fresh water and salt water), within 200 feet of any proposed or existing wastewater disposal systems
   c. location of solid waste storage and disposal sites (Note: you are encouraged to use existing permitted sites for the disposal of solid wastes. If there are not any existing permitted disposal sites in the area and they are necessary in your operation, you must contact the ADEC for authorization)
   d. areas used for fuel and chemical storage

I. US ARMY CORPS OF ENGINEERS GENERAL PERMIT EVALUATION

The US Army Corps of Engineers (USACE) has developed a General Permit (GP) for Aquatic Farm Structures within the State of Alaska. The GP only applies to projects that can meet the specific GP conditions. The Departments of Natural Resources and Fish and Game will evaluate your application and help determine if you can apply for authorization under the GP. If your proposed project does not meet the GP conditions, you will need to apply to the USACE for an Individual Permit using Department of Army (DA) permit application.

J. APPLICATION SIGNATURE BLOCK

AQUATIC FARM APPLICATION SIGNATURE AND PROGRAM CERTIFICATION STATEMENT

The information contained in this aquatic farm application is true and complete to the best of my knowledge and certify that the proposed activity complies with, and will be conducted in a manner consistent with all State and Federal Agency policies and regulations. I understand that modifications to the proposed activity may require additional review and that I may need to apply for an Individual Permit with the US Army Corps of Engineers.

This certification statement does not provide authorization necessary to sell my product. I understand I must separately apply for and hold a Growing Area Certification and a Harvesters Permit from the Department of Environmental Conservation.

Printed Name ____

Signature of Applicant ______________________________ **Date** ____________________

Printed Name ____

Signature of Applicant______________________________**Date** ____________________

☐ **I have enclosed the application fee of $100 for individuals or $200 for corporations**

K. AQUATIC FARM OPERATION AND DEVELOPMENT PLAN – PARTS A & B

Your 10-year operation and development plan (ODP) is an important tool for both you and state agencies. Your aquatic farm is a commercial endeavor. Personal use or subsistence is not part of the Aquatic Farm Program. Therefore, your farm must meet a commercial use requirement (CUR) no later than the end of the fifth year of your lease and sales must be maintained or increased in the remaining years of the lease. Commercial use of the site means annual sales of aquatic farm products, as defined in AS 16.40.199, of at least $3,000 per acre or fraction of an acre, or $15,000 per farm, whichever is less. The CUR applies to the combined total of all species and is not a "per species" requirement. The 10-Year ODP should be an accurate reflection of your operations for each year you are farming. Therefore, the estimated amount of sales must correlate to the estimated amount of seed you plan to purchase minus mortality rates. ***Note: You must complete <u>one 10-Year Operation and Development Plan for each species you propose to farm</u>.**

***Complete one operation and development plan for each species**

AQUATIC FARM OPERATION AND DEVELOPMENT PLAN – PART A

Part A includes questions regarding your proposed operation. Your proposed aquatic farm or hatchery plans must demonstrate technical and operational feasibility (AS 16.40.105(4). Please provide any additional information that you consider pertinent to your operating plan on additional sheets of paper as necessary.

Name ________________________________ **Species** ____________________________________

ADNR Lease ADL No.: __________________ **ADF&G Permit No.** _____ - _____ **-AF -** ___________

