AQUACULTURE IN ALASKA

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A RESOURCE POTENTIAL

SAME AS 73-5

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FOREWORD

a case for transference
of Alaskan effluents to resource affluence

Man has the capacity to make good use of the environment and at the same time to realize its full potential. Rational human exploitation can reinforce rather than deteriorate natural resources.

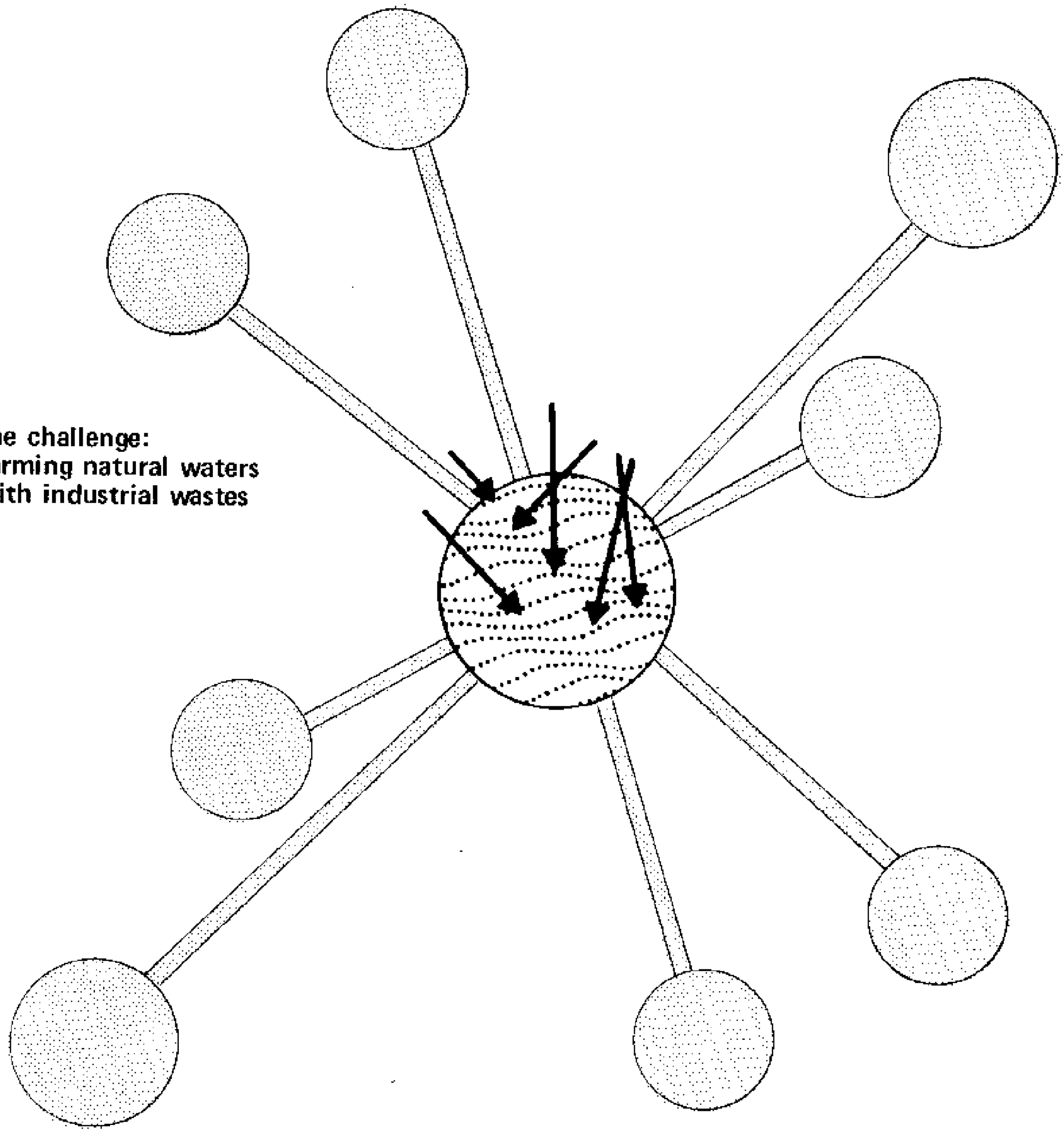
The Alaskan lumber, oil and fishing industries are all consumers in common: they burn fuel and require factory housing commodities ... they discharge wastes and build cities. By cooperative interaction, however, the collective back door of these operations can become a positive resource. It is only up to our ingenuity and awareness to implement means of recycling these unused materials and energies to the benefit of economic stability and growth. Potentially available is a natural ocean pasture to be farmed through aquaculture.

To accomplish these productive and complementary goals, it is essential that special effort be made to understand the environment. Research is required to explore the several possible approaches to sound resource utilization. Here is a task for the University: to provide fundamental knowledge and to suggest ways in which such knowledge can be wisely put to use. Here, too, enters the role of the enlightened Alaskan citizen: moving acceptable ideas into experimental practice through legislative support.

Wm R. Wood

President

The University of Alaska
Fairbanks, 28 June 1973



the challenge:
farming natural waters
with industrial wastes

THE TASK AT HAND

*investigating mutual opportunities
between fisheries and other
Alaskan industrial interests*

The vast and intricate system of coastal waterways in Alaska constitutes an uncommon juxtaposition of sea, land, air and fresh water -- an environment fortified in its remoteness as yet against the incidence of marine habitat destruction underway in many other coastal areas of the United States. Alaska's wealth of highly productive inlets, fjords and estuaries offers an exciting potential to stimulate the production of fish and fish products through various methods of aquaculture. Such techniques would allow the effective utilization of materials, both natural and man-made, and much energy routinely cast off in the present operational course of municipalities and industry.

Economic growth within Alaska and demands outside the state for Alaskan resources are imposing ever-increasing pressures for use of the coastal zone in support of food supply, transportation, energy, lumber, mineral extraction, recreation, waste disposal and for urban and industrial development. A timely glimpse in the forward direction reveals a matter of dollars and sense:

... a need for more adequate and reliable personal income for Alaskans and Alaska-based enterprises, particularly for fishermen and workers in related enterprises that comprise a way of life and sustenance for many residents

... a need for higher domestic production of fish products to lessen the nation's dependence on imported fish for its own market, thus aiding a seriously distorted balance of trade

... a need for additional U.S. supplies of essential protein to help offset the increasing costs and shortages of animal-based protein resulting from limited and increasingly costly petroleum-based nitrogen fertilizers

... an opportunity to grow luxury fish species now in short supply for a persistent market

... an opportunity to use supplemental aquatic organisms to capture and utilize an inexhaustible but dilute supply of natural ocean nutrients

... an opportunity to utilize low-level thermal energy sources that are presently largely wasted

... an opportunity to utilize raw materials that are presently treated as wastes by industrial plants and municipalities

Although Alaska's major prospects of lumber and oil often appear to be inherently incompatible with fisheries interests, there is substantial indication to the contrary that each of these enterprises can actually reinforce the other through wisely enhanced application of modern technology. Alaskan industries share common needs of energy, building materials and waste-discharge requirements. To their mutual advantage, however, is the unique capacity of biological organisms to assimilate industrial waste products, thereby converting an otherwise costly disposal process into a source of energy and food for increased production of commercially valuable fish stocks and feed products.

As demands of a growing population inevitably advance, maximum effort should be expended to insure that the productive capabilities of the nation's waters are maintained at the highest levels consistent with wise utilization of other resources. It was the purpose of this workshop to evaluate such possibilities in Alaska.

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What is aquaculture?

The term *aquaculture* applies generally to any method designed to control the selection and increase the production of aquatic organisms beneficial for human use and compatible with ecosystem welfare. Specifically in Alaskan context, aquaculture means a technological step forward in more effective utilization of existing feedstuffs and energy, both natural and industrial, to build the state's coastal zone resources into a viable and economically attractive fisheries system.

