Alaska Underutilized Species
Volume III:

SEA URCHIN

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ALASKA'S UNDERUTILIZED SPECIES

VOLUME III

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The appendices to this report have been published in a separate volume. They contain more detailed information relating to the various sections in this report. If you are interested in this additional information, request copies from:

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The appendices are as follows:

APPENDIX A: Results of selected cruises of the National Marine Fisheries Service in the Bering Sea, and Gulf of Alaska, by statistical block, showing incidental catches of sea urchin

APPENDIX B: Japanese and Korean sea urchin catch in the Bering Sea and Gulf of Alaska, by statistical block

APPENDIX C: The estimated incidental sea urchin catch by mothership and stern trawler, by statistical block, derived from NMFS foreign observer data

APPENDIX D: Detailed results of the feasibility analysis of diving operations for sea urchin

APPENDIX E: Survey questionnaire and background information

APPENDIX F: Import and export statistics for countries reporting trade in sea urchin

APPENDIX G: A summary of major producers of the world's sea cucumber, sea urchin, squid, octopus, and cuttlefish resources with synopsis on the availability of import-export data from the country

ACKNOWLEDGMENTS

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ALASKA'S UNDERUTILIZED SPECIES-SEA URCHIN

INTRODUCTION

Only a few countries have consumer markets for sea urchin. The roe or gonads of the animal are the only parts eaten. Japan and Korea are the largest consumers. There are also markets indicated in Greece, Italy, Spain, and France. Chile is also a fairly large consumer, but has no need for additional supplies.

Sea urchin is marketed in three forms: live, fresh-frozen, and in patés or pastes.

The sea urchin belongs to the class Echinoidea. In this class there are 14 orders including 800 species of urchins (Barnes 1974). Many of these species are rare, with no commercial value. Others are common but not usually eaten, like the sand dollar. Only four of the orders are of commercial importance: Diadematoida, Arbacioida, Temnopleuroida, and Enchinoida. Eight orders are actively sought by the Japanese fishery. Although there are no studies on the subject, it is possible that all urchins are edible (Mottet 1976). Roe doesn't seem to differ much among the various species, so there may be considerable room for expansion in the fishery if existing markets can absorb increased supply.

Japan is the largest single harvester, processor, importer, and consumer of sea urchin roe (or uni). As such, its influence on the market is great. There has been a trend recently toward harvesting and exporting additional urchin species to Japan. Exporting countries include the United States, the Koreas, Philippines, Chile, Mexico, Australia, and New Zealand. In 1977 the United States and South Korea were Japan's largest suppliers.

There are several species in North American waters with commercial potential. The species Strongylocentrotus pallidis is an arctic urchin that is rarely found south of Massachusetts Bay on the East Coast and Oregon on the West Coast (Jensen 1974, Mottet 1976). It is also found in waters off Japan and Korea. In all areas, it lives in water depths from 16 to 4,900 ft. The shell diameter is 2.5 in.

Strongylocentrotus droebachiensis, or green sea urchin, is another cold water species. Its distribution extends around the northern pole, into Northern California in the west and Massachusetts in the east.

Strongylocentrotus franciscanus and Strongylocentrotus purpuratus are represented as far south as California and are major commercial species for a large sea urchin fishery there and in Washington.

The species diadema occurs in the Atlantic, Carribean, and Gulf Coast, and is a limited fishery. The species Allocentrotus fragilis lytechinus sp. and Centrostephanus coronatus are common in Southern California. None of them are used commercially.

DISTRIBUTION OFF ALASKA

The urchins that inhabit coastal Alaska are numerous in the intertidal and subtidal region. One species of questionable commercial value is found in depths of over 100 m (328 ft). All of the sea urchins of interest to Alaskan processors and fishermen are from the family Strongylocentrotidae. The species of greatest importance are: Strongylocentrotus franciscanus, S. purpuratus, and S. droebachiensis--the red, purple and green sea urchins, respectively. Sometimes, it is not easy to conclusively distinguish the species of any one urchin because of the hybridization that goes on with the three urchin types. The following general descriptions with photographs may help distinguish these three urchin types.

Strongylocentrotus franciscanus (red urchin)

This is the largest sea urchin occurring on the West Coast (Figure 1). It lives at a shallow depth, 5 to 10 m (16 to 32 ft) and occasionally to 135 m (433 ft). Its distribution extends from Baja California to the Aleutian Islands and over to the southern end of Hokkaido, Japan. An impressive American and Canadian fishery has developed around this resource.

S. franciscanus spawns during the colder months. Spawning has been recorded in December and January at Corona del Mar (Macginitie and Macginitie 1968); February to March at Pacific Grove (Macginitie and Macginitie 1968); April through May at Johns Hopkins Marine Station (Bennett and Giese 1955); March to April in Puget Sound (Johnson 1930); and, possibly June to July near Vancouver Island (Miller 1974).

It is unclear from Mottet's (1976) discussion whether the maturity period for most of the red urchins in Alaska's waters might come later or earlier. However, one would guess that if roe maturation cycles are similar to that of other marine life in Alaska waters, red urchins would mature in late fall. In the absence of data supporting this assumption, fisherman involved in the fishery would have to experiment to determine the best maturation times. This means systematically opening a sample size of urchins to determine roe maturation, and observing the spawning activity. Another piece of information that should help is that red urchins consume large algaes for food, and may be found encroaching on large kelp forests or other seaweeds.

Strongylocentrotus droebachiensis (green urchin)

The green sea urchin (Figure 2) has a circumpolar distribution. In the Pacific it ranges from Point Barrow, Alaska, to Puget Sound; and through the Aleutian Islands westward to the Kamchatka Peninsula, Korea, and Hokkaido. In the North Atlantic it is commercially fished along the east coast of the U.S. and Canada. It is also present in waters off Greenland, Iceland, and Northern Europe, and in these areas it is harvested by the French. It can be found from the intertidal region down to about 128 m.

These animals appear on gravel, shell, and sand bottoms, suggesting that these urchins do not thrive on macro algaes as much as the red urchins. The quality of their roe is directly related to the availability of smaller fixed and floating algaes that may be present on the sea bottom.

Figure 1. Strongylocentrotus franciscanus (red sea urchin). Photo by W. Heard

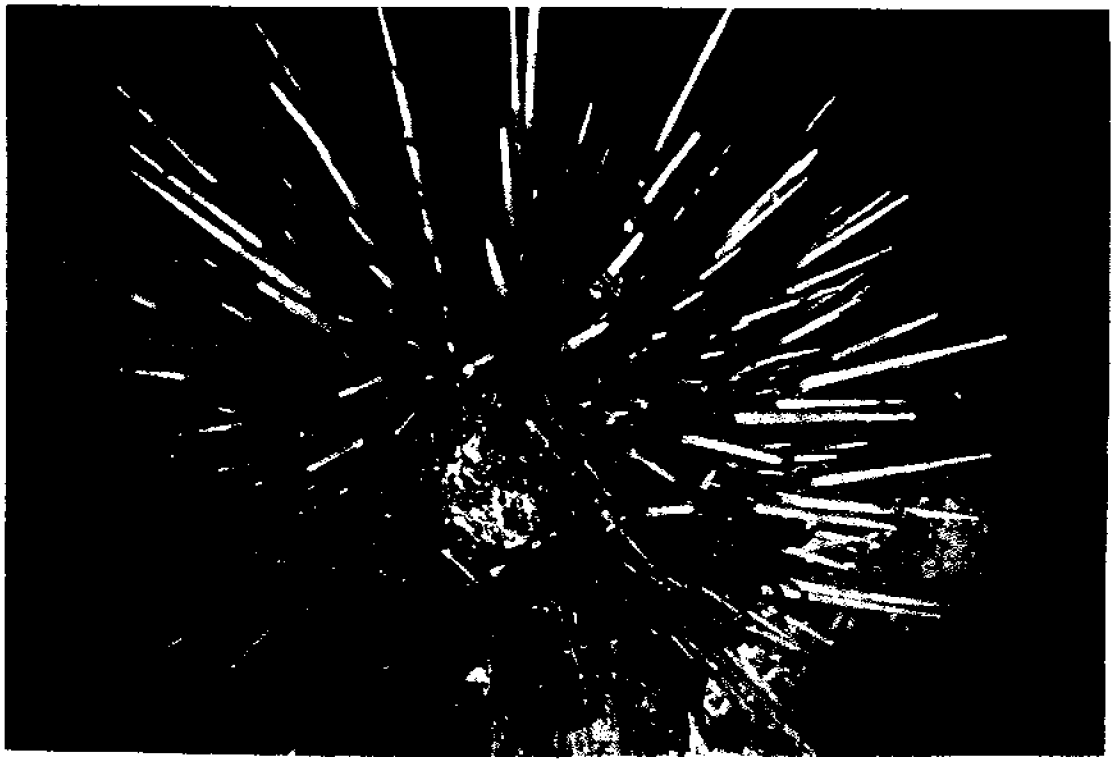

Figure 2. Strongylocentrotus droebachiensis (green sea urchin). Photo by M. Dahlberg

S. droebachiensis is a cold water animal and is very intolerant of warm water, especially as larvae. Live, they should be kept between 0° and 10°C. S. droebachiensis is known to spawn in the winter or early spring (between December and April in waters surrounding Cape Cod). Males become mature nearly two months earlier than females, and they remain mature about a month longer (Mottet 1976).

Two factors may preclude a strong commercial development of this urchin resource: small size and slow growth. Most green urchins average 1.8 in. in diameter (although they can grow to 2.5 in.) with a body weight averaging 3.1 oz. With the roe yield at 17 percent of total body weight (Mottet 1976), one can expect a yield of only .53 oz. For the Japanese trade, when 200 g (7.05 oz) trays are used, 13 urchins have to be opened to yield one tray of product. It may, however, fall short of the optimum roe size, which is reported to be about 5 cm (1.96 in.) (Kato 1972a). This, and the fact that an inexpensive short-term labor supply in Alaska may be hard to find, may make the exclusive processing of this urchin species too expensive (Kato 1979; Earl 1979, personal communication).

Strongylocentrotus purpuratus (purple urchin)

This purple sea urchin (Figure 3) is found from Baja California to Sitka, Alaska (Mottet 1976). These urchins like rocky shores and strong wave action, although they can be found to depths of 210 ft. It is more sedentary than other urchins and is occasionally found embedded in rock surfaces in intertidal areas where heavy wave action occurs.

The purple sea urchin also shows a preference for large algae. Food consumption is directly related to water temperature within certain limits. The mature animal has a wide range of temperature tolerances (2° to 23°C) although it takes time for it to acclimate. Substantial mortality does occur, however, at temperatures of 25°C and higher.

The distribution and abundance of sea urchin in Alaska is difficult to assess. In order to make an estimate of abundance and location, readily available survey data was collected, mostly from the National Marine Fisheries Service (NMFS). Data was taken from periodic NMFS trawl surveys (NMFS 1975a and b, 1976, 1977a, b, and c, 1978a and b, 1979a, b, and c), from catch data supplied by divers (personal communications: Rosenthal 1980, Hansen 1980, Earl 1979, Barr 1980, Ellis 1980, Shimek 1980, and Powell 1980), and information from the NMFS Foreign Observer Program (NMFS 1973, 1978c).

TRAWL SURVEY DATA

During the trawl surveys, NMFS uses a variety of trawling gear and attachments for targeting species. A careful record is kept of incidental catches.

For this study we selected 11 surveys, taken between 1973 and 1979. They covered parts of the Bering Sea and the Gulf of Alaska. Figures 4 and 5 show the general survey areas. Appendix A is a detailed station-to-station summary of catch and catch rate for the cruises.