1. **Site Monitoring/Maintenance**
   a. How often, in days per month, do you intend to monitor your site for things such as adequate anchoring, disease, exotic species settlement, fouling, gear drift, snow load, wind damage, vandalism, etc.?
   Growing season ________ (days/month) **Winter months** _________ (days/month)
   b. Where will you store any farm gear and/or equipment when not in use? ____________________________
   c. How will you keep the gear and shellfish free of fouling organisms (hot-dip, air dry, pressure washing, etc.)? ____________________________
   d. How will you manage incidental species over the course of operations (sea urchins, sea cucumbers, butter clams, or other non-targeted species)? ____________________________
   e. If you intend to use predator netting, how long will you keep netting over your product?________(months)
2. **Record keeping**
   a. What methods are you going to use to measure the success of your operation (growth, survival or mortality rates, production, etc.)? ____________________________
   b. Will you maintain records of aquatic farm product, such as counts and measurements to track survival and growth? **Yes** ☐ **No** ☐ **Describe:** ____________________________
   c. Do you plan to record other physical or environmental parameters at your site such as water temperatures and salinity? **Yes** ☐ **No** ☐ **Describe:** ____________________________
3. **Harvest**
   a. How often do you intend to harvest your product?____________________________
   b. How do you intend to harvest your product? **Suspended:** Manual ☐ other______________________
   On-Bottom: Hand/Digging ☐ Hydraulic wand ☐ Manual ☐ other______________________
   Near-Bottom: Manual ☐ other ☐ ____________________________
4. **Sales**
   a. DNR has a commercial use requirement (CUR) of $3,000 per acre per year or $15,000 per farm, whichever is less. What is your anticipated CUR by the end of year 5? $____________________________
5. **Seed Acquisition**
   a. Which certified shellfish seed source(s) will you use?____________________________
   b. How do you intend to collect wild seed? (applicable for indigenous species: i.e. mussels, scallops, abalone, etc.) ____________________________

PART A – SIGNATURE BLOCK

Signature: ________________________________ **Date:**________________________

AQUATIC FARM OPERATION AND DEVELOPMENT PLAN – PART B (Page 1 of 2)

Complete one operation and development plan for each species using a reasonable expectation of what you believe is possible for each year of the 10-year lease and operation permit. This is a projection to help you visualize a 10-year farming plan keeping in mind that annual sales at the end of year 5 must meet or exceed the commercial use requirement and sales must then be maintained or increased in the remaining years of the lease. Commercial use equals the annual sum of farm sales from all species combined. The commercial use requirement does not have to be met for each species. Your plan can be amended to reflect any changes as the aquatic farm operations develop.

Name ___________________________ **Species**_________________________ **ADL Number** _____________ **ADF&G Permit No**. ___ ___-AF-___

Calendar Year	Installation Schedule: Support Facility Types/Numbers[1]	Installation Schedule: Equipment/ Gear Types/Numbers[2]	Installation Schedule: Anchoring System Types	# of Hatchery-Produced Seed	#of Seed Collected Onsite (Only applies to indigenous sp.)	Aquatic Farm Production Projected Harvest and Sales: Projected Sales[3] ($)	Aquatic Farm Production Projected Harvest and Sales: # of Animals	Aquatic Farm Production Projected Harvest and Sales: # of Pounds
(Year 1) **20____**						$		
(Year 2) **20____**						$		
(Year 3) **20____**						$		
(Year 4) **20____**						$		
(Year 5) **20____**						4$		

1 Support facility examples: caretaker, storage, or processing facilities, work rafts, etc. This must correspond to diagrams and drawings.
2 Equipment examples: grow-out rafts, longlines, buoys, etc. Gear examples: trays, tiers of lantern nets, or predator netting. This must correspond to diagrams and drawings.
3 Projected sales are based on Farm Gate Income which is defined as the unprocessed value, excluding the cost of packaging or transport of the product to its' first point of sale.
4 By the end of your 5th year, ***projected sales for all species combined must meet the commercial use requirement*** (CUR) defined as the annual sales of at least $3,000 per acre or fraction of an acre, or $15,000 per farm, whichever is less (11 AAC 63.03(b)). The CUR applies to the combined total of all species, is not a "per species" requirement and must be maintained or increased in Years 6 - 10.

I understand I must improve productivity according to above operation and development plan for this species and that this plan can be amended to reflect any changes as the aquatic farm operations develop.

SIGNATURE ____ **DATE** ___________________________________

(Continued – Page 2)

AQUATIC FARM OPERATION AND DEVELOPMENT PLAN – PART B (Page 2 of 2)

Name ________________________________ Species________________________ **ADL Number** ____________ **ADF&G Permit No.** ____ _____-AF-____

Calendar Year	Installation Schedule (For each year)			# of Hatchery-Produced Seed	#of Seed Collected Onsite (Only applies to indigenous sp.)	Aquatic Farm Production Projected Harvest and Sales		
	Support Facility Types/Numbers[1]	Equipment/ Gear Types/Numbers[2]	Anchoring System Types			Projected Sales[3] ($)	# of Animals	# of Pounds
(Year 6) 20____						$		
(Year 7) 20____						$		
(Year 8) 20____						$		
(Year 9) 20____						$		
(Year 10) 20____						$		

[1] Support facility examples: caretaker, storage, or processing facilities, work rafts, etc. This must correspond to diagrams and drawings.
[2] Equipment examples: grow-out rafts, longlines, buoys, etc. Gear examples: trays, tiers of lantern nets, or predator netting. This must correspond to diagrams and drawings.
[3] Projected sales are based on Farm Gate Income which is defined as the unprocessed value, excluding the cost of packaging or transport of the product to its' first point of sale.