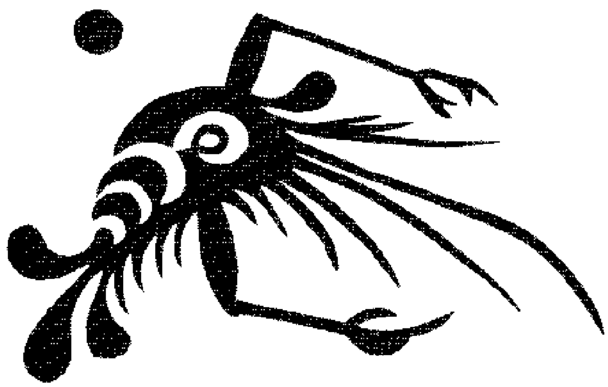
Certain basic considerations underlie any aquacultural endeavor:

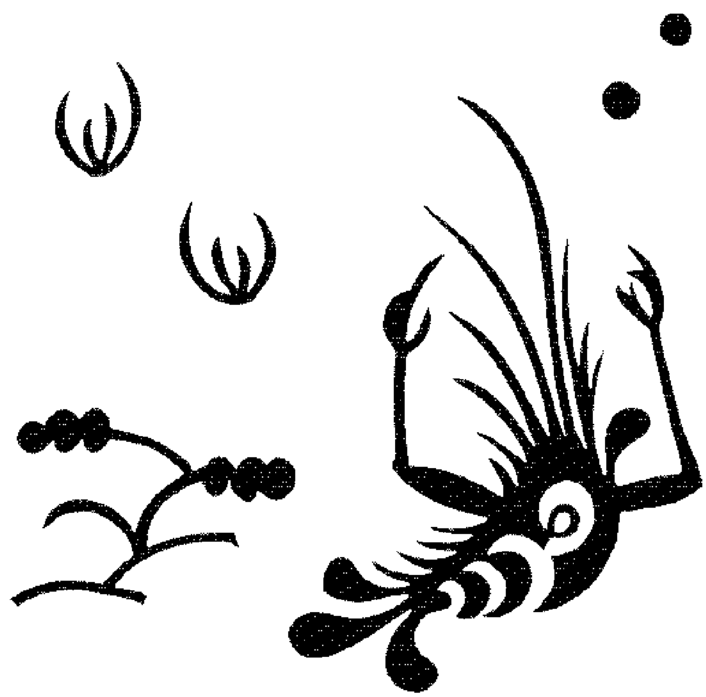
-- Recognition of what species are appropriate for enhancement by aquaculture

-- Provision for feedstuffs to sustain enhanced crops of selected species

-- Development of suitable substitute habitats for culturing selected species

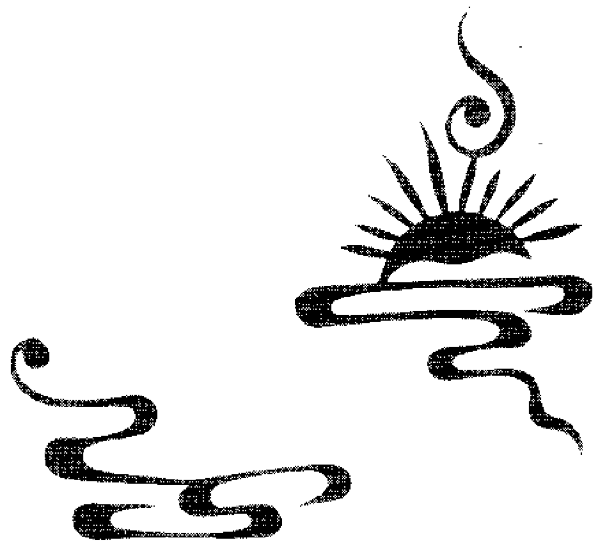
-- Harvesting and marketing of cultured species and associated by-products

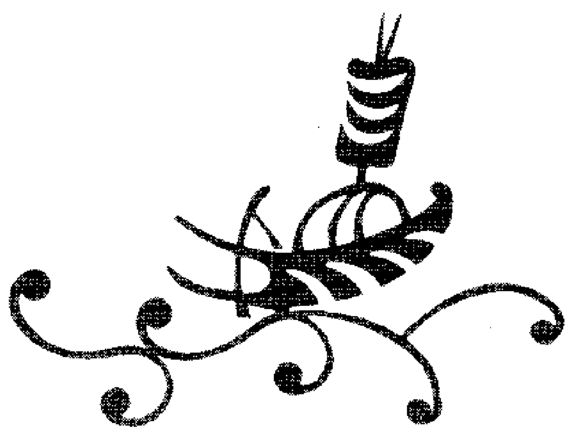




What biological resources are appropriate for aquaculture in Alaska?

Techniques for enhancement and protection of aquatic resources can be applied to a number of species simultaneously. Enclosed aquaculture systems ideally should contain species that interact with each other so as to achieve maximum production without accumulating excessive waste products and organic debris. External control of a particular system would dictate the nature of the photosynthetic organisms present; thus, either phytoplankton (one-celled plant life in the water column) or benthic algae (attached small and large seaweeds) could be encouraged, depending on the end product desired. A water column rich in phytoplankton would support a variety of suspension feeders such as clams, mussels, oysters and scallops; while a system designed to encourage bottom algal growth would lend itself to the support of species such as abalones and sea urchins, which are feeding on such plant material. Utilization of herbivore protein in both systems by predaceous or omnivorous species such as crabs, lobsters, salmon or other fish would permit development of additional links in food-chains. Input of supplemental protein by way of waste products from processing plants and heat from thermal effluents would encourage rapid growth in the system. The activities of scavenger species such as amphipods and crabs would help maintain oxygenated bottom conditions by removing wastes usually consumed by bacteria.





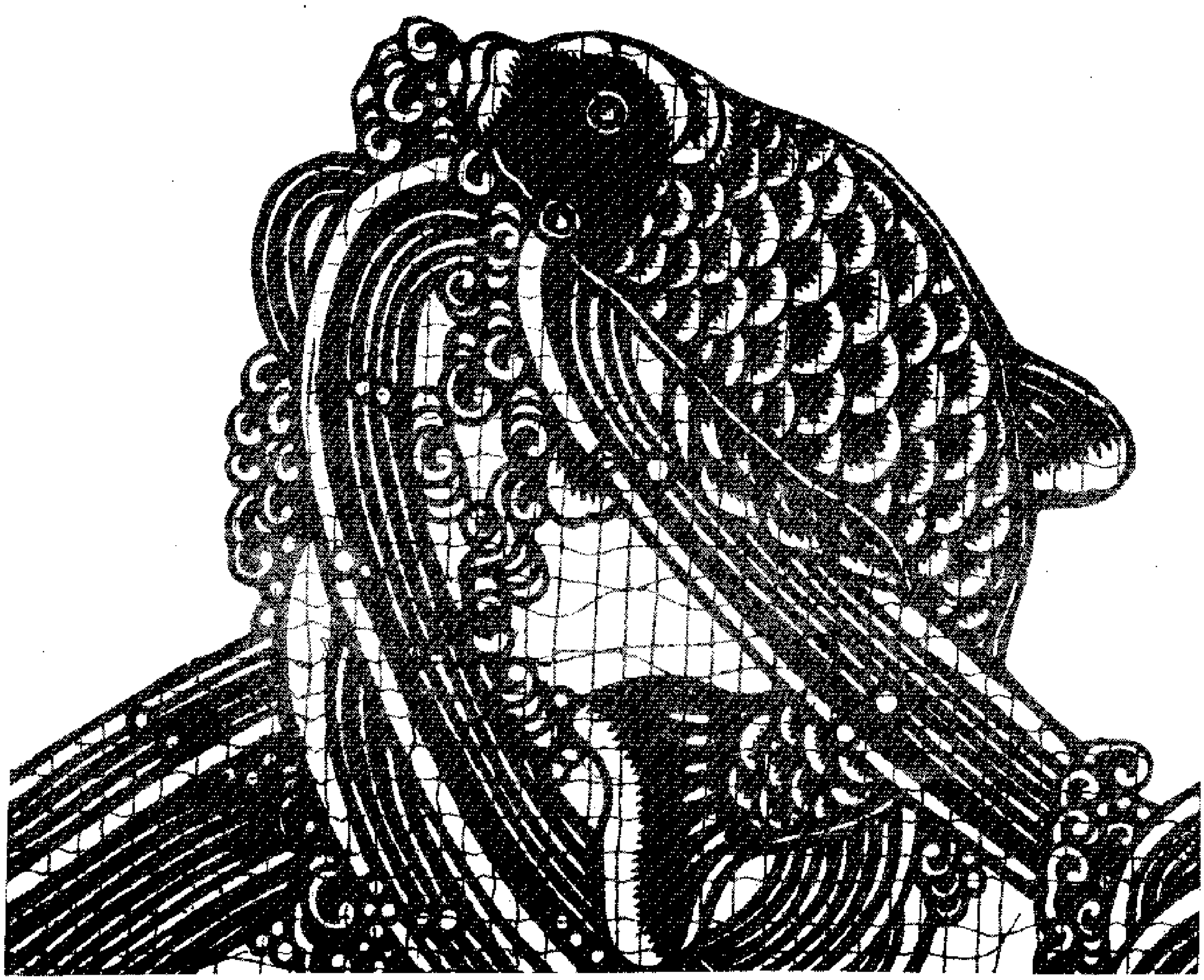
Of all cold-water fish, salmon appear to be tailor-made for aquaculture. The most important attributes of salmon that adapt them so well to the practices of animal husbandry are:

... A large and varied gene pool for selective breeding. Of the five North American species of Pacific salmon, there are tens of thousands of races--each adapted to the specific sets of environmental conditions encountered during its particular life cycle.

... The relative ease of rearing the eggs and young fish through the freshwater phase. An already well-developed hatchery technology can be readily modified to fit the requirements of the Alaskan environment.

... The adaptability of certain salmon stocks to alteration of their natural growth rates. The various stages of development can be controlled to synchronize with optimum conditions for feeding and marketing or for release of the salmon to the open ocean range and their ultimate return to preselected homing sites.

... The migratory characteristics of salmon to return to a specific stream for spawning. With newly developed early-rearing techniques, that trait can be modified to permit selection of the homing site of a planted stock.



MOLLUSKS

There are six Alaskan and one exotic bivalve species suitable for acquaculture exploitation within nutrient-enriched systems. Manner of habitation varies. The four species of **clams** live typically in the sediments (littleneck clam *Protothaca staminea*, butter clam *Saxidomus nutallii*, pinkneck clam *Spisula polynema* and the soft-shell clam *Mya* spp.); the **scallop** *Patinopecten caurinus;* lives on the sediments; the **blue mussel** *Mytilus edulis* attaches itself by secreted threads to a hard surface; and the **Pacific oyster** *Crassostrea gigas* is attached by one valve to the substrate. All of these mollusks are suspension feeders that filter small organisms (plankton) from the water column. All are slow-growing in cold Alaskan waters, but nutrient enrichment and possible thermal enhancement of the surrounding waters should increase their growth rate. Hanging culture methods such as rafting have proved highly successful elsewhere and should offer a further means of improving growth potential.

Although existing worldwide expertise on culture of bivalve mollusks should ensure success in rearing any of these bivalve species, there is particular advantage in directing initial efforts toward the highly marketable oyster and scallop.

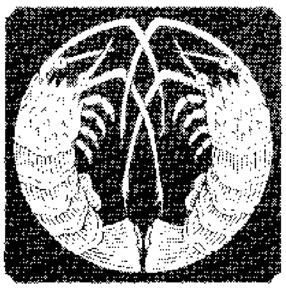
**Oyster culture in Japan:
8 tons of marketable meat
per acre each year . . .**

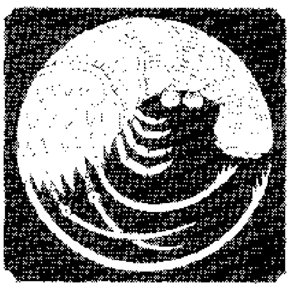
The **abalone** is the only member of the gastropod class of mollusks to be successfully cultured. Seed abalone are produced in abundance at several Japanese laboratories and at one California site. Only one species, ***Haliotis kamtschatkana***, occurs in Alaskan waters and is eagerly sought by coastal residents. Abalone feed on large algae and live well in laboratory enclosures. A ready source of large seaweeds should ensure adequate growth potential for this molluscan species, whose worldwide reputation for taste excellence and ready marketability as a gourmet food make it a particularly attractive prospect for an Alaskan marine aquacultural system.

CRUSTACEANS

Shrimp. Although nine species of the northern pink pandalid shrimp are found in Alaskan waters, only five are presently of commercial value. The most abundant species, comprising 60-90 percent of the harvest, is the pink *Pandalus borealis*. Another 10-20 percent of the catch is the sidestripe *Pandalopsis dispar*. The spot *Pandalus platyceros* is the largest in individual size of the five main species, followed by the coonstripe *P. hypsinotus* and the humpie *P. goniurus*.

**More than a million pounds
of shrimp consumed daily
in the United States . . .**





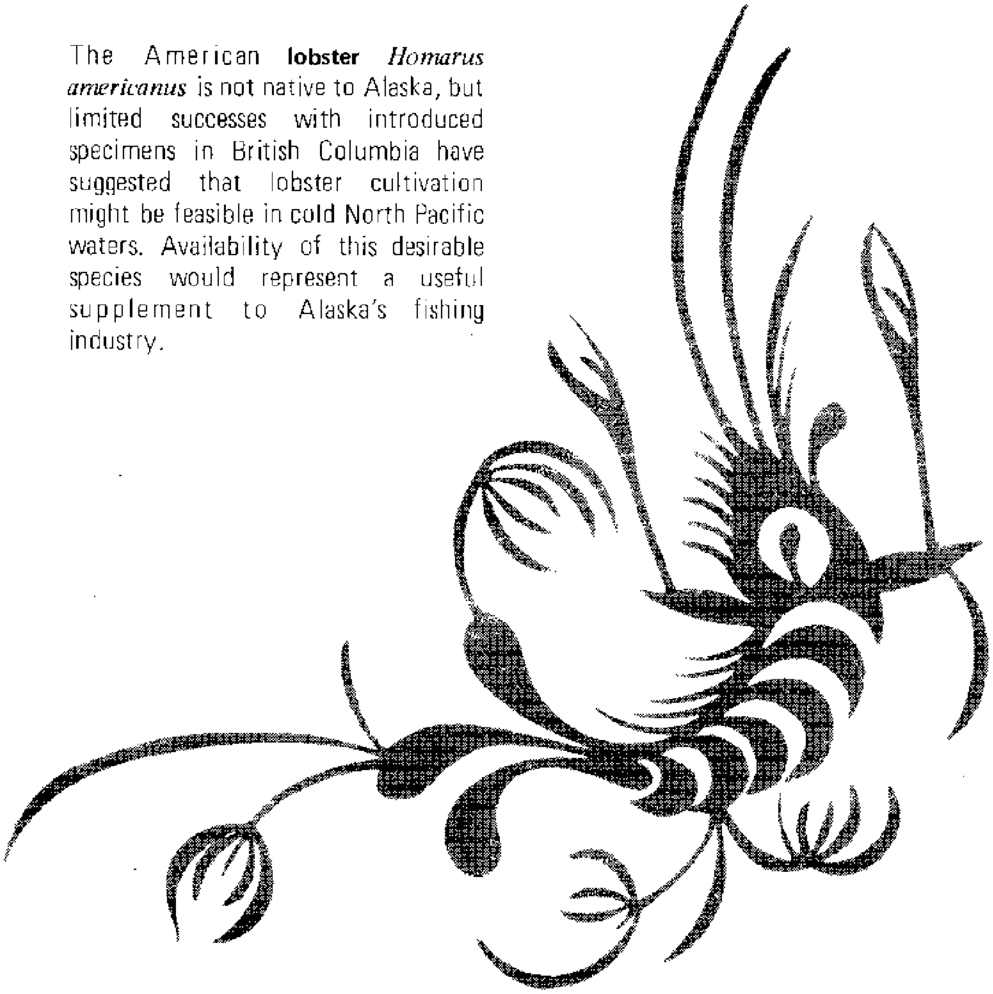
Despite occasional setbacks in a still developing shrimp culture technology, programs in other parts of the country have resulted in dramatic success toward improved quality and increased abundance of stock shrimp. Nationally, shrimp is the most valuable of all marine species harvested domestically. They are themselves an important food source for many North Pacific marine organisms.