Figure 3. Strongylocentrotus purpuratis (purple sea urchin). Photo by L. Barr

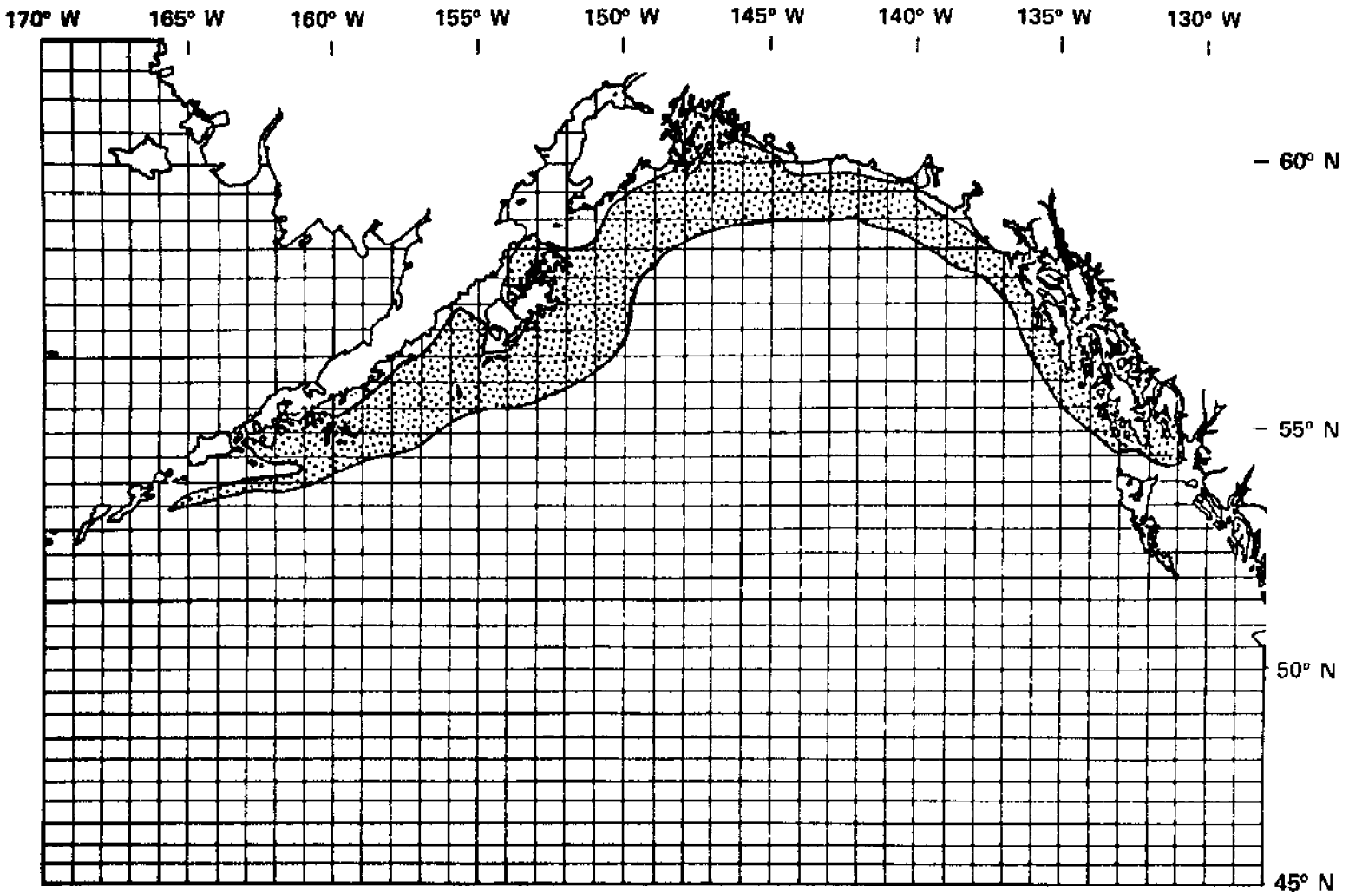

Figure 4. Area covered by selected NMFS Gulf of Alaska surveys 1973-1979. (NMFS 1973a, 1975 a and b, 1976, 1977 a and b, 1978 a and b, 1979 a and b)

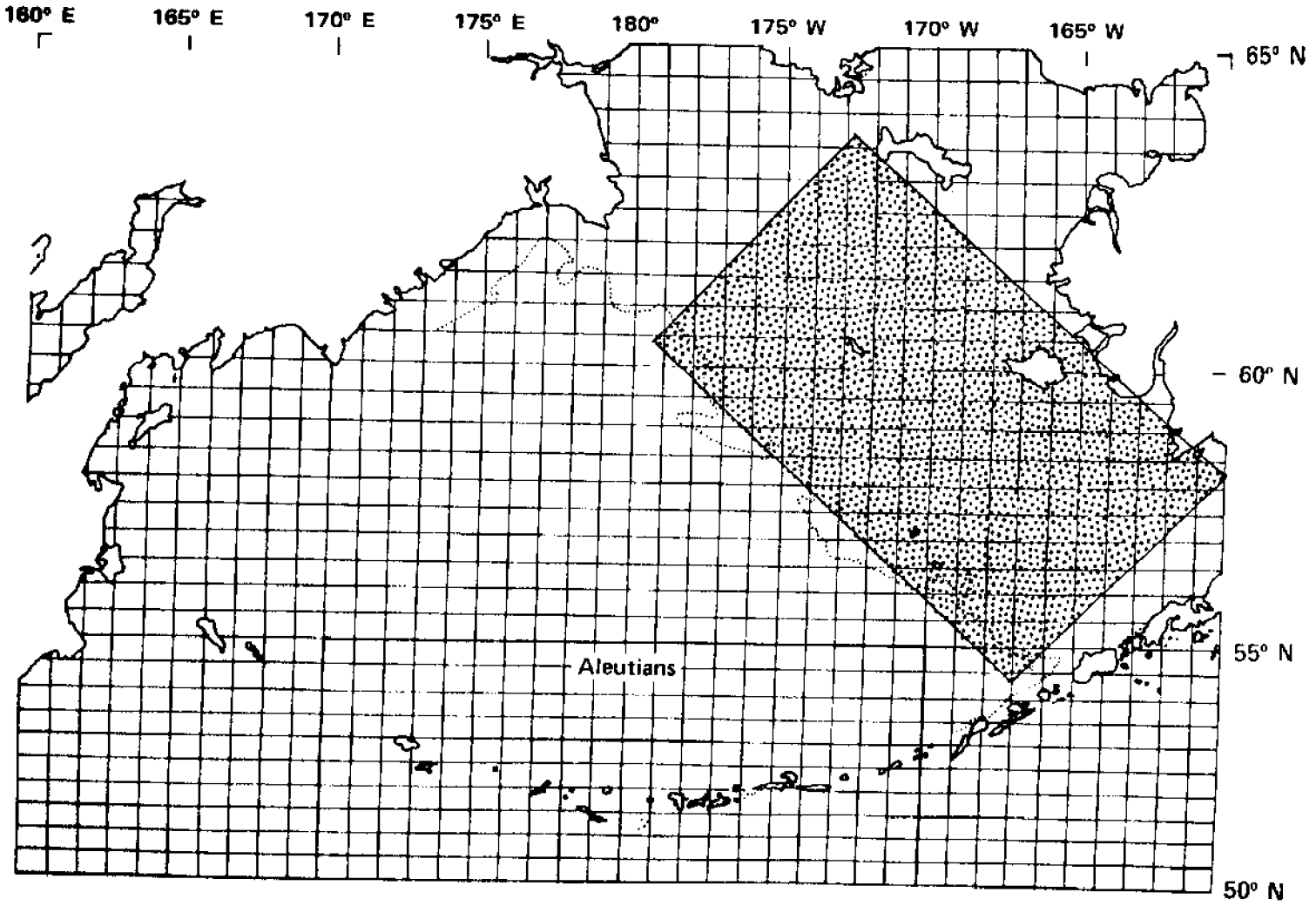

Figure 5. Area covered by the 1979 NMFS Bering Sea trawl survey. (NMFS 1979c)

Several cautions are in order about this data. First, most the surveys were taken in deep water and the figures are good only for those depths. Second, most cruise samples were not conducted in enough detail to identify the species of urchin caught. Crew members are generally not specialists, although the NMFS encourages scientists to take part in the cruises. Third, almost none of the gear used is preferred for harvesting urchin.

DATA FROM DIVERS AND BIOLOGISTS

Since diving for urchin is the preferred method of harvest, and since active divers are most likely to have encountered large collections of urchin, we asked for advice based on their experience. We also used Mottet (1976), the trawl surveys and work done by Earl, Baker, and Hansen (1980) to estimate range. This information has been summarized in Figures 6, 7, and 8 for S. franciscanus, S. droebachiensis, and S. purpuratus.

These maps, are gross generalizations based on information supplied by divers about specific locations. Since diving is usually carried out on a local basis, one should not infer that all shaded areas have been explored.

FOREIGN OBSERVER PROGRAM

The Foreign Observer Program allows U.S. observers with quasi-enforcement powers to accompany foreign vessels operating in U.S. waters. Observers are placed on selected vessels and monitor catches of targeted and incidental species. These appear in Tables 1 and 2.

Generally, random samples are taken from trawl hauls. The species mix for that trawl weight is recorded. The relative proportion of each species to the sample weight is used to infer the total catch in that haul.

Observers also note the areas fished, the number of days fished in an area, hours of actual trawling, weight of the sampled trawls (mt), weight of the whole catch (mt), and the estimated catch of a species in an area. Some other variables may be inferred from this data, but are not important to this study.

We used 1978 observer data. It appears by statistical block (.5° lat. x 1° long.). Most of the observations were taken from motherships or independent stern trawlers. Appendix C contains the results of this survey.

The numbers shown are not absolute, but statistical inferences based on samples of a whole catch. Also, observers often are not given full cooperation of the foreign crew and differences among the surveys reflect this. Finally, the type of gear used or the conditions under which the ships fished are unknown.

Tables for mothership operations show hours of trawling that do not match the days spent on the fishing grounds. This is because the mothership fleet may have several trawlers that fish daily. Their trawling hours are totaled.