I understand I must improve productivity according to above operation and development plan for this species and that this plan can be amended to reflect any changes as the aquatic farm operations develop.

SIGNATURE ____ **DATE** ____________________________________

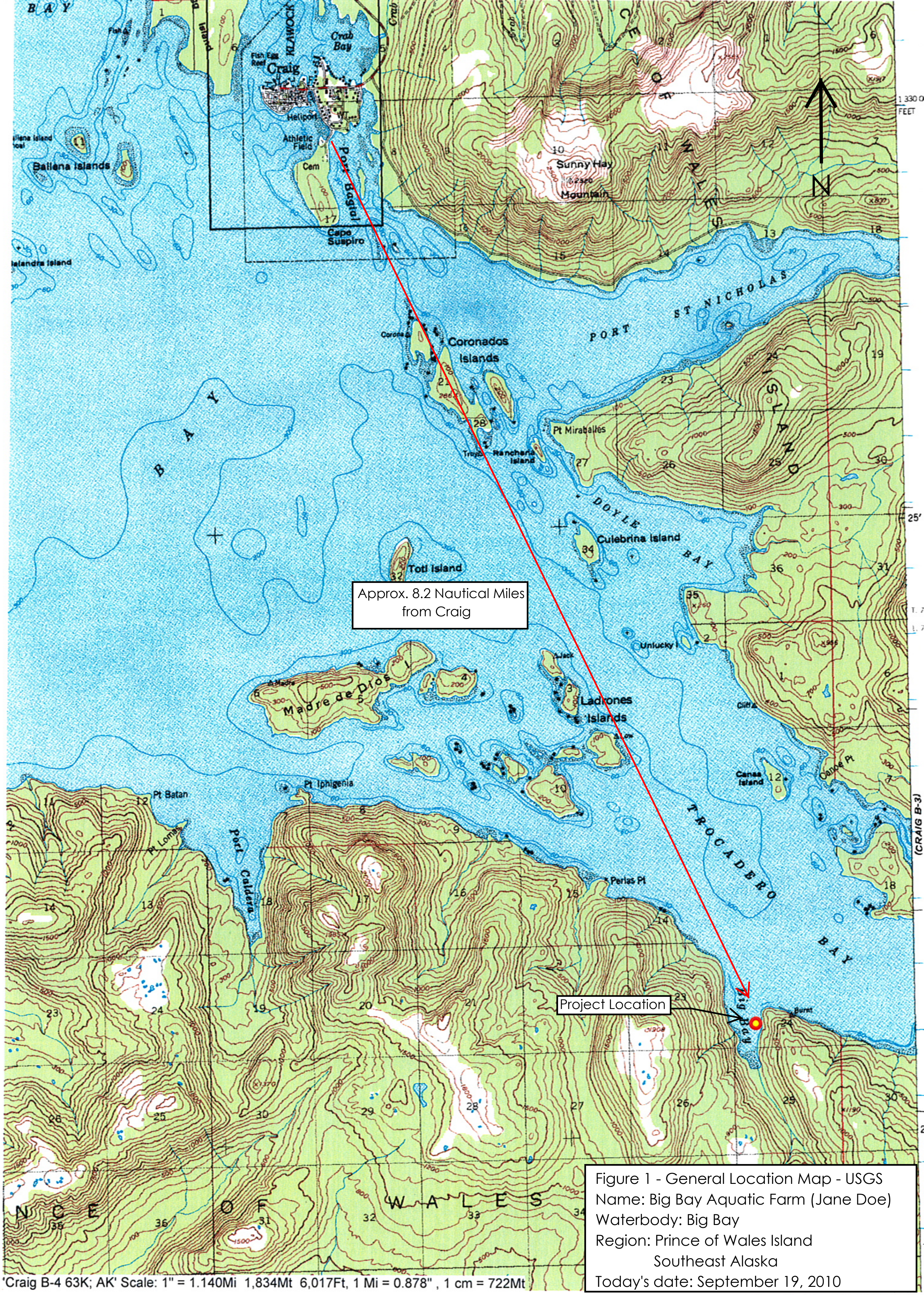
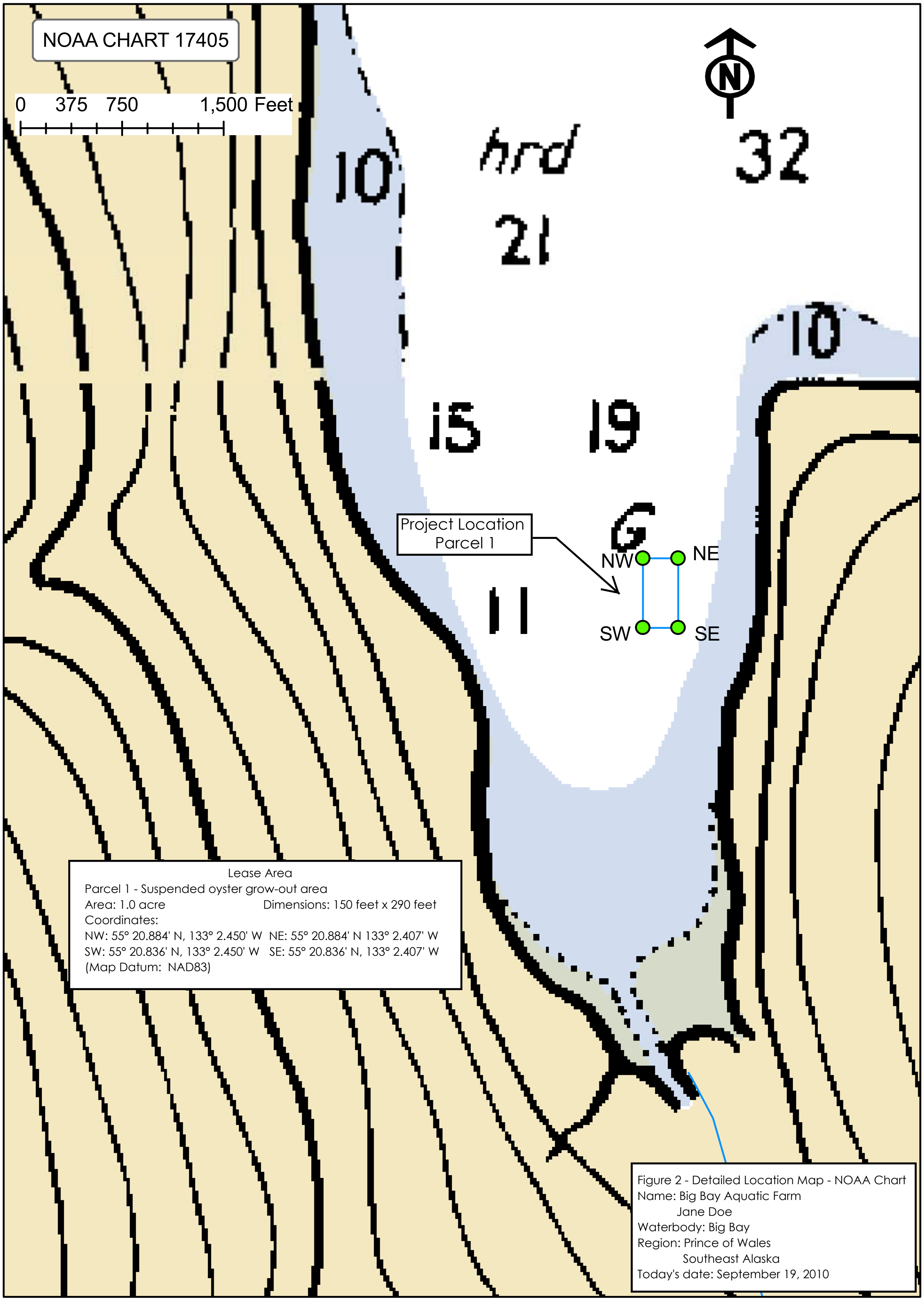