An unexplained peculiarity of Alaskan shrimp populations is their intermittent depletion, believed to be due not to overfishing but to a combination of environmental factors. Enhanced and continuous harvests through the aid of aquacultural techniques should serve to stabilize an uncertain market in the face of a steady upward trend in shrimp product prices and constant consumer demand reported by market analysts.

Shrimp are much less abundant in Southeastern Alaska than in the more fisheries-intense Kodiak area. Southeastern Alaska shrimping undergoes a traditional closed season during the most active spawning period from mid-February through April, thus interrupting a steady flow of raw shrimp to keep crews and costly plant machinery productive. This problem is compounded by the fact that Alaskan shrimp mature slowly and are significantly smaller than other commercial species in the southern U.S. and import sources, thus causing increased processing costs (six pounds of raw shrimp produce only one pound of picked shrimp meat).

**Shrimp forecast for Texas:
one ton per acre,
three to five times a year**

The American **lobster** *Homarus americanus* is not native to Alaska, but limited successes with introduced specimens in British Columbia have suggested that lobster cultivation might be feasible in cold North Pacific waters. Availability of this desirable species would represent a useful supplement to Alaska's fishing industry.



The **tanner crab** *Chionoecetes bairdi* and **king crab** *Paralithodes camtschatica* are both intensively harvested along the Pacific coast. The existence of an ongoing fishery for each suggests, however, that neither species would presently be a high-priority candidate for aquaculture. Further biological information concerning these valuable species is essential to a satisfactory resource understanding, and aquaculture enclosures would serve as useful tools for studying captured individuals. The hardiness of young tanner crab equips them for use as bottom scavengers to keep aquaculture enclosures clean of excess organic debris.

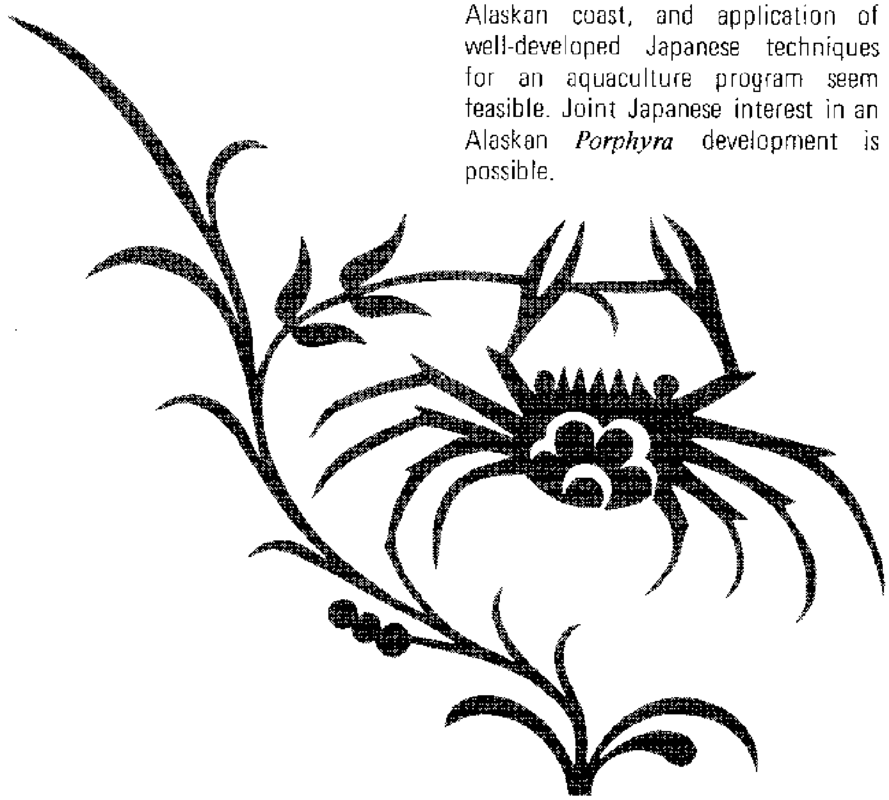
Limited success in rearing the commercially valuable **Dungeness crab** *Cancer magister* does not favor it for aquacultural application, although the aquaculture system might be used to examine its biology. Adults of this species might be useful also as bottom-scavengers.

SEA URCHINS AND SEA CUCUMBERS

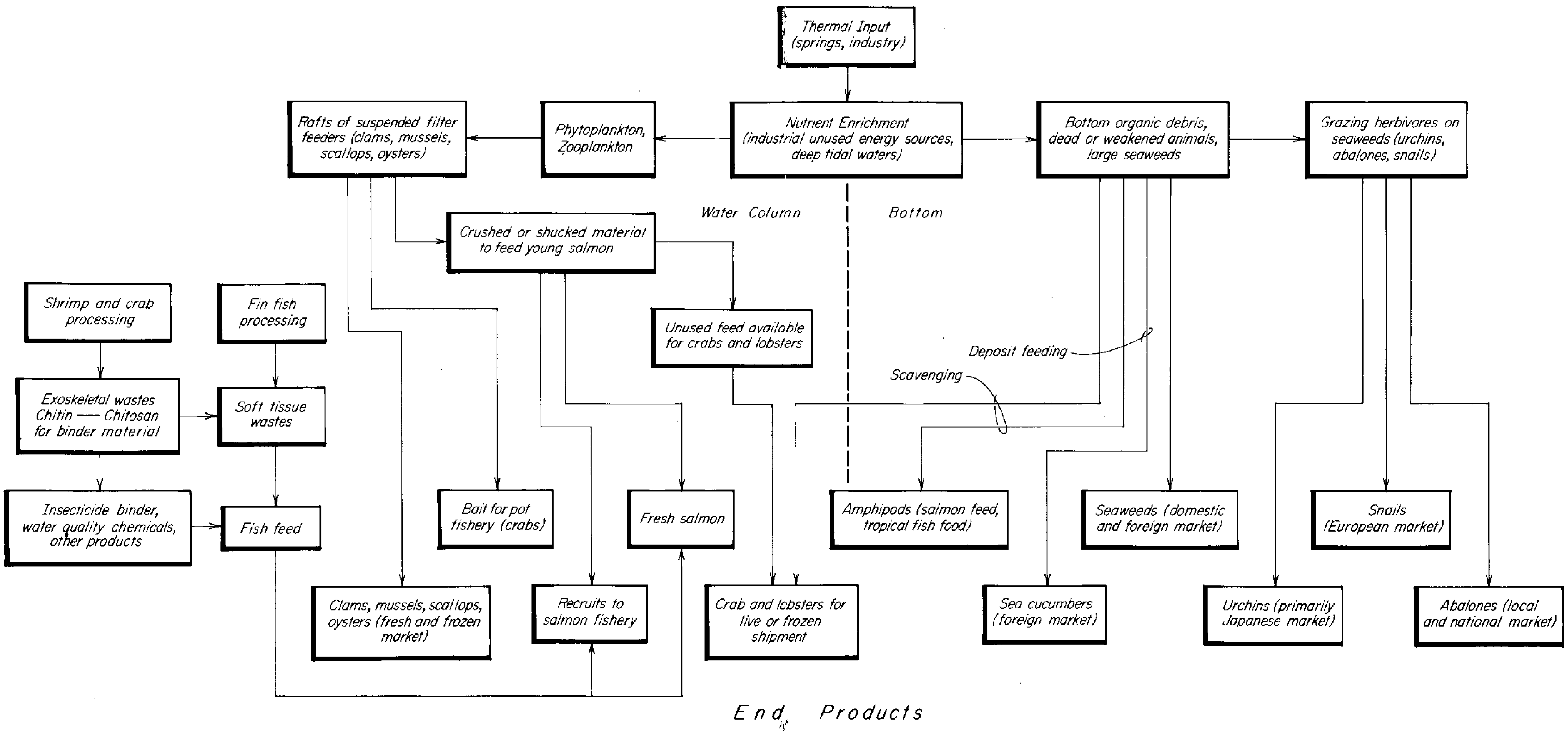
Two edible members of this echinoderm class are found along the Alaskan coast, occasionally in great density. The sea urchin *Strongylocentrotus* spp. feeds primarily on seaweeds, and the sea cucumber *Parastichopus californicus* utilizes bottom deposits. Related species are harvested intensively in the Orient, and the sea urchin is already of some interest along the Atlantic and Pacific coasts. The Japanese have shown particular interest in the southcentral Alaskan wild stocks, and both species should be examined for future aquaculture possibilities.