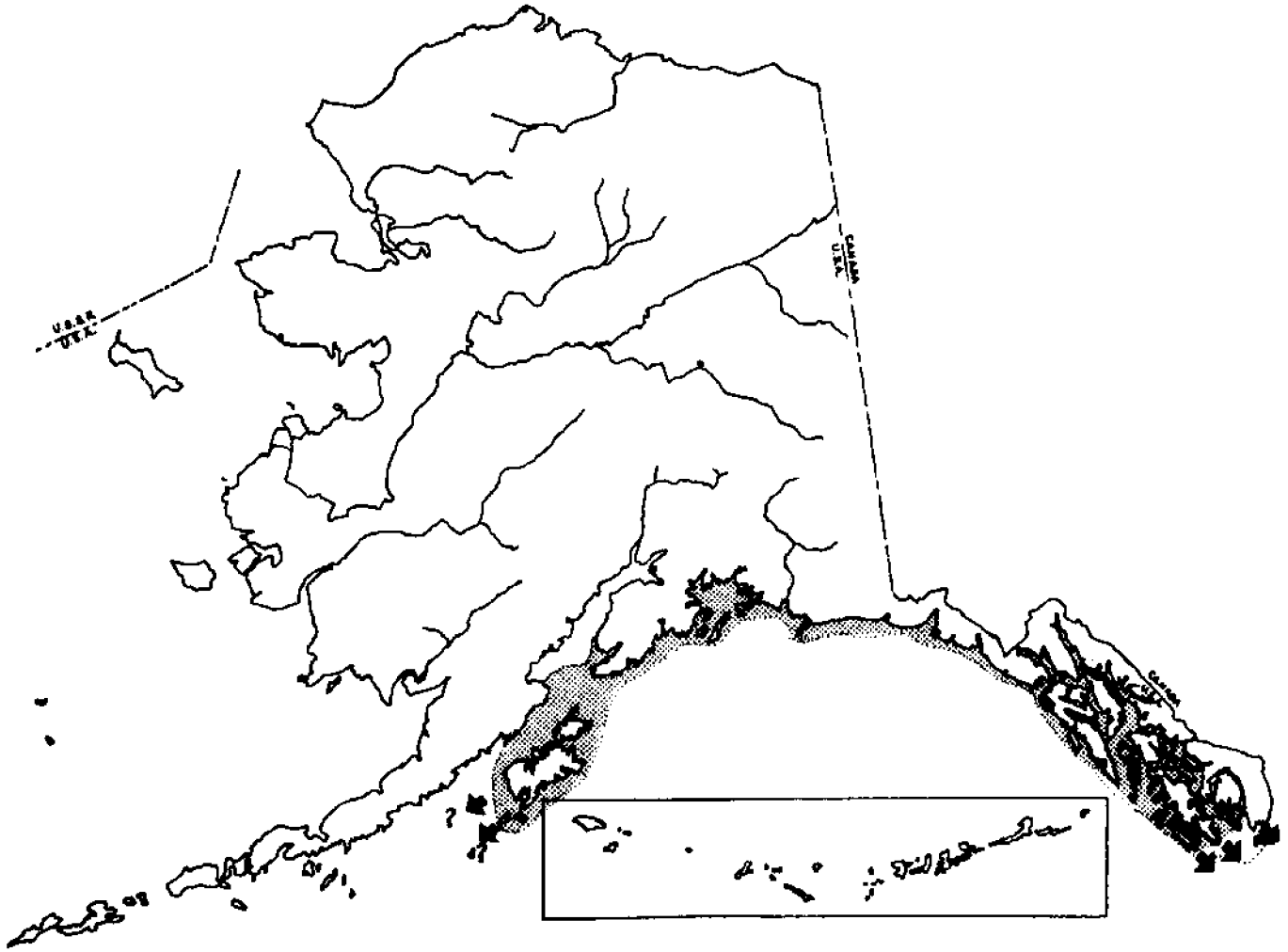

Figure 6. General distribution of S. franciscanus based on diver accounts and selected literature. Mottet 1976 indicates that the westward distribution is at least to Hokkaido; southern distribution to Baja California.

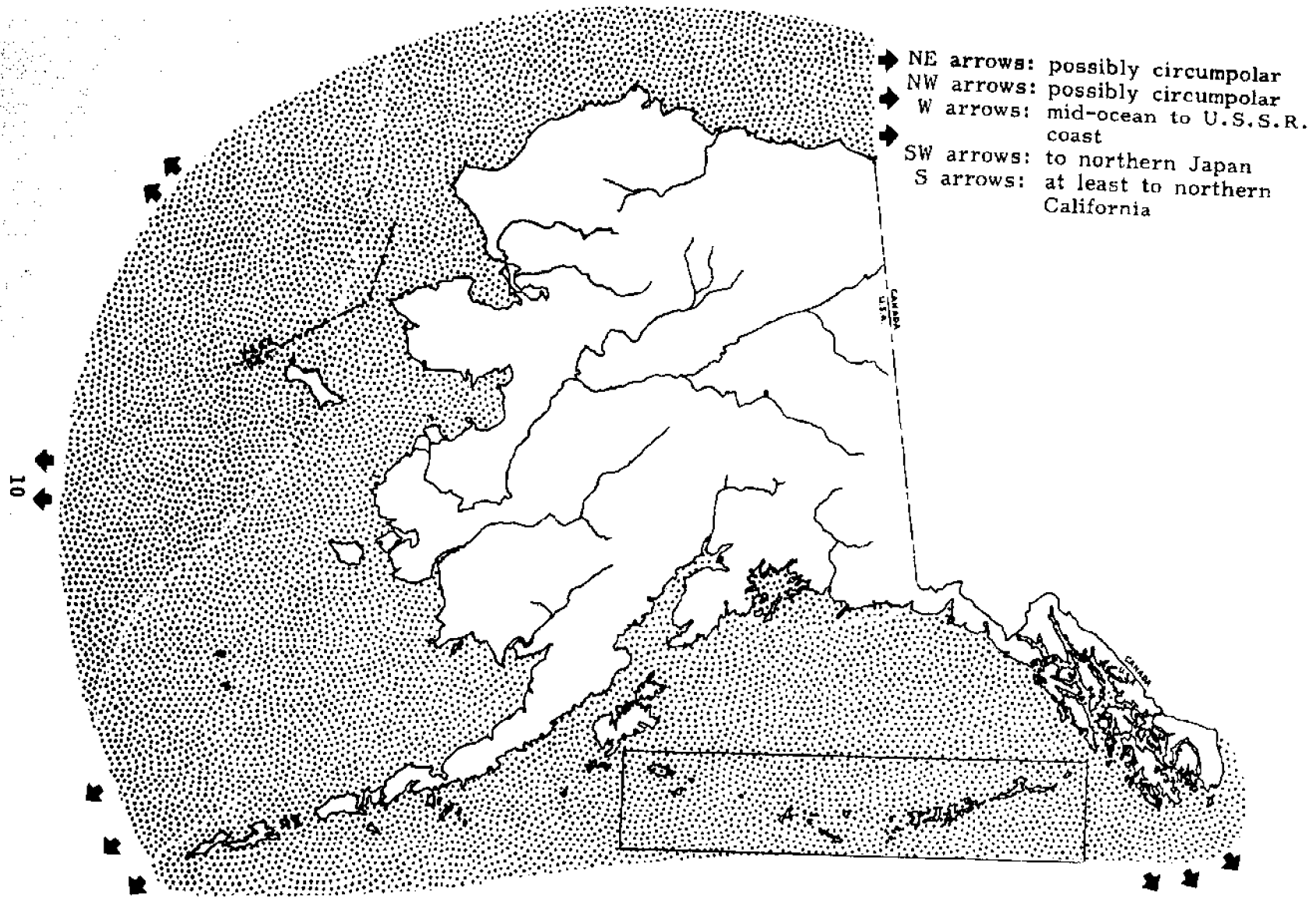

Figure 7. General distribution of S. droebachiensis, based on diver accounts and selected literature. Northern and depth limits are not listed because of considerable mixing with S. palladis.

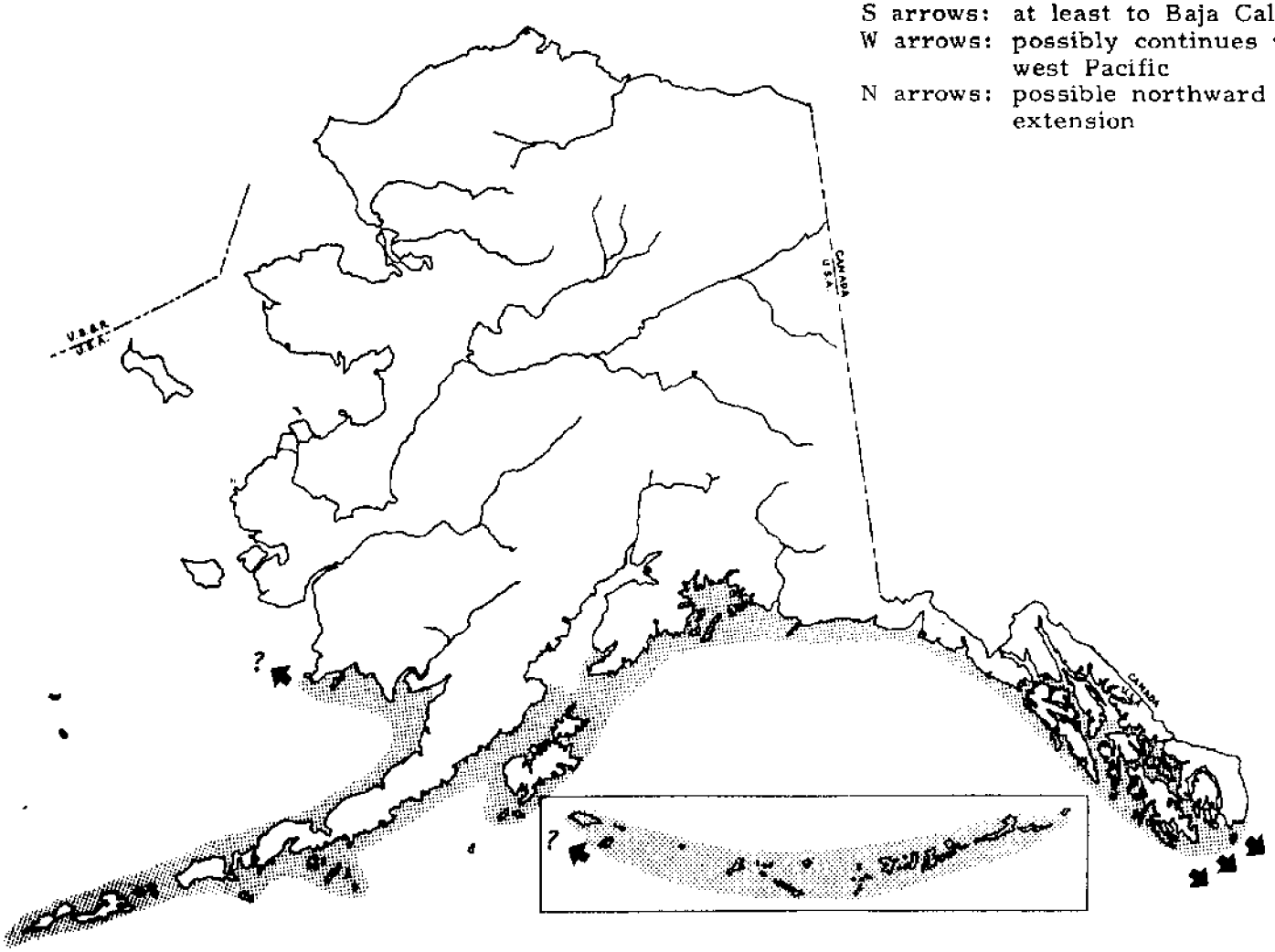

Figure 8. General distribution of S. purpuratus based on diver accounts and catch data. Prefers rocky, windswept shores. Hybridization within the species makes depth and boundary information inexact.

Table 1. The estimated 1978 foreign incidental catch of sea urchin by stern trawler from half by one statistical blocks

Area	Dates		Fishing Days	Hours Actually Trawling	Weight of Sampled Hauls	Weight Total Catch mt	Sample Weight mt	Sea Urchin mt	Sea Urchin mt/hr
				Japanese Stern Trawler					
168560	6/23	6/30	28	289.4	1098	1705.00	40.010	.204	.0007
165543	7/16	9/19	64	611.3	3897	6259.00	20.369	.164	.0003
168553	7/01	8/16	16	102.9	644	795.10	4.662	1.179	.0115
168560	7/03	8/27	15	89.6	366	618.80	4.848	.607	.0068
150570	10/06	10/22	15	142.6	47	114.30	3.610	.674	.0047
				U.S.S.R. Stern Trawler					
179523	4/25	6/05	47	367.5	731	1947.23	8.961	.227	.0006

SOURCE: National Marine Fisheries Service, Foreign Observer Data Set for 1978, showing estimated catch for statistical blocks of .5° latitude by 1° longitude.

Table 2. The estimated 1978 foreign incidental catch of sea urchin by mothership from half by one statistical blocks

Area	Dates		Fishing Days	Hours Actually Trawling[1]	Weight of Sampled Hauls	Weight Total Catch mt	Sample Weight mt	Sea Urchin mt	Sea Urchin mt/hr
167560	7/26	7/26	1	60.5	720	720.00	1.129	.287	.0047
168560	7/24	8/21	4	204.6	2290	2290.00	3.737	.192	.0009
172573	7/03	7/04	10	1611.8	7422	7422.00	7.537	.540	.0003
174593	7/28	9/30	26	4472.8	17343	17343.10	19.196	.192	.0000
168560	10/21	10/21	1	44.6	726	726.90	1.073	.135	.0030

SOURCE: National Marine Fisheries Service, Foreign Observer Data Set for 1973, showing estimated catch for statistical blocks of .5° latitude by 1° longitude.

[1] Total hours of all trawlers associated with the mothership.