Figure 1 - General Location Map - USGS
Name: Big Bay Aquatic Farm (Jane Doe)
Waterbody: Big Bay
Region: Prince of Wales Island
Southeast Alaska
Today's date: September 19, 2010



NOAA CHART 17405
0 375 750 1,500 Feet
N
hrd
10
21
32
10
15
19
11
Project Location
Parcel 1
NW
NE
SW
SE
Lease Area
Parcel 1 - Suspended oyster grow-out area
Area: 1.0 acre Dimensions: 150 feet x 290 feet
Coordinates:
NW: 55° 20.884' N, 133° 2.450' W NE: 55° 20.884' N 133° 2.407' W
SW: 55° 20.836' N, 133° 2.450' W SE: 55° 20.836' N, 133° 2.407' W
(Map Datum: NAD83)
Figure 2 - Detailed Location Map - NOAA Chart
Name: Big Bay Aquatic Farm
Jane Doe
Waterbody: Big Bay
Region: Prince of Wales
Southeast Alaska
Today's date: September 19, 2010

Figure 3. Aquatic Farm Site Plan Example

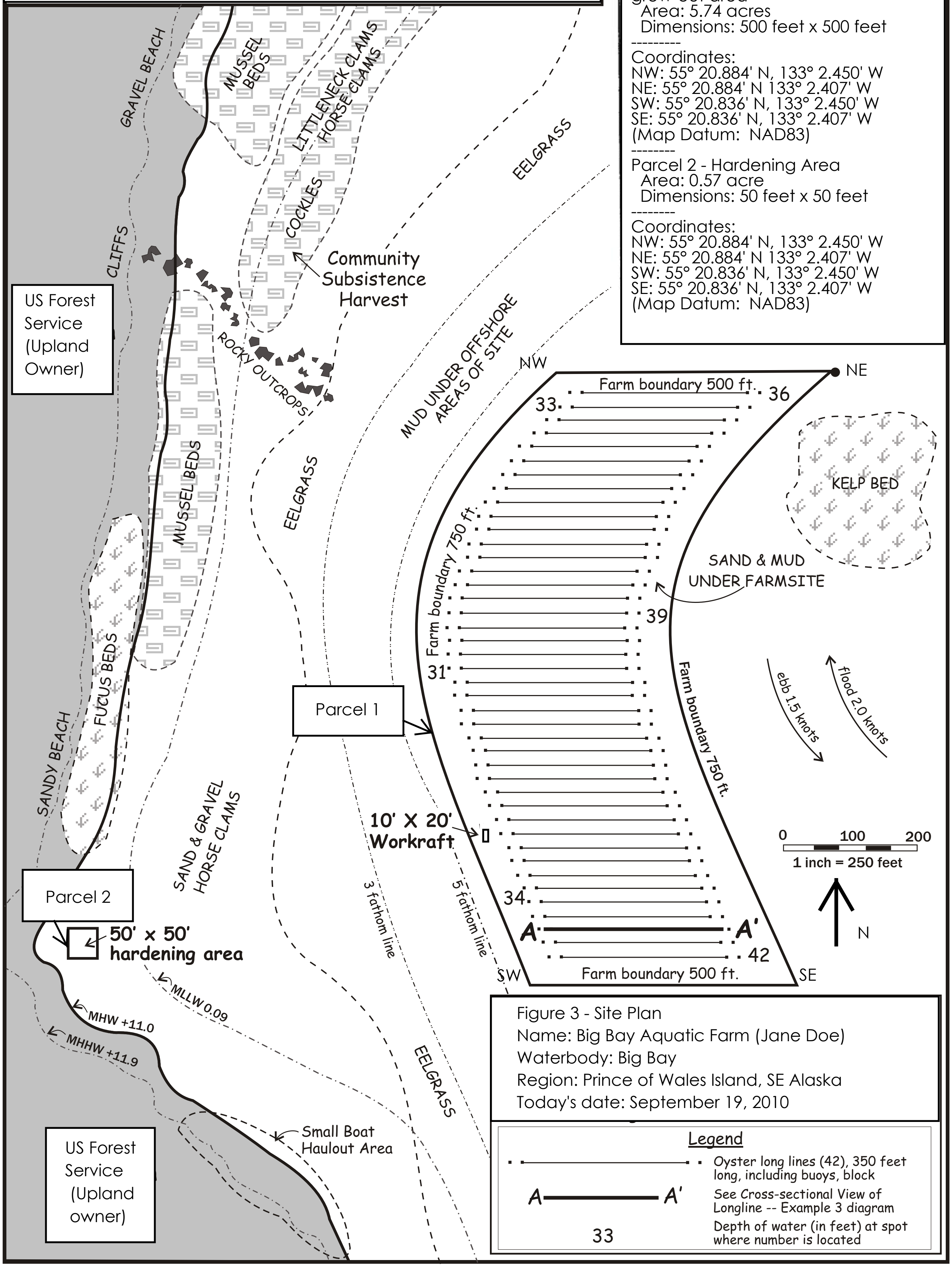


Figure 4. Aquatic Farm Site Plan Example 2

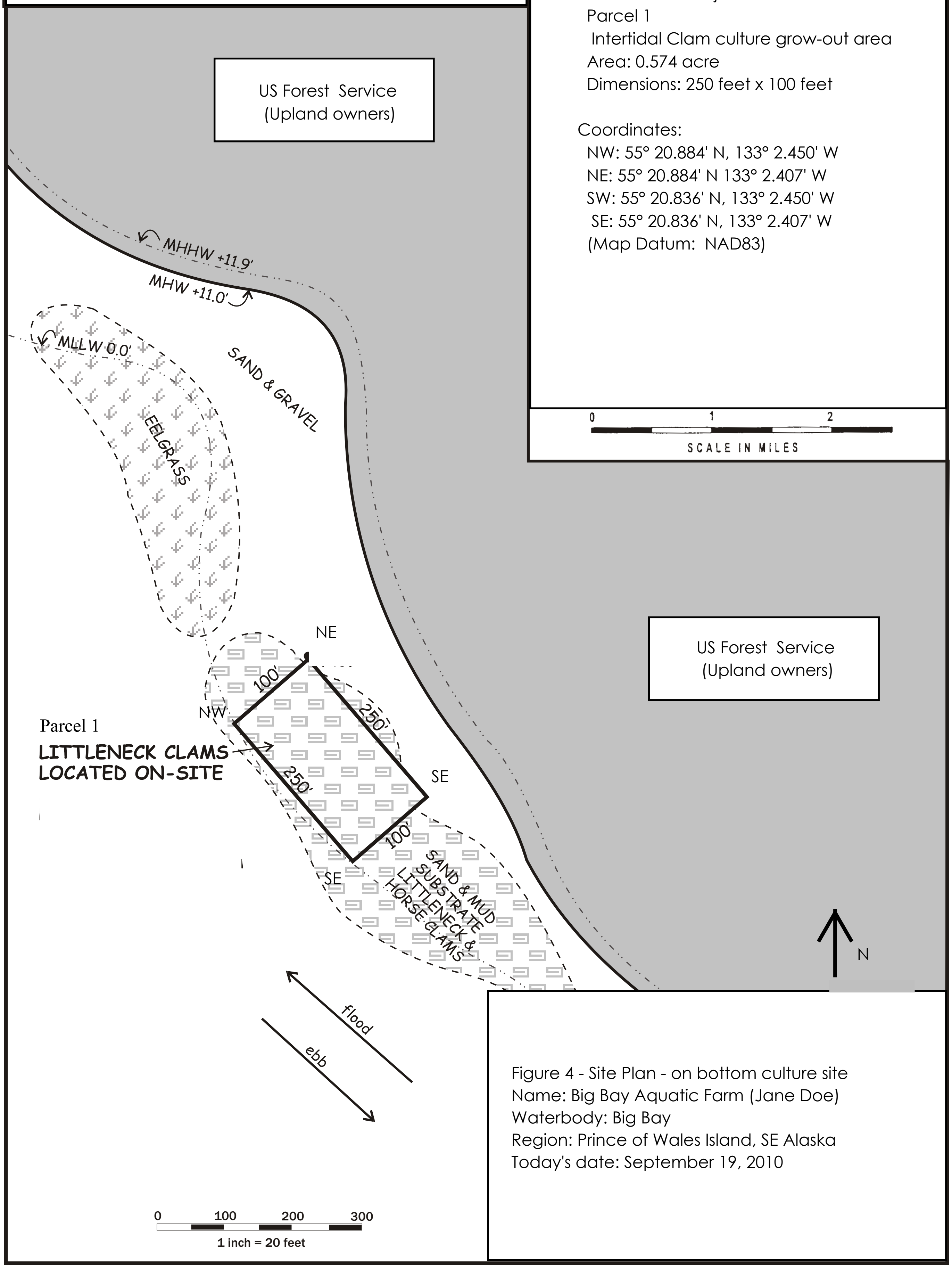
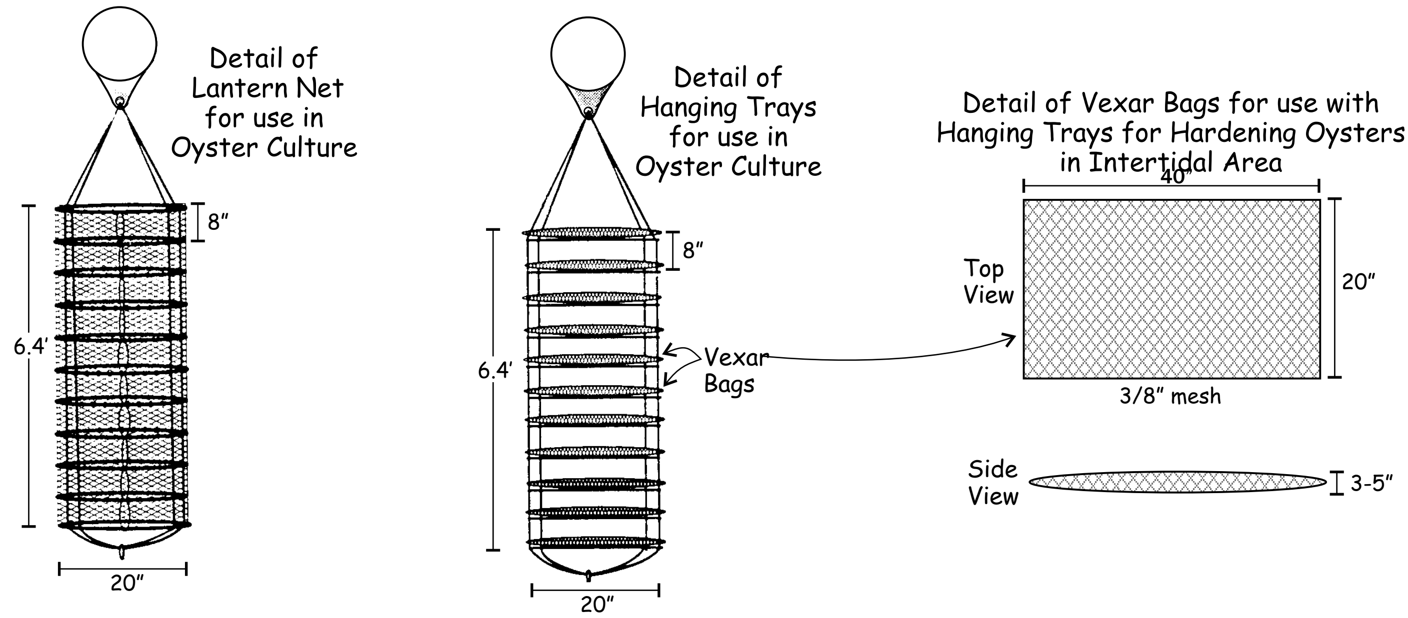
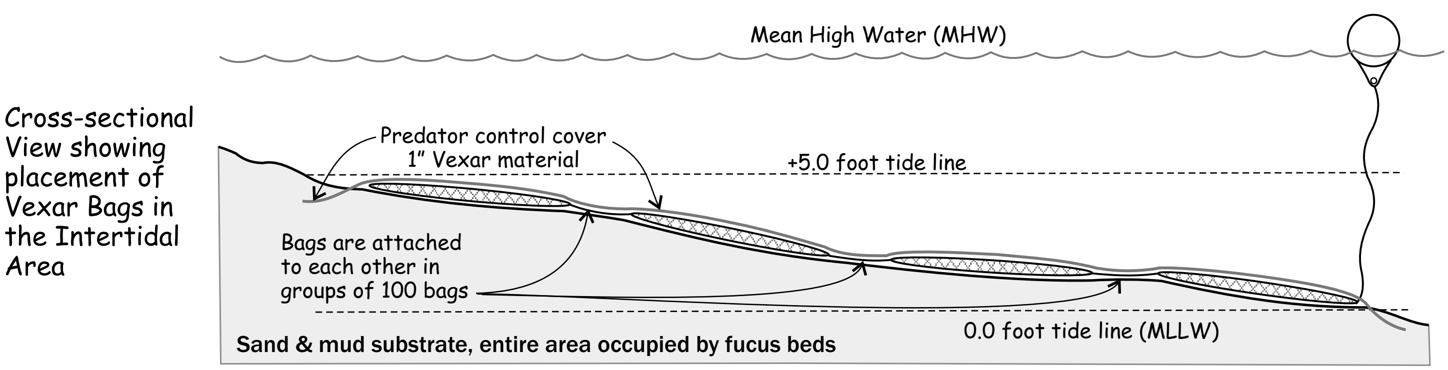
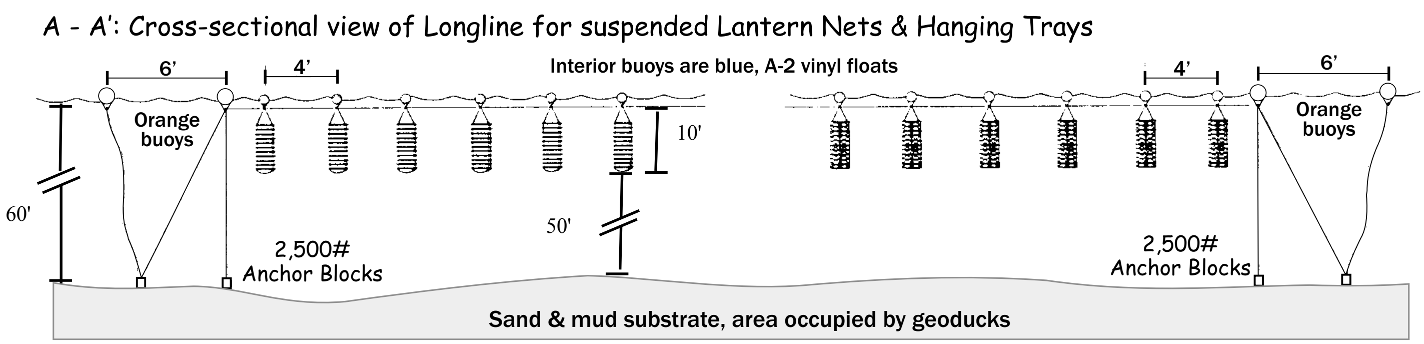


Figure 5. Aquatic Farm Cross-Sectional Diagrams and Drawings Examples







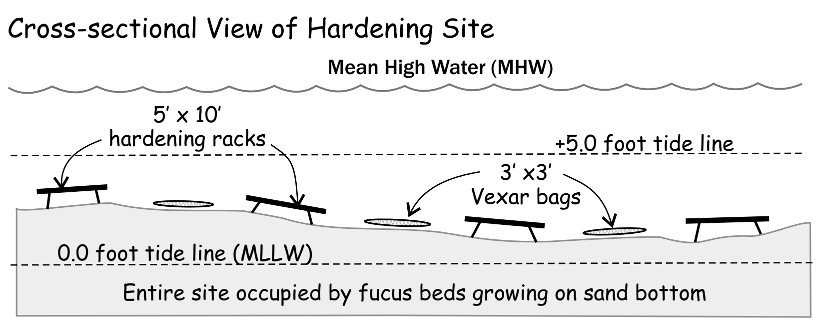


Figure 5 - Detailed Cross-sectional Diagrams and Drawings

Name: Big Bay Aquatic Farm (Jane Doe)
Waterbody: Big Bay
Region: Prince of Wales Island, SE Alaska
Today's date: September 19, 2010

All drawings not to scale