SEAWEEDS

A profusion of seaweeds occurs along the Alaskan coast. Although none are utilized commercially at the present time, abundant stands of economically valuable brown seaweed (kelps) are present. Seaweed culture is presently of little interest in the United States despite its considerable importance in the Orient, where culture techniques are widely practiced. In particular, a type of red algae known as nori is intensively cultivated by the Japanese. Several related species of nori (*Porphyra*) are available along the Alaskan coast, and application of well-developed Japanese techniques for an aquaculture program seem feasible. Joint Japanese interest in an Alaskan *Porphyra* development is possible.



Interaction Potential of Some Species in an Enclosed Aquaculture System



What is the Alaskan potential for producing feedstuffs from wastes?

Industry and urban development in Alaska provide certain waste commodities which could be recycled for either direct use by cultivated marine organisms or to manufacture bulk feeds for aquaculture and other animal industries. Among present industrial wastes are excess heat from generating plants, organic material from pulp mills, nitrogen discharged as ammonia from the petrochemical industry, fish wastes from processing plants and from urban areas, and sewage either in a treated state or as activated sludge.

The property that these industrial wastes have in common is that they are potential sources of energy.

HEAT

Practically all industries discharge substantial quantities of energy in the form of warm or hot water, often uncontaminated: Condenser cooling water is used but briefly in power plants, in liquified natural gas (LNG) operations and in pulp mill steam plants. This water is clean at the time of discharge and could be used in direct contact with marine organisms. Warm effluent water from other sources may contain dissolved or suspended matter, but the heat can be recovered by means of heat exchangers.

Hatcheries and rearing ponds are a prime example of potential consumers for recycled heat energy. In such impoundments the warm-water discharges could be used to stimulate hatching and increase the growth rate of the organisms being cultivated. This is especially important in an area such as Alaska, where suboptimal growth temperatures prevail for much of the year.

NITROGEN

The gas-based petrochemical industry in Cook Inlet discharges low concentrations of ammonia with a nitrogen potential estimated in excess of 2 tons per day. Although the ammonia concentrations are too low to be commercially recovered, the level is high enough to be utilized by certain marine organisms for production of protein.

The use of organic material from the paper industry may be possible in a system which uses nitrogen from seawater to produce plankton. Such a system would have the advantage of being productive throughout the year, since the energy source of cellulose and wood-fiber (lignin) wastes would be independent of changes in solar radiation which govern the natural productivity of marine systems in northern regions.

By adding nitrogen to waste cellulose and lignins from pulp and paper manufacturing, an appropriate medium can be made for growing yeast, an excellent source of protein for the bulk manufacture of animal feeds. Constitutional deficiencies in the yeast could be made up from protein material discarded in cannery wastes.

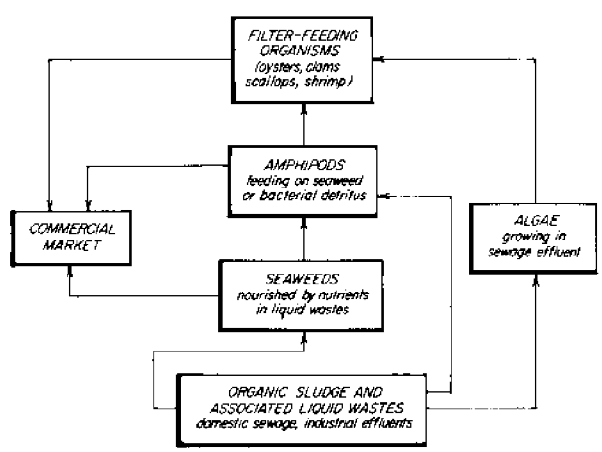
SLUDGE AND ASSOCIATED LIQUID WASTES

Biodegradation of domestic effluents, required by both state and federal regulation, produces as a by-product large quantities of organic sludge. Since this material consists mainly of the bodies of bacterial organisms grown as a result of the treatment process, sludge would seem to offer a potential source of protein nitrogen for use in aquaculture.

Although sludge-associated debris from domestic and industrial activity may not be directly usable by commercial or sports fish, certain small marine organisms are able to utilize aggregated forms of such materials directly as food and are in turn ingested by larger fish.

The most ubiquitous groups of scavengers to be considered in this role are the small marine crustacean **amphipods.** A particularly common Pacific species *Anisogammarus pugettensis* feeds on a variety of materials, including plant and animal debris. Under natural circumstances they are found in large numbers in association with seaweed on beaches, in tide pools, under log booms, and as scavengers on dead fish and other organism. They are capable of living under a wide range of environmental conditions in which temperature and salinity may vary drastically over a single tidal cycle, or in waters which are largely depleted of oxygen.

It is possible that solid sewage from urban areas can be recycled through amphipods to an economically useful marine resource. Experiments conducted at Woods Hole Oceanographic Institution have demonstrated the effectiveness of such an application in rearing oysters, scallops and seaweeds of commercial importance from a food-chain based on sewage substrate. In another project, Sea Grant investigators at the University of California, Santa Barbara, are studying the possibility of raising algae in sewage effluent. The algae would then be used as food for filter-feeding organisms. Also being considered by the Santa Barbara researchers is the use of sludge as a substrate directly for growing *Orchestia traskiana* an amphipod species potentially valuable both a shrimp food and fish bait.



It is known that in many cases amphipods may be the principal food for young salmon. In view of the known shortage of fish feeds and the need to recycle industrial and urban waste commodities, it would appear expedient to cultivate a domestic amphipod as a suitable food material for salmonid culture. A large market already exists for frozen zooplankton in the form of the California-based brine shrimp industry, and frozen amphipods could be expected to offer a comparable product potential.

FISH AND SHELLFISH PROCESSING WASTES

The need for fish feeds in association with aquaculture projects makes the economical use of shrimp, crab and fish processing wastes one of the most relevant opportunities in waste recycling. This prospect is of mutual interest to the fish processors themselves, who are faced with increasingly strict requirements for clean-up of waste discharges.

Fish-processing residue is a natural food for all levels of aquatic life and could constitute a primary source of feed for aquaculture purposes with only a modest amount of development work. In many applications, the wastes could be merely pulverized and distributed scientifically in appropriate areas for direct consumption by cultivated organisms.