The hours spent trawling form the basis for estimating catch per hour trawling and are therefore taken at face value.

BIOLOGY

ROE

The successful urchin fishery is dependent on a complete knowledge of gonad (roe) development in a specific geographical area. This requires extensive individual research on the reproductive cycle of the local urchin resource.

The gonads are located on the roof of the urchin shell (Figure 9). They are the main nutrient storage organs as well as the generators of sex products (Mottet 1976). These storage organs, called nutrative phagocytes (Gonor 1973), take on food in direct proportion to its availability. In areas with little or no algae growth, roe size will be proportionately small. In well-fed sea urchins, however, the roe size can approach almost one-fourth of the total body weight.

Stages of Roe Development

Miwa (1966) discusses urchin roe development in stages. Each stage corresponds to a certain level of nutrient as well as sexual activity.

The first, or inactive, stage corresponds to a post-spawn period or immature stage in the urchin's sexual or growth cycle. There are no reproductive products, although sex can be determined microscopically. The roe during this period are "spent"--meaning small (5 to 10 percent of body weight)--and have a high water content. This type of roe is unacceptable for any market.

The second stage is one of active feeding, storing food within the gonad, and producing immature sex products.

In the third stage, the roe weight approaches its maximum; mature sex products are produced, and the first signs of sexual differences occur in the roe color and consistency.

In the fourth stage, the roe attains maximum weight (25 to 30 percent body weight). However, in the sexually mature condition, the male and female roe are easily determined. The male roe is of especially inferior quality, because it holds more water and turns whitish just prior to spawning.

The final, and fifth stage recorded by Miwa is the spawning stage: a rapid drop in roe weight occurs, along with the drop in nutritional level and an increase in water level. At this point, the roe is again useless for processing.

Harvest should take place during the third stage of development. In order to determine when to harvest, considerable test fishing is required. Unfortunately, the only way to determine the condition of the roe is to destroy the animal, so a careful record of the maturation cycle should be kept to reduce waste.

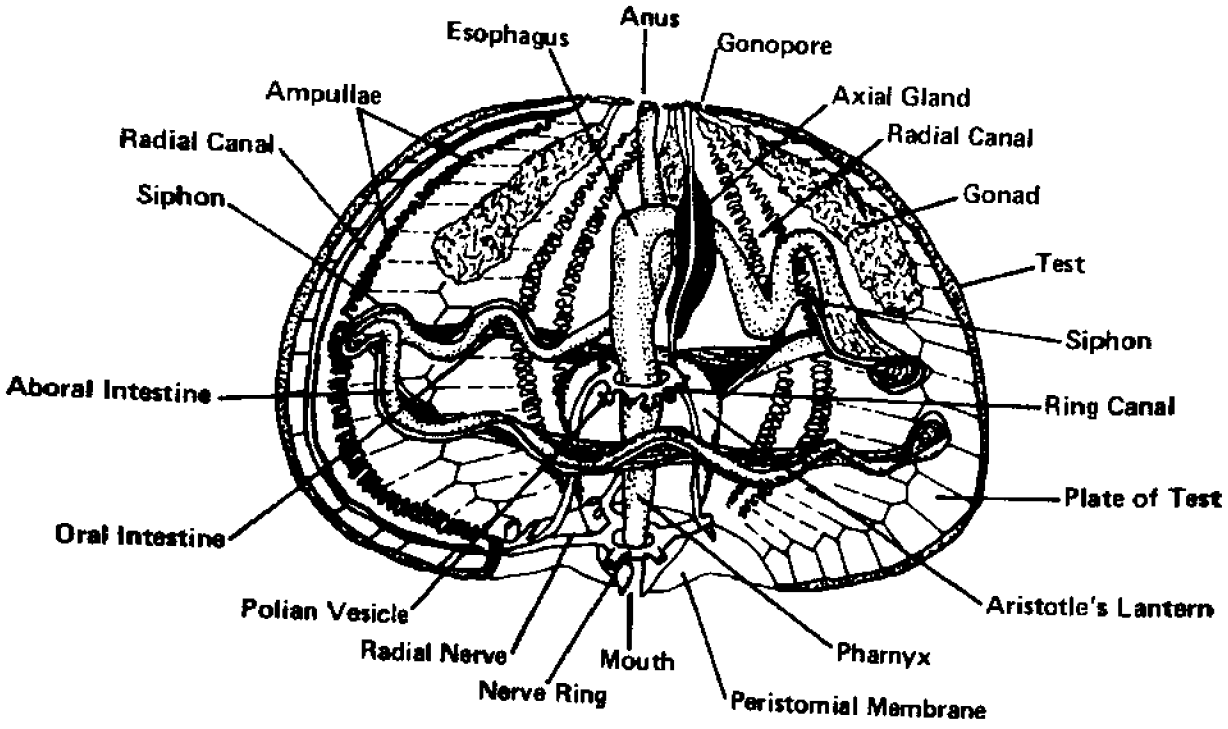

Figure 9. Cross-section of sea urchin with spines removed showing the internal organs, including the gonads. (Barnes 1974)

SEA URCHIN HARVESTING

TRADITIONAL METHODS

Sea urchin harvesting is similar to oyster harvesting. Urchins have been taken by hand, with dip nets, traps (Figure 10), and cotton mops[1] on the East Coast, and by a variety of towed gear in France (Allain 1972). Small trawls and dredges made especially for sea urchins have been used in France, but are now outlawed because of their effect on the sea bed (Bedard 1973).

However, some other major problems with surface collection of sea urchins exist. Unless tonging or mopping is done with the aid of divers, there can be little size control of the catch. Size and quality, however, are very important factors in the marketability of sea urchin roe in practically any country. Also, sea urchin beds mature at different times. It is not reasonable to expect to harvest sexually mature urchins in all areas during a designated season. Since it is hard to frequently test a few urchins from the surface prior to a large harvest of an area, surface harvesting may actually yield less roe per unit weight of urchins surfaced than a similar diving operation.

ALTERNATIVE METHOD

An alternative to traditional surface harvesting is the use of diving equipment. It is especially appropriate since most urchin populations lie in easy working depth for diving. Diver harvesting allows careful size selection, and the condition of the roe may be more easily monitored. Also, careful selection cuts waste, an important management concern. This waste factor may be very high in some species, since it is impossible to determine by external features if an urchin is ready for harvest. Thus, management must be initiated early in the fishery to avoid depletion of the resource.

DIVING OPERATIONS

Although diving provides superior product control, it also requires skilled labor and special equipment. Even though the diver may spend less time underwater than a conventional fisherman would spend harvesting from the surface, the total energy expended in the process is substantial. Physiological problems resulting from breathing air at pressures greater than sea level must be circumvented through precise dive planning. It is highly advisable to use divers certified through one of the national organizations, both from the standpoint of safety and also for convenience in obtaining equipment (most shops will not sell to uncertified divers). Certification to at least the level of a sport diver is needed, and training beyond this level would be preferred.

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[1] A "cotton mop" is usually a string of chains attached to a crossbar and laced with frayed cotton rope. This is dragged across the bottom and the urchins are entangled in the cotton fibers. This method has also been used for oystering and starfish eradication.

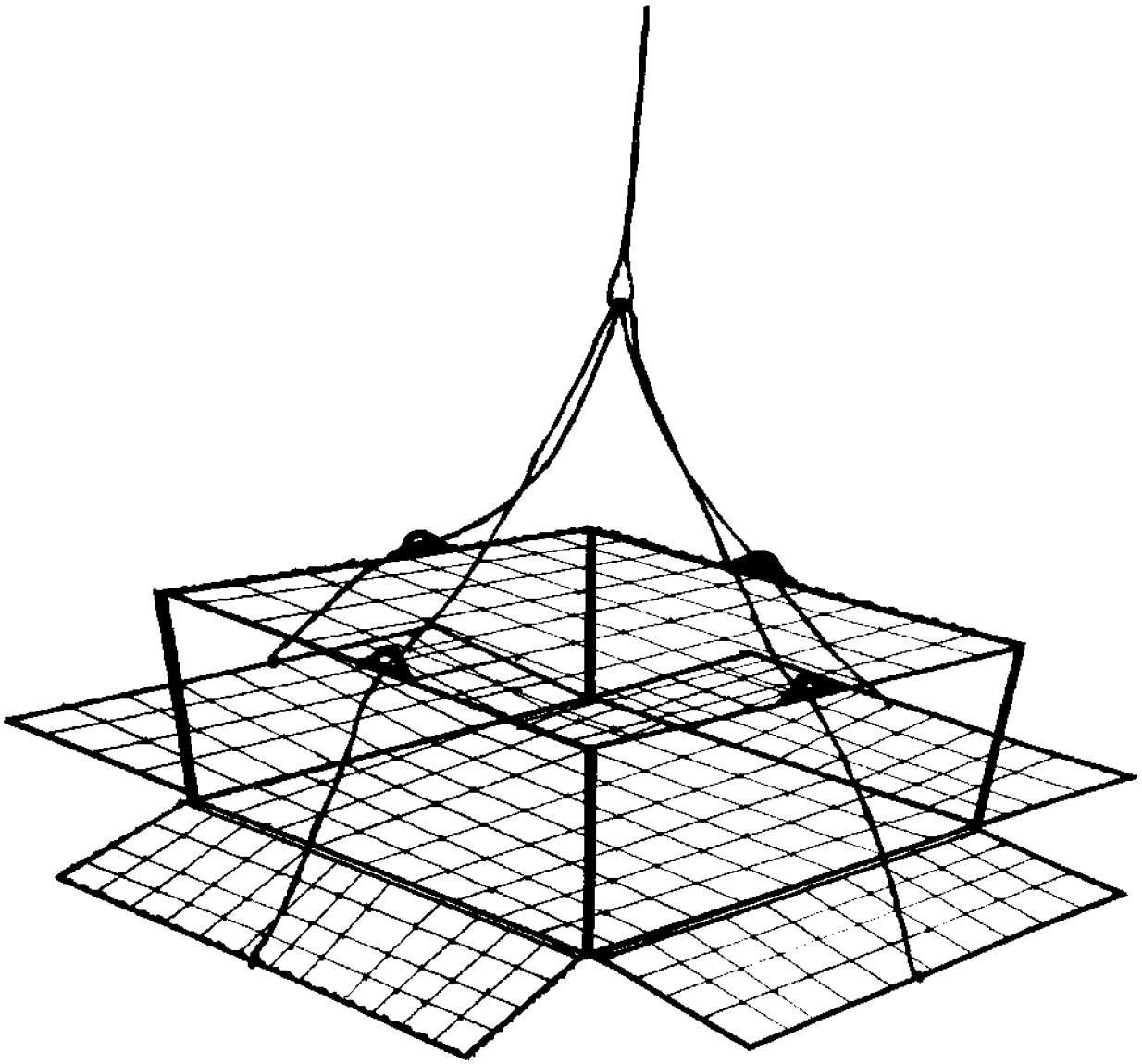

Figure 10. A sea urchin "trap" adapted from the East Coast blue crab trap. Dimensions about 3 ft by 3 ft by 1.5 ft.

There are two methods of diving for shallow subtidal species. One method is the use of high pressure tanks that are self-contained (scuba). The other method is the hookah setup. This is an air delivery arrangement where the diver uses a hose attached to a low pressure second stage regulator, then linked to a surface compressor.

Each method has distinct advantages. Scuba gear allows a high degree of mobility and is a more reliable system. However, tank filling can be time-consuming and out-of-water, the gear is very cumbersome. For this reason, we suggest that conventional tanks and regulators be used as a backup, and that hookah gear be used for day-to-day operations.

Hookah gear has the advantage of uninterrupted air supply (which makes planning for decompression less critical), a built-in lifeline system, and eliminates filling the tanks. Hookah also eliminates the cumbersome backpack equipment.

By far the most important part of the diving operation in Alaska is choosing the exposure suit. A good suit will enable the diver to remain under water for an extended period of time without fear of hypothermia or even numbing of the extremities. A good suit reduces post-dive fatigue which results from chilling.

Alaska dive shops indicate that the Unisuit by Poseidon Systems is a choice of many divers. Dry suits are sealed at the wrist, ankles, face and neck (Figure 11). This model is made of 1/4 in. neoprene, double backed with a nylon fabric to prevent ripping. All of the seams are double sewn inside and out. The suit material is similar to that of wet suits, but the construction is different. The seals in the extremities keep the body dry. Because of its water tightness, the suit can be used for buoyancy compensation, and the rear waterproof zipper entry is fairly easy to use.

The Unisuit with boots, mitts and helmet is expensive, about $600 to $700 new (1981 prices). A velour undergarmet is available for about $165, but long underwear should do almost as well. Masks run from $15 to $40 (full face masks: $78 to $115); fins from $20 to $75; snorkel from $5 to $10; lead weights (consider from 40 to 60 lbs of weight depending on size of diver) at about $1.75 per pound; weight belt at $15 to $20; and a knife between $20 and $50. It is also wise to invest in an underwater watch with a moveable bezel, a depth gauge, and if diving consistently below 33 ft, decompression meters (this should not take the place of a dive plan), underwater scratch pad, and waterproof dive tables.

Back-up regulators and tanks are available in a bewildering array of models and there is considerable latitude for individual preferences. Practically all regulators are now two stage, single hose, with the first stage separated from the second stage (at the mouthpiece) by a high pressure hose rated at 150 to 200 psi (Figure 12).

Regulators range from the very simple and cheap (about $60) to the very expensive (over $200), with just about every fixture one can think of to put on a regulator. A regulator that has wide applicability is one with a built-in reserve mechanism in the first stage. This eliminates the expensive J valve on all of the tanks used. Choose a first stage that has ports for an extra

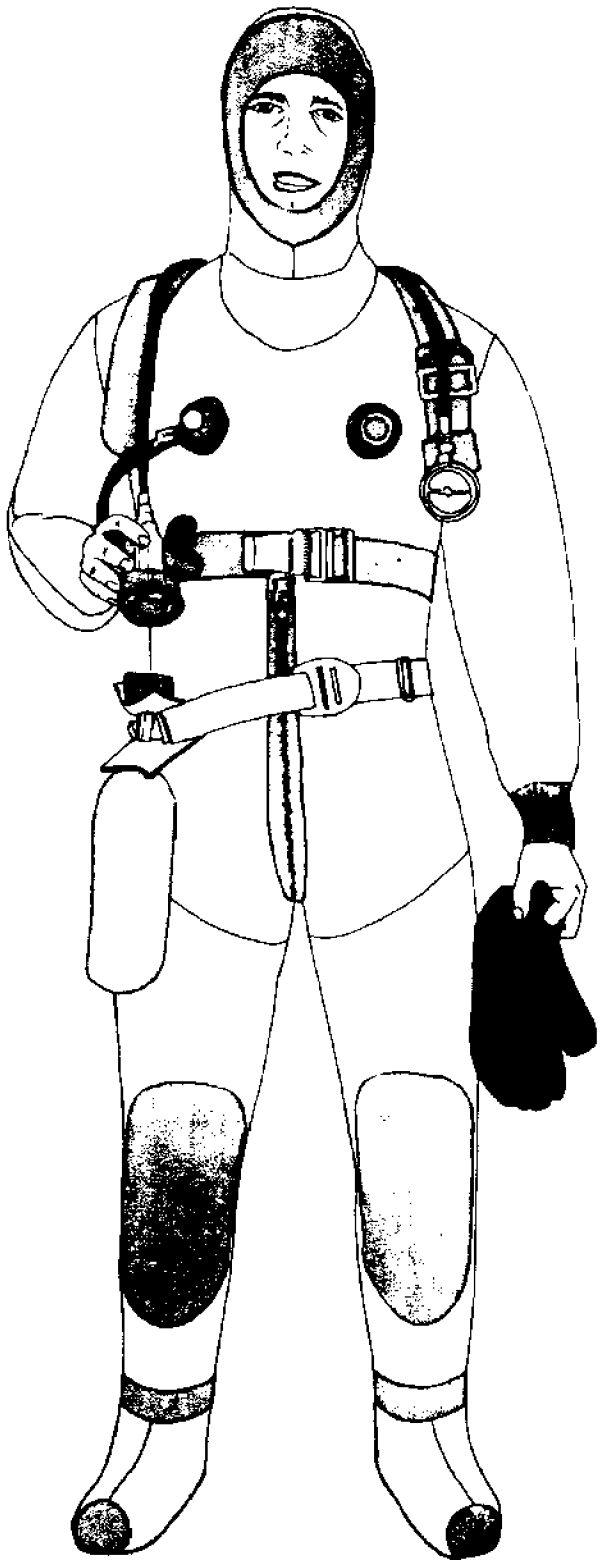

Figure 11. Exposure suit used for cold water diving. (After Poseidon Systems, U.S.A. 1978)

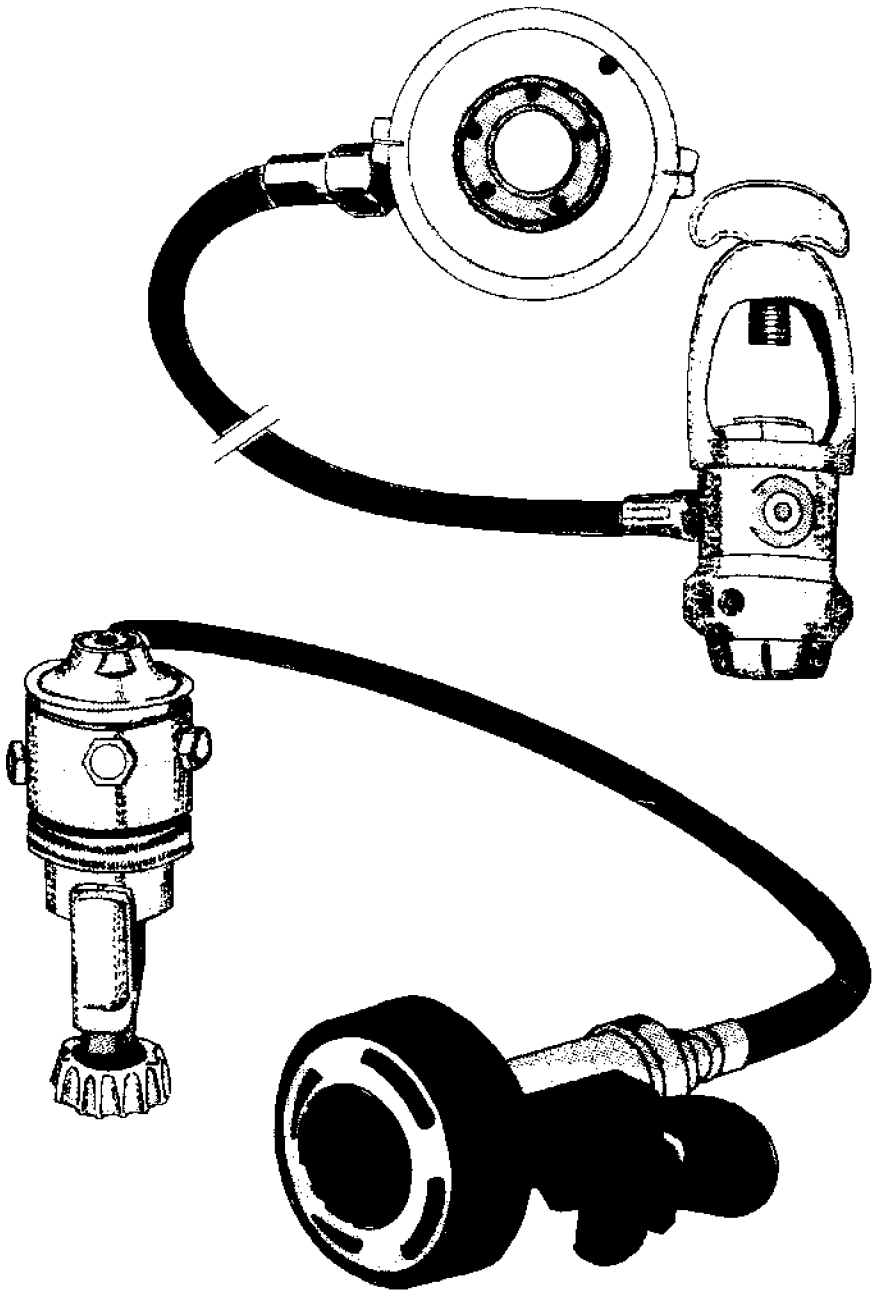

Figure 12. Two models of single hose regulator popular among divers. A: diaphragm for second stage mounted to the mouthpiece side, B: mounted directly in front of the mouthpiece. (After Poseidon Systems U.S.A. 1978, and Scubapro U.S.A. 1980)

second stage regulator and a high pressure port for a tank pressure gauge. Poseidon Systems, U.S. Divers, Scuba Pro, and Dacor, as well as other reputable companies all carry fine regulators that have these features. Examples of the modern two stage regulator are shown in Figure 12.

The hookah is flexible, and easily adapted to most compressors, if the air delivery is great enough and free of oil or combustion products. In a commercial hookah dive system, safety is the first consideration. For example, a normal diver will use about 2.5 cu ft of air per minute in depths up to 80 ft. To be safe, allow 3 to 4 cu ft of air per minute. This safety margin would help a rescue, if needed.

ITT produces compressors from $800 to $1,500 per unit depending on size. Other good compressors and compressor systems include those produced by Keene Engineering and Duo-fast Alaska. These companies produce oilless compressors, both with and without motors, over a great range of capacities. The choice of a compressor is closely related to the diving activity. Table 3 shows different compressor capacities and their ratings in terms of depth and number of divers it can support.

Back-up tanks are necessary in the event of hookah failure, or in the unlikely event that a diver is highly saturated and in need of decompression. There should be at least two tanks per person with 2,250 psi rating. Each tank, supplied with a K valve will cost about $160. Quick release backpacks can be expected to cost $25 to $70 depending on complexity. Both Poseidon Systems and Mako make portable compressor rigs for $2,000 to $2,500. Again, these are 1981 prices.

In addition to the diving gear, one will also need to reserve money for an extra hose and suit if the operation is to last more than four years. One should also devise a "send up" system so the diver will not have to constantly surface. A very good method is to supply the diver with a number of goodie bags with buoys and line. A goodie bag is filled, and a buoy is sent up attached to a line. The bag acts as (or has attached to it) an anchor which keeps the buoy from moving until the diver and tender can collect them. An example of this setup is shown in Figure 13.

Table 3. Compressor selection based on air displacement (CFM)

Air Displacement	10 to 50 feet				50 to 100 feet				Approximate cost
	1 Diver		2 Divers		1 Diver		2 Divers		
	Light Duty	Heavy Duty	Light Duty	Heavy Duty	Light Duty	Heavy Duty	Light Duty	Heavy Duty	
3.0 CFM									90.00 (with electric motor)
3.4 CFM									100.00 (without motor)
3.5 CFM									140.00 (without motor)
6.8 CFM									180.00 (without motor)
5 CFM									300.00 (without motor)
20 CFM									300.00 (without motor)

SOURCE: Keene Engineering, Inc 1979; Waszkiewicz 1979 personal communication; Duo-fast Alaska 1980.