At a more sophisticated level, development of bulk fish-food pellet manufacture would offer further utilization of waste materials from fish factories.

One Alaskan harbor polluted with nearly 67 million lbs. of fish processing wastes in a single year.

An area of historical environmental concern is Kodiak harbor, which has been heavily polluted by shrimp, crab and salmon processing debris. Divers have reported up to 20 feet of clutter in areas of the harbor bottom.

75-85 percent 'waste' found in most species of shellfish

In the case of shrimp alone, about 80-85 percent of the volume harvested is discarded in the form of shells, organic solids, and liquids containing dissolved salts and oils.

Ingredients of crustacea shells:

Chitin	15-25 %
Protein	25-40
Calcium chloride	40-55

Although the greatest volume of shellfish waste is calcium chloride, a salt of little commercial value to outside markets, even this is a resource of known potential within Alaska for de-icing and road dust control.

Chitin is the structural, cellulose-like material that holds together the shells of crustacea such as crab and shrimp. Because the material is not easily biodegraded, shellfish wastes contribute heavily to pollution problems. Chitin as an industrial commodity, however, offers substantial new product and market potential:

- additive to newsprint paper
- additive to baby foods
- water treatment coagulant
- additive to stomach anti-acids
- treatment of wounds
- pesticide release control
- textile finishes
- water-base paint emulsions
- new synthetic fiber
- food thickener
- film manufacture
- specialty adhesives

The Department of Commerce's National Oceanic and Atmospheric Administration recently announced establishment of a pilot chitin-chitosan plant in Seattle to study practical and profitable means of utilizing this valuable component of the thousands of tons of shellfish carcasses dumped each year into ocean waters. In a complementary process developed through the University of Washington Sea Grant program, protein is extracted from the leg shells of Alaskan king crabs and local Dungeness crab for production of fish protein concentrate. Together, these processes totally utilize fish and shell wastes.

What other Alaskan resources could benefit aquaculture development?

MANPOWER

Approximately 20,000 fisheries-related people inhabit the coastal areas of Alaska. A substantial portion of these residents lack year-round employment and would comprise a valuable resource for aquaculture projects.

Labor costs borne by other industrial enterprises in the course of their routine waste discharge activities would dilute the overhead expense of acquiring feedstuffs for aquacultural use.

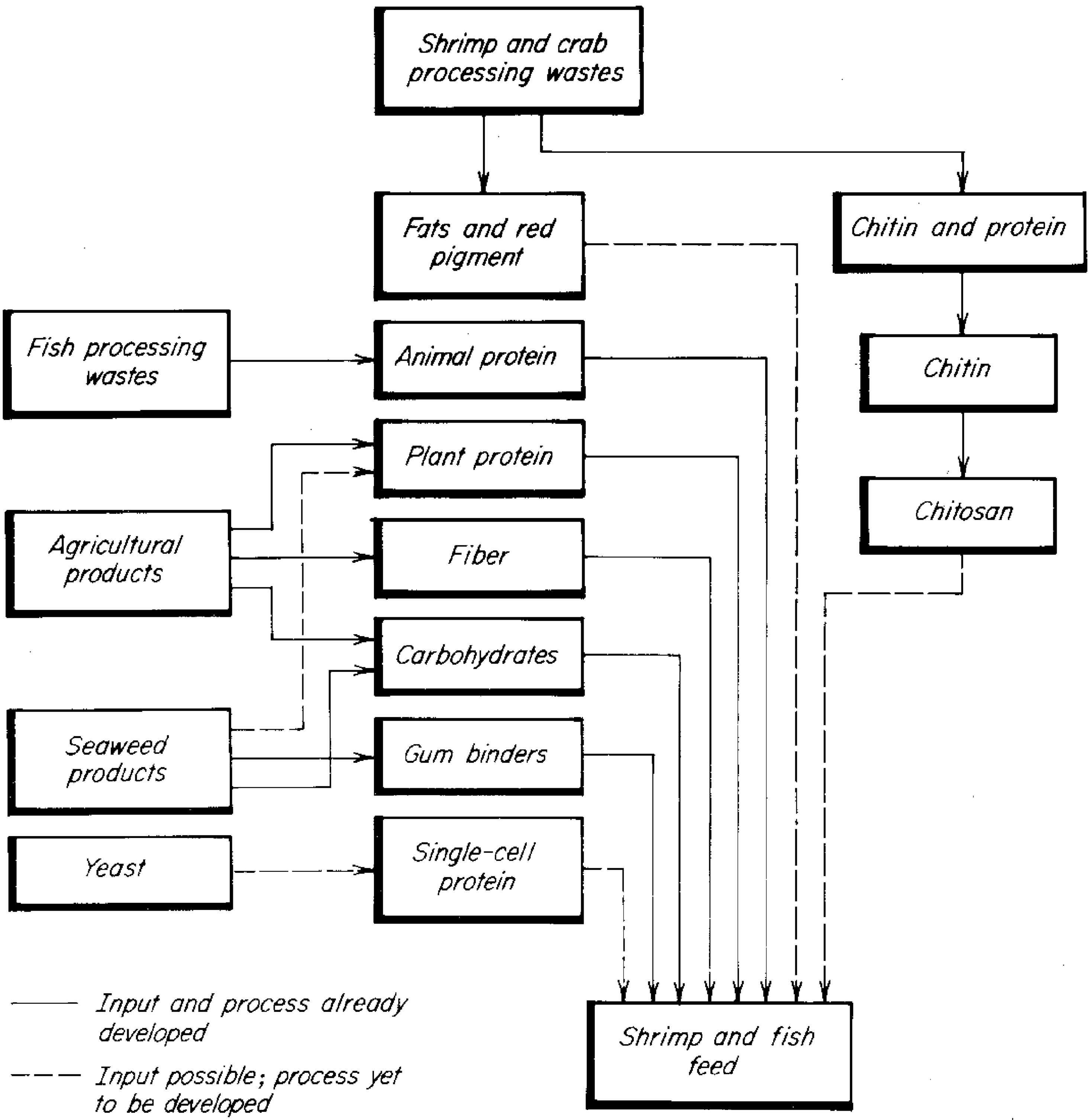
EQUIPMENT

Particularly the timber industry would present a possible cooperative opportunity for the use of heavy machinery and ready building supplies for development of aquaculture installations and for construction of access roads to such facilities.

FUTURE RESOURCES

Additional materials and energy sources will be considered as they become recognized to have significant potential in the aquaculture field. Such resources could include use of carbon dioxide and hydrocarbons from the petrochemical industry and carbohydrate derivatives from the pulp plants.

Aquacultural Feeds—Sources and Intermediate Products



Feedlot and early-rearing systems

HABITAT SURFACES

A basic requirement for many bottom-dwelling forms of marine life is an appropriate surface for attachment. Substitute surfaces often can be provided that make possible a much greater production of selected organisms from a given area than would be possible on natural bottoms. The culture of seaweeds, oysters, clams, mussels and scallops can be greatly enhanced by providing appropriate surfaces for their growth. Here the variety of materials that can be used is limited only by the imagination of the aquaculturist. In France, for example, cheap plastic hair curlers are coated with lime and used as oyster cultch.

HATCHERIES

Fish hatcheries serve both to provide seed stock for the restoration and enhancement of natural populations and to protect the young fry during their vulnerable early-rearing stages.

Because salmon are not only highly valuable commercially but undergo lengthy migration in their life cycle, they are rendered particularly susceptible both to over fishing and habitat destruction. New hatchery technology appropriate to the Alaskan environment and to Alaskan races of salmon should be easily derived from an already substantial reservoir of knowledge on the life cycles of salmon and well-established techniques for rearing them through their freshwater phase.