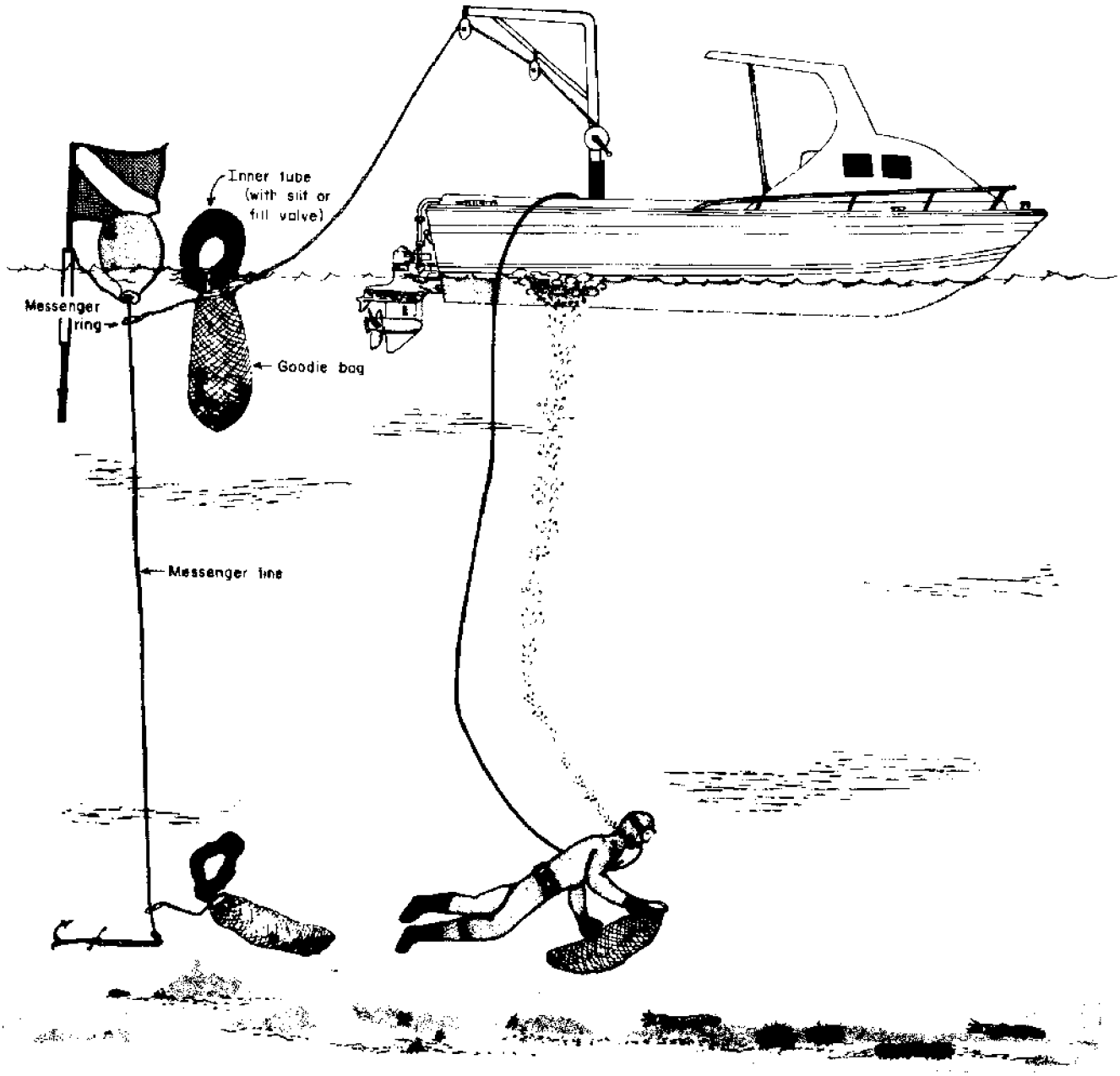

Figure 13. Suggested diving set up for benthic organisms that can be hand collected.

SEA URCHIN PROCESSING

INTRODUCTION

Sea urchin gonads are processed and shipped in a number of ways, but the major methods include:

1. Alive, in shell

2. Roe extraction:

    a. Fresh
    b. Frozen
    c. Baked on clam shells, shipped frozen or fresh
    d. Canned
    e. Bottled in alcohol
    f. Paste or paté

Fresh roe is popular in Europe as are urchin pastes and spreads. Demand for frozen roe in Europe is uncertain, however considerable work has been done in Japan on freezing roe.

PROCESSING LIVE URCHIN FOR EUROPE

The easiest processing technique is to box the live urchins and ship them by air, under refrigeration, to their destination. This is the method used by Canadian harvesters/processors to ship to France. Live urchins may be kept in cold running sea water without food for at least two weeks with no significant mortality or apparent decrease in roe quality or size (Bedard 1973; Miller and Bishop 1973).

If green sea urchins are stored in a holding tank, the water flow should be a minimum of .8 gallons/min/100 lbs of sea urchin (Miller and Mann 1972). Sea urchins are far better kept in cold moist air than stagnant sea water (Miller and Bishop 1973). They are susceptable to dehydration, which, in combination with heat, reduces survival time (Figure 14). Canadian researchers have found that shallow, waxed cardboard cartons (19 by 11 by 4 in.) lined with a polyethylene bag are suitable containers for air shipment of sea urchins out of water. Shipment is best made at 0°C (32°F). At this temperature, a large percentage of urchins should be able to right themselves within one hour of being placed on their backs. This test for livelihood, as well as sampling the roe, should indicate a product in good condition if shipped at these temperatures.

For urchins that naturally occur in warmer waters, a slightly warmer holding temperature may be called for. Although most urchins are susceptable to extreme heat or cold, short-term exposure to extremes during transit should not ruin a shipment.

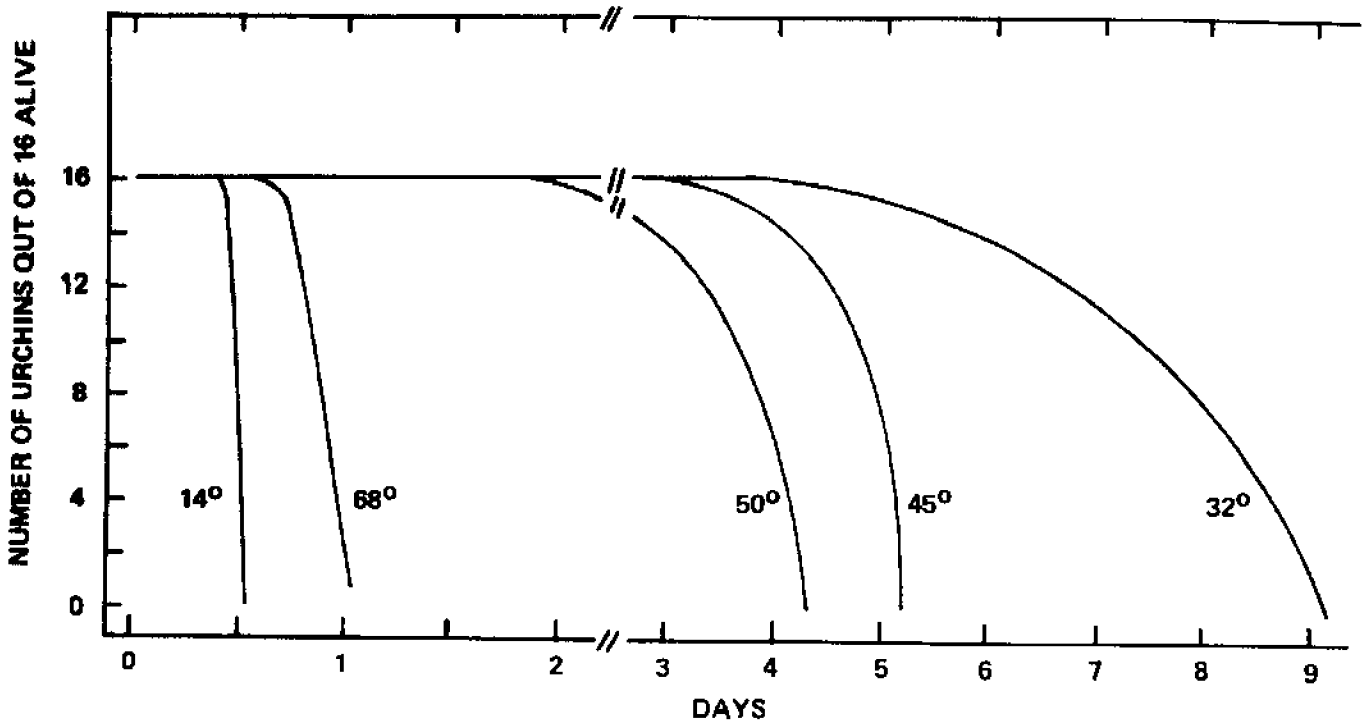

Figure 14. Survival time for sea urchins during flight at a range of temperatures (°F). (Miller and Bishop 1973)

PROCESSING FOR JAPAN

Fresh Roe

The most common method of roe processing is to extract it from the shell and package either fresh or frozen. Condiments are made from inferior grades of roe. Japanese processing companies introduced a sea urchin paste to France, Spain, Italy, and West Germany in 1969. Consumers in France, at least, have reacted favorably toward the new product.

Extracted urchin roe is also bottled in 95 percent alcohol and salt. This process, (especially on "bafun uni", a variety of sea urchin roe from California) produces a bright orange, sticky product (Kato 1972b). Broken pieces and off-color roe, are blended together with salt, flavoring, starch, and artificial coloring to produce a paste. It is bottled and attractively packaged. This paste serves as a condiment and ingredient in a variety of sauces common to Japanese cookery and as a spread or paté in continental European cooking.

Extracting roe from the shell is deceptively simple. The grading process however, makes extreme care necessary for a good product. Keep in mind that the emphasis is on appearance in the Oriental roe market. There are very few taste tests on the wholesale block. Therefore, pay particular attention to appearance.

When the live urchins are taken in for processing, the shell is cracked open with a heavy knife. An alternative method has been used by urchin processors in eastern Canada (Figure 15). A heavy knife attached to a backing plate. The urchin is placed in the "V" and the knife is drawn down. It is important that the shell be cracked without damaging the inside. Some processors specify cracking the shell lengthwise along the urchin's ambulacral grooves (Figure 16a). In other methods, the mouth parts are removed prior to cracking (Figure 16b). In some cases, this is the first step to a fairly efficient cracking method which calls for the removal of the mouth parts, the enlargement of the hole, and the removal of the gonads. In Japanese processing plants, the spines may be removed from the urchin before the shell is cracked by tumbling urchins in a loosely-woven bamboo basket.

Most sea urchins have five sections, with a gonad for each section, just along the inside wall of the shell (Figure 16c). The gonads are then scooped out with a spoon or spatula. The body cavity, once opened, will seem to be almost filled with roe. Despite this, the yield of roe is fairly low. In mature urchins under optimum feeding conditions, the gonads may be 20 to 25 percent of the body weight, although this yield will be considerably lower in most cases.

Tsuyuki and Razzell (1976) report that Japanese processors use sea urchin cracking machines, however, no further information is available. Sea urchin processing has been attempted in eastern Canada, and has been reported on by Kramer (1979). An example of a processing floor plan designed for a green sea urchin plant is shown in Figure 17.

After roe is removed, it is placed in colanders with smooth plastic or metal edges and bathed in cold sea water. This bath serves two purposes:

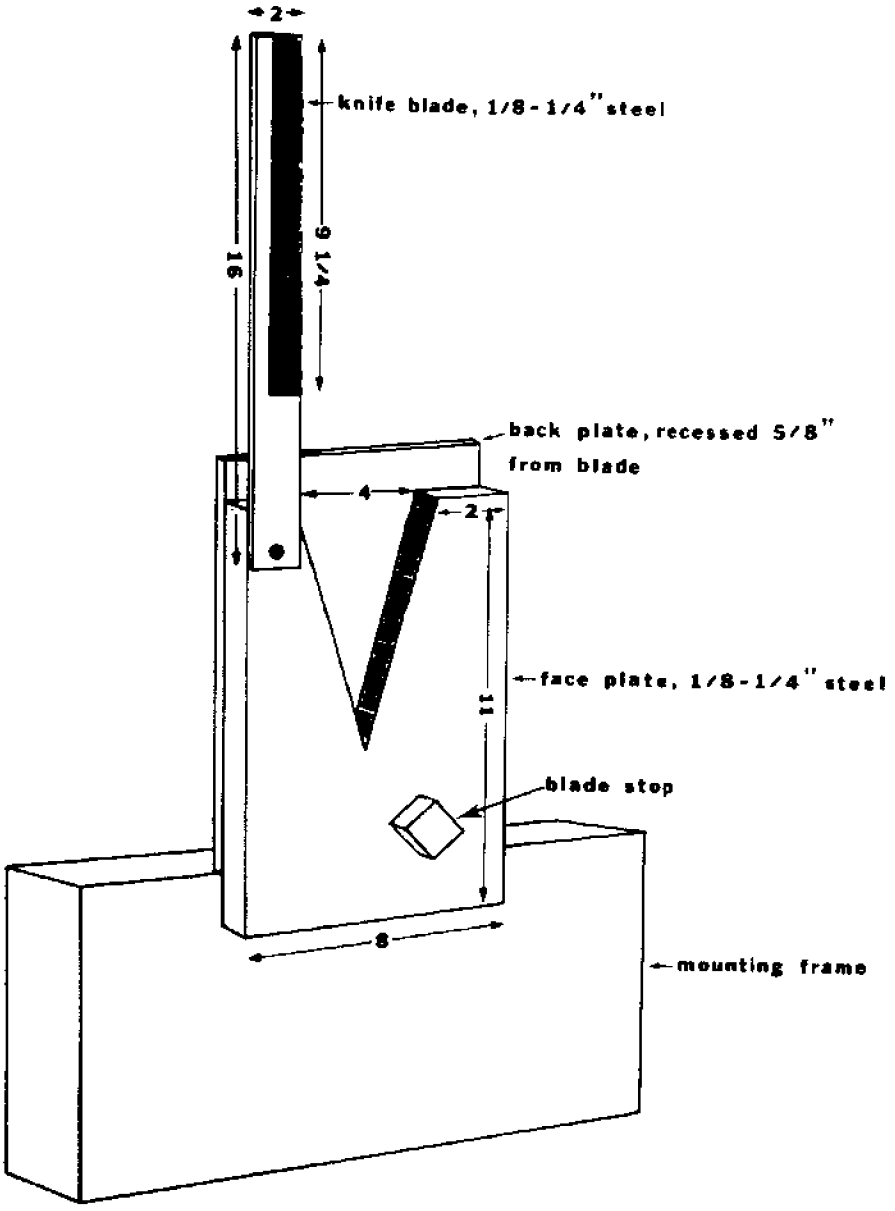

Figure 15. Design adaption of a hand operated green sea urchin cutting tool, after Kramer 1979.

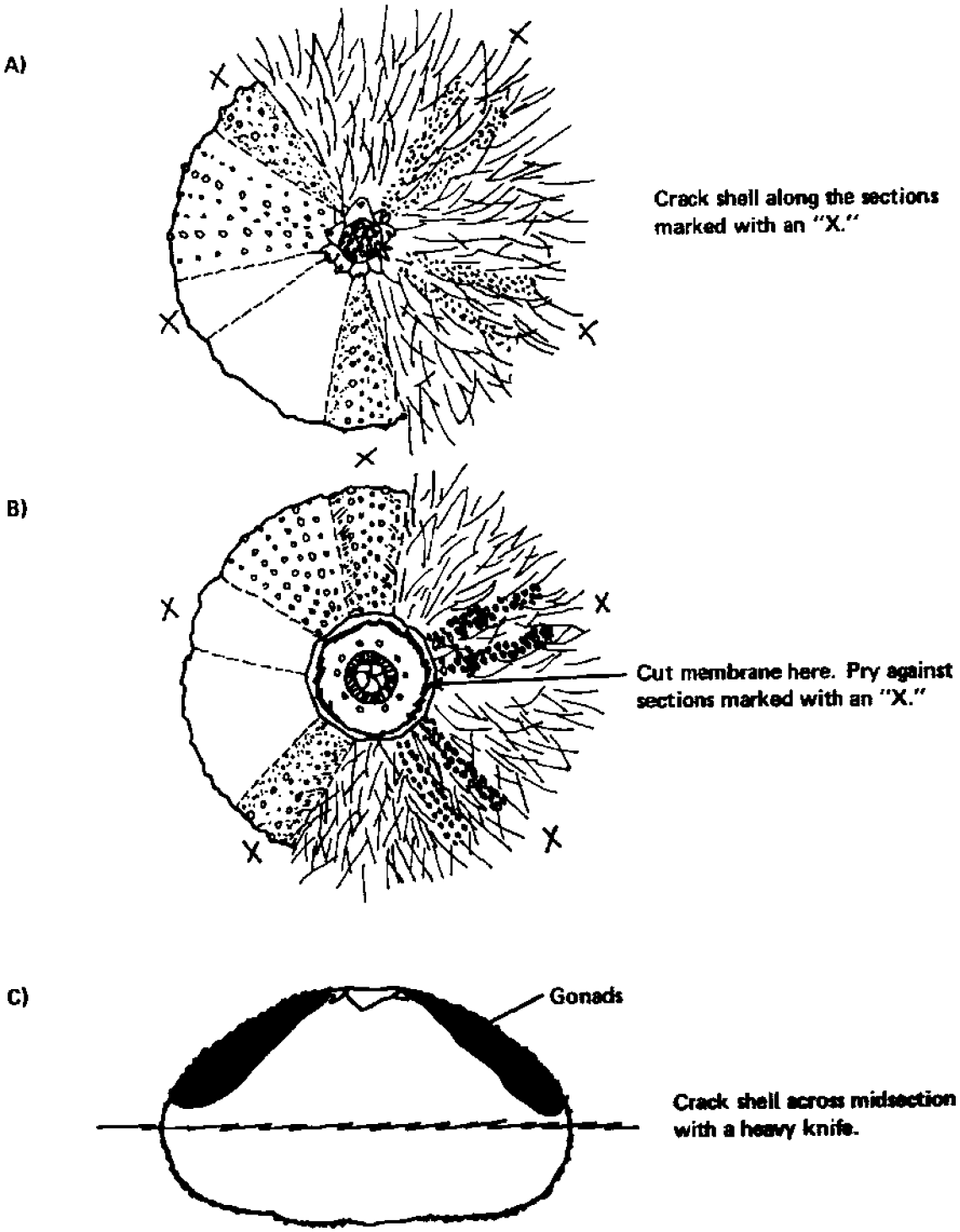

Figure 16. Three methods of removing sea urchin gonads.

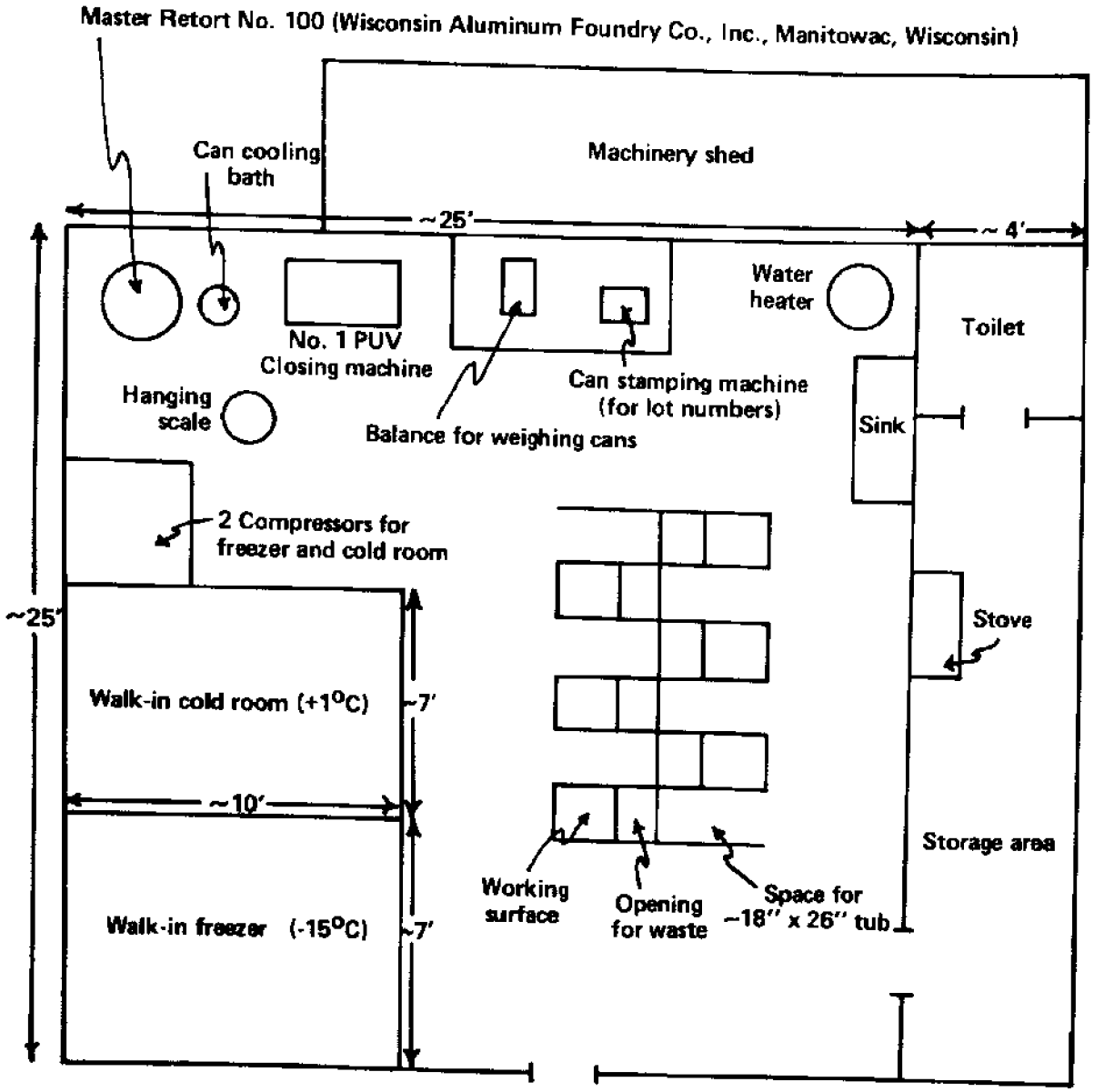

Figure 17. Floor plan of a sea urchin processing facility built at Bic, P.Q., by Robert Parent. (Kramer 1979)

1. Aids in removal of viscera and spine debris
2. Firms the roe sufficiently to further process the product

From this point on, several factors become important in processing roe:

1. Time
2. Temperature
3. Roe quality and keeping qualities

These factors determine the price paid for the product. Research in sea urchin roe processing has been leveled at these three factors: making the time factor less crucial, determining the best temperature for storage, and discerning roe quality at the harvester level.

One of the first problems in dealing with these factors is how to keep the fresh urchin roe from losing fluid, while maintaining a favorable flavor. There are a number of suggested chemical treatments, including applications of magnesium chloride solutions (Kato 1972b).

The other major problem with urchin roe is making the outer bag of the gonad tougher, so it can be handled without losing quality. This is where most experiments with chemical applications have taken place.

Processes using alum, and other ingredients have been tried to eliminate the draining roe/firmness problems. Too much alum in a solution used for rinsing will yield a product that is bitter. Some companies in British Columbia use a solution of .5 percent alum (Kramer and Nordin 1979). Tsuyuki and Razzell (1976) report rinses of .3 percent solutions, while Kato (1972) has reported a 2 percent solution used in Japan and Santa Barbara, California (Kramer and Nordin 1979). The Aomori Prefecture Fisheries Section (1968) reports that in Hokkaido a preparation of 2 percent burnt alum, 5 percent saltpeter, and .001 part of potassium sorbate has been used to control draining and to firm the roe as well as to maintain freshness. Sorbic acid or its sodium salt is also used for the same reason.

Citrate has been tested by Kramer and Nordin (1979) with fairly good flavor results. Solution strengths were as great as 10 percent and soak time was as long as 10 minutes without appreciable change in texture or flavor of the roe. Kato (1979) has also suggested citric acid as an alternative to alum.