Hatcheries to provide seed for the development of salmon aquaculture in Alaska need not be expensive, massive installations. Simple gravel incubation systems designed for placement on small streams would serve very efficiently. Ideal sites for such systems would be near a coastal town or logging facility in order to minimize costs and to regulate commercial interception of returning spawners.

NURSERIES

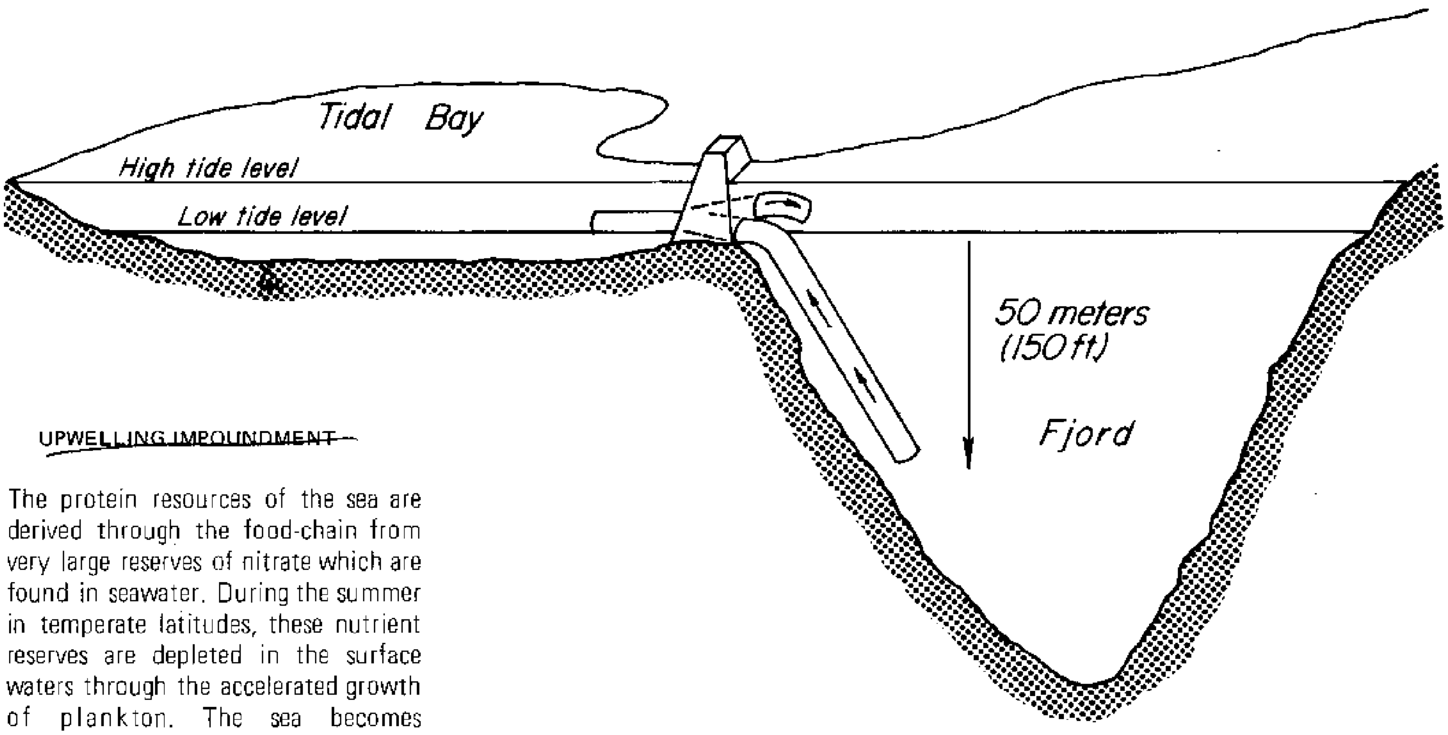
The transfer of wild or hatchery-produced seed of various marine organisms to nursery areas for protection during their fragile juvenile stages poses excellent opportunities for enhancing the survival of valued stocks. Lagoons and fjords could be appropriately fenced to afford protection to the impounded organisms but yet permit the inflow of new water and food organisms and the flushing out of wastes. Diked impoundments on tide flats which are flushed by gravity and tidal action have been widely used as nurseries in release systems and even for the complete rearing of organisms to adulthood in many programs of aquaculture throughout the world. The culture of selected shellfish and seaweeds, as well as salmon, should profit significantly from the development of suitable nursery systems designed to maintain critical temperature levels in a harsh environment.

LAKE FERTILIZATION

Studies in Alaska and other parts of the Pacific Northwest have indicated that sockeye salmon nursery lakes can be improved by the addition of inorganic fertilizers. Commercial fertilizer compounds of nitrogen, carbon, phosphorus and essential trace elements would improve the size and vitality of sockeye salmon smolts at the time of their seaward migration. Under-sized sockeye salmon leaving nutrient-poor lakes have shown a record of significantly less chance of ocean survival than the larger, hardier smolts.

The natural productivity of many lakes in Alaska has been sustained in part by the carcasses of dead salmon. With the removal of a large fraction of the sockeye salmon run by the fishery, less nutrient has been available for the growth of plankton and young sockeye during their year of lake life.

Studies should be conducted regarding the feasibility in certain cases of converting by-products of the salmon canning process into forms which could be returned to salmon nursery lakes to help replace nutrients critical to salmon production.

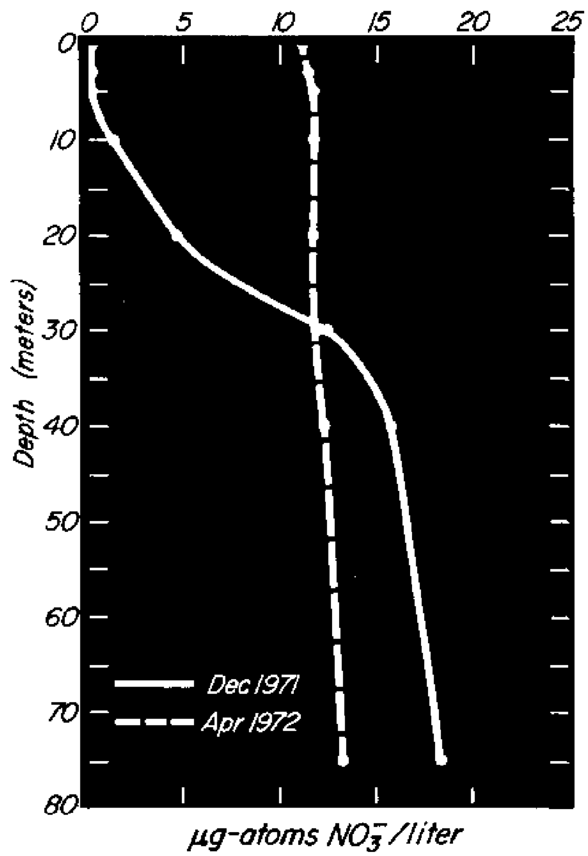


UPWELLING IMPOUNDMENT

The protein resources of the sea are derived through the food-chain from very large reserves of nitrate which are found in seawater. During the summer in temperate latitudes, these nutrient reserves are depleted in the surface waters through the accelerated growth of plankton. The sea becomes essentially nitrogen-deficient therefore during a large part of the summer. Below the thermocline layer (usually 30-100 meters), however, a high concentration of nitrate occurs; this is mixed up into the surface layers by winter storms to be depleted again during the following spring.

In areas where there is considerable tidal exchange, a natural mechanisms exists for enriching the surface water throughout the summer. This device consists of two pipes, one penetrating below the seasonal thermocline into the bottom of an enclosed coastal impoundment and a second pipe leading out of the top of the impoundment. On each tidal cycle, nutrient-rich water from below the thermocline is pushed up into the impoundment; as the tide falls, nutrient-poor water in the surface layers of the impoundment flows out through the upper pipe. This system has been tested experimentally, and it can be shown that it results in an approximate ten fold increase in the natural productivity of coastal waters. The type of food-chain leading to an economically useful resource within the impoundment could then be manipulated to produce the exact choice of commodities as determined by the technical feasibility and economic considerations.

Artificial impoundment systems to tap unlimited source of nutrients only 90-120 feet below surface



Vertical distribution of nitrate (summer and winter) in typical Alaskan fjord

Open-range salmon ranching

Any public policy decision to encourage ocean ranching of salmon should recognize that conservation of wild stocks should take precedence in any management program of mixed wild and hatchery stocks. Many other questions must be considered in formulating management policy:

Ocean ranching appears to have greater immediate economic promise than feedlot systems because of slow winter growth in inshore waters and high operation costs (food, handling and facilities) for fish raised entirely in captivity.

Hatchery-reared king, coho and sockeye salmon can be conditioned to return to selected streams by holding them in pens in salt water near the mouths of streams for brief periods before releasing them to grow to maturity at sea. The spawning run is harvested at the homing station. Pink and chum salmon are released from hatcheries to emigrate directly to sea. Harvesting occurs when the matured salmon return from the ocean. A corollary use of open-range ranching would be the conditioning of stocks to return to areas where it would be desirable to stimulate sport or commercial fishing.

.. Should ocean ranching corporations be permitted to assess their membership for the purpose of establishing a fund intended to finance hatcheries? One by-product of a private hatchery program will be the enhancement of recreational salmon fisheries. The establishment of salmon production systems by ocean ranching corporations should not restrict opportunities for sport-fishing or for tourism.

.. Should membership in an ocean ranching corporation be limited to fishermen, processors and other economic interests that obtain income from a definable common property fishery? This would help to insure that any plan to develop salmon production systems would enjoy local support.

.. Should fishermen be encouraged to form corporations to engage in ocean ranching? Would ocean ranching through private salmon production systems be compatible with present management policies for common property salmon fisheries?

.. Should other industries (fish processors, etc.) or private citizens who do not hold permits to engage in the limited entry fishery be permitted to engage in ocean ranching? One possible approach is to allow these interests to purchase a minority interest in ocean ranching corporations. This type of arrangement would encourage salmon processors and other interests sharing a desire to play a role in the orderly development of salmon fisheries to participate.

.. Should ocean ranching corporations be licensed by the State of Alaska solely for the purpose of raising fish for the common property fishery and for the harvest and marketing of surplus hatchery fish?

.. Should the licensing of hatcheries give highest priority to distressed and impaired fisheries as defined in the limited entry bill?

.. Should costs incurred by the Alaska Department of Fish and Game for monitoring and administering salmon production systems be charged to the ocean ranching corporations?

.. Should ocean ranching corporations derive all of their income from the sale of surplus hatchery fish escaping the common property fishery? Should such corporations have the discretion to assess participants in the common property fishery to obtain funds required to subsidize salmon production systems if the value of surplus fish do not equal or exceed the costs of operation?

How can aquaculture be promoted in Alaska?

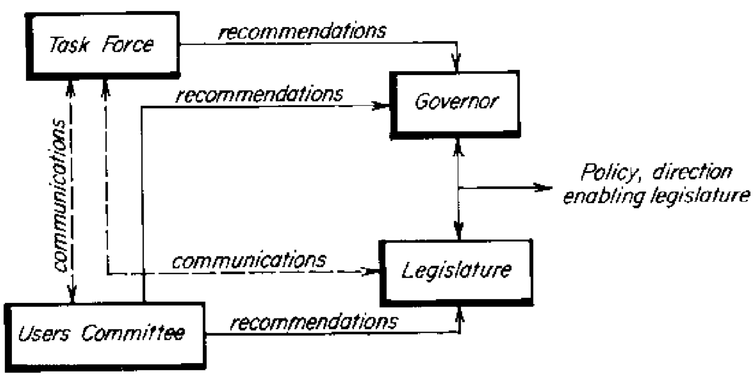
Formation of a committee of Alaskan resource users to identify and quantify resources and opportunities would coordinate diverse interests of the member groups. Such a committee should include representatives from all contributory Alaskan industries: fishing and fish processing, lumber and pulp, mining, tourism sports, petroleum and petrochemicals.

The state government could then establish a task force to represent the state in cooperation with the users committee. The task force and users committee should develop procedures for identifying specific resources, matching resources that could complement one another, estimating the economics of aquaculture projects based on these resources, and defining the legal requirements and means of accomplishing them. On the basis of these considerations, the users committee could then recommend enabling legislation to promote commercial aquaculture.

These recommendations should be made known to the state and to the public for implementation by public or private entities.

General public support is essential for the development of aquaculture. Information must be made known to the public, to appropriate governmental agencies and industrial groups and to potential private investors. Because investment funds will be low at the start, citizens are urged to encourage their state representatives to authorize the establishment and operation of demonstration projects to investigate aquaculture feasibility and profitability. The news media should be kept fully apprised of progress, problems and potential benefits of the aquaculture experience elsewhere as well.

After an aquacultural system has received social acceptance, numerous legal considerations will have a continuing influence. Such requirements will include enabling legislation, issuance of permits (rights to water, use of land, tidelands and navigable waters, waste disposal), environmental impact statements, operation of rearing systems (disease diagnosis and control, transplantation, marking of animals), harvesting and marketing.



A preliminary examination of sociolegal prerequisites for aquaculture has led to the conclusion that starting aquaculture in Alaska will require:

- .. acceptance by the public
- .. active promotion by administrative agencies
- .. support of participants in common-property commercial and recreational fisheries
- .. advisory services from university, government, and consulting technical groups

What regulations presently constrain the utilization of industrial by-products by aquaculture systems?

In recent years numerous federal, state and local laws have been developed which regulate the quality and quantity of industrial by-products being returned to the environment. Although it is recognized that a basic and real need exists for controls of this type, the tendency to consider these by-products as "wastes" and "pollutants" has hindered investigations related to beneficial uses of such by-products. Furthermore, some regulations controlling discharge of industrial by-products may inadvertently prevent the beneficial utilization of these products.

As an example, discharge of heated water from industrial processes into a stream, lake or estuary is controlled by federal regulation. The temperature of discharged water can exceed that of the receiving water by only a fixed number of degrees. Some industrial plants are therefore required to develop water-cooling systems to dissipate the heat prior to discharging water. In specific cases, the discharge of heated water may have little or no detrimental effect on the environment of the receiving waters. It could have, on the other hand, some beneficial effect such as the improvement of growth rates of salmon fry being reared in enclosures in the vicinity of the discharge. Existing regulation can prohibit the use of heated water for this purpose.

Laws regulating the disposal of industrial by-products should be flexible enough to recognize, and allow, use of by-products when this use is compatible with the intent of the law and at the same time benefits production of fish by an aquaculture system.

PL 92-500, the Federal Water Pollution Control Act Amendments of 1972, provides specifically for development of aquaculture in Section 318 "(a) The Administrator is authorized, after public hearings, to permit the discharge of a specific pollutant or pollutants under controlled conditions associated with an approved aquaculture project under Federal or State supervision. (b) The Administrator shall by regulation, not later than January 1, 1974, establish any procedures and guidelines he deems necessary to carry out this section."

:: Citizens and potential investors should encourage the state and federal agencies to establish and operate **demonstration experiments** to investigate the feasibility and profitability of developing

animal feeds from processed fish wastes and other Alaskan raw materials

impoundment systems for production of aquacultural seed stocks and market-ready commodities

:: The University of Alaska, the state and contributors to this report should encourage users of Alaskan resources to form an advisory **users committee.** Similarly, the Governor should be encouraged to form a **task force** to work together with the users committee and the state to

prepare legislation for removal of institutional barriers to permit beneficial uses of by-products from industrial processes

provide for a comprehensive study of the advisability of allowing private ocean ranching of salmon