Alcohol firms roe and is used in several Japanese preparations of bottled (or jarred) roe. However, alcohol substantially changes the fresh product, and makes it unfit for the fresh market.

Kramer and Nordin did a number of experiments with treatments to prevent problems with draining and to find firming methods which maintained quality. Their experiments were performed using the two species also common in Alaska: S. franciscanus and S. droebachiensis.

To reduce drainage, Kramer and Nordin used 10 minute stirred baths of the following buffer solutions:

1. Ten percent salt solution
2. Sodium acetate in 3.5 percent salt solution (.1 molar at pH 5.0)

3. Sodium phosphate in 3.5 percent salt solution (.1 molar at pH 6.5)
4. Sodium phosphate in 3.5 percent salt solution (.1 molar at pH 7.5)
5. Sodium borate in 3.5 percent salt solution (.1 molar at pH 9.0)

The only two preparations of potential commercial use are the sodium phosphate solutions.

The affects of alum, citrate and alcohol were recorded by a taste panel. Baths using solutions of .5 percent alum or less did not significantly affect roe taste. As the concentration increased, the texture of the roe improved. For concentrations greater than 1 percent, the roe became bitter.

Samples soaked in 10 percent citrate solutions for 10 minutes were rated as good. Alcohol soaks did not improve flavor or texture of the roe.

Grading

Roe is graded by color in Japan, although specimens of around 5 cm (1.96 in.) are preferred and roe is packed in trays according to size. Figures 18a and b show some color as well as size differences for male and female red (S. franciscanus) and green (S. droebachiensis) urchins. Note the brick red color of the male urchin roe (frame 1; A, B, C). Sample A is very near spawning stage. The darker samples are less preferred than the more golden ones.

Roe color is closely related to the fat content. Fat content determines how well the roe will keep. The most commonly accepted roe color is bright orange (Figure 18a and b). Reddish orange roe is also good, but has a higher fat content and will not keep as long in certain preparations. It is probably best to solve these color problems by placing roe of the same size and color in a tray. Packing lesser grade roe with best quality roe is also common.

Frozen Roe

One of the major problems of dealing in fresh sea urchin roe is that roe has to be consumed two to three days after it is extracted. This is only possible using air freight. Thus, food researchers have been testing different ways to freeze roe. That would eliminate dependence on air freight and increase product holding time.

The major problem with freezing the roe comes in thawing. Conventional freezing breaks down the granular consistency of the roe, making it soft. There can be pungent odors and bitter taste resulting from keto acid and aldehyde formation (Miwa 1975). Nordin and Kramer's report (1979) is the most comprehensive in English on roe freezing research.

The following methods were tried by authors before Nordin and Kramer:

1. Kato (1972a) describes dipping the roe in magnesium chloride and sea water.

2. Valladares and Pinilla (1970) froze roe using:

   a. Liquid nitrogen

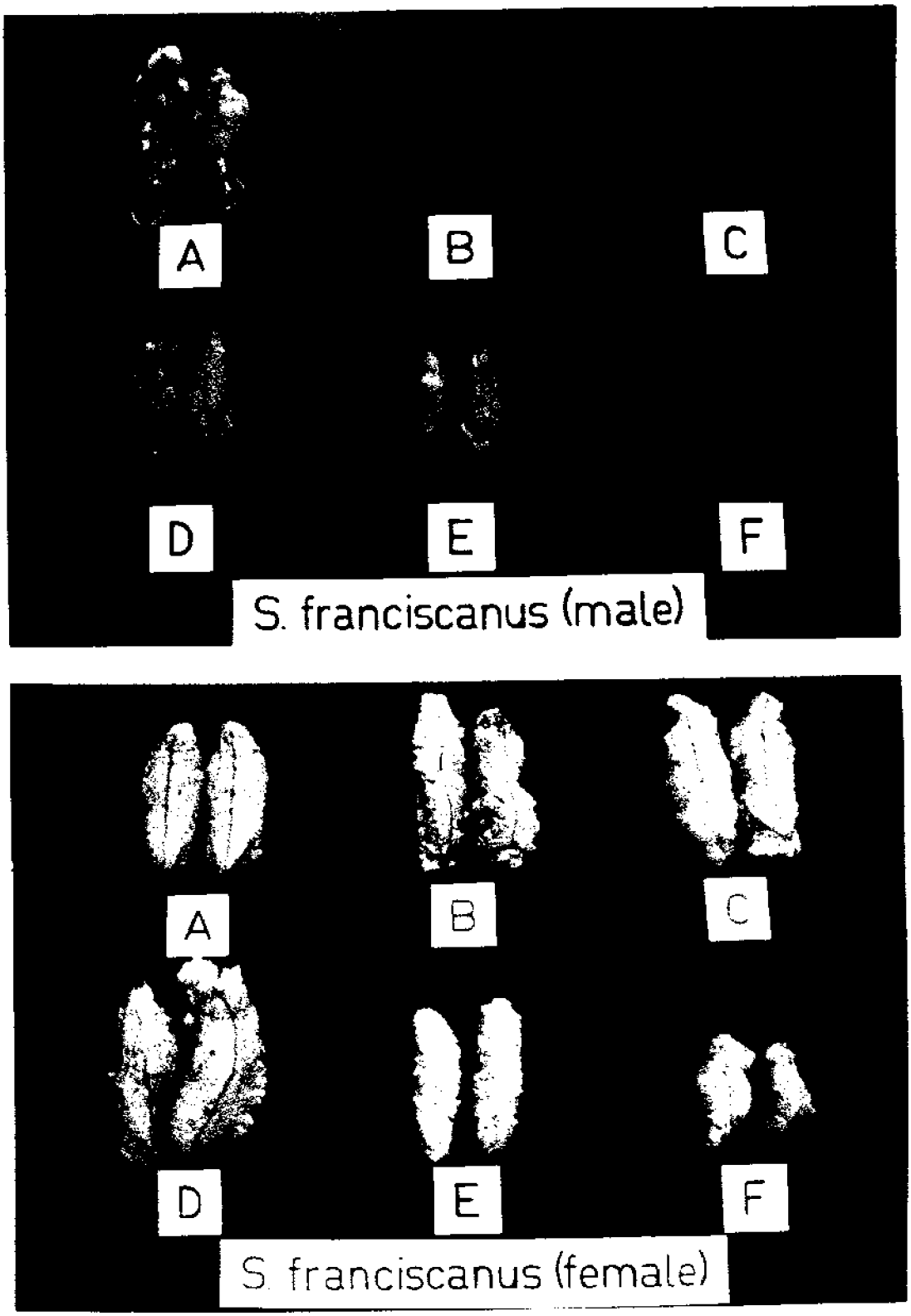

Figure 18a. Comparison of roe color and size for male (top A-F) and female (bottom A-F) red sea urchin (Strongylocentrotus franciscanus). Photo courtesy Don Kramer

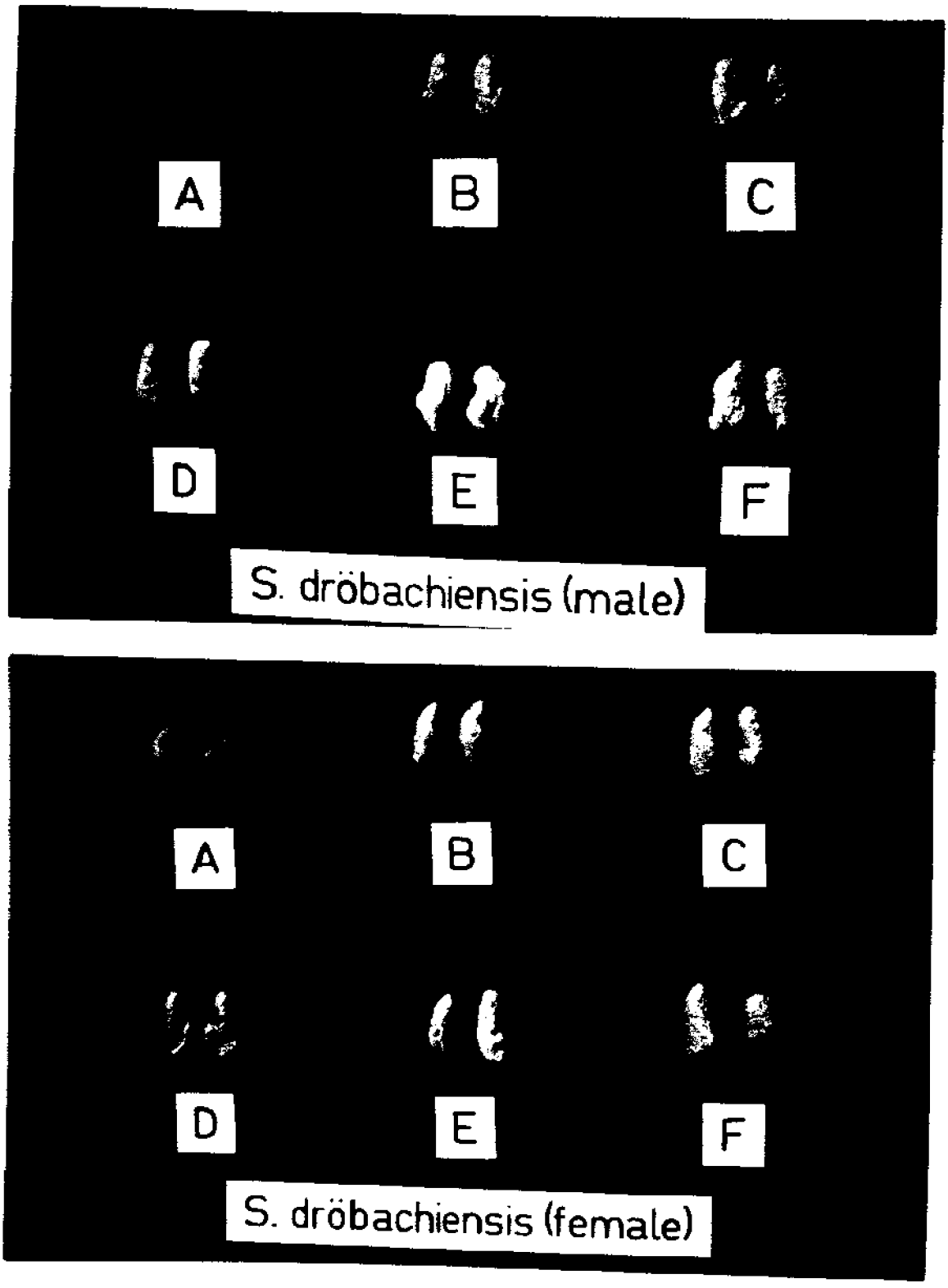

Figure 18b. Comparison of roe color and size for male (top A-F) and female (bottom A-F) green sea urchin (Strongylocentrotus droebachiensis). Photo courtesy Don Kramer

b. Plate-frozen and stored at -25°C for 90 days after a one-minute soak in 0.1 percent citric acid and 0.01 percent propyl gallate

Both methods yielded desired quality in the roe.

3. Miwa (1975) dipped roe in a) 5 percent salt solution, which decreased the moisture content and the drip problem on thawing, and b) 1M (molar solution) KC (potassium chloride) or 1M CaC_2 (calcium chloride). Miwa's final recommendations based on research performed are:

   a. Immerse very fresh sea urchin roe in a 5 percent table salt solution for 15 minutes.
   b. Drain to remove excess salt solution.
   c. Blot the roe on a sponge, filter paper or similar porous surface.
   d. Freeze quickly at -30°C.
   e. Thaw at 5°C.

4. Tanaka and Matsuda (1970) recommend a freeze-drying technique:

   a. Remove, clean, drain, and pack roe. After the roe is clean, keep it dry.
   b. Air blast freeze at -20°C or below.
   c. After the roe is homogeneously frozen, glaze with water in a cold environment (below freezing). The product can then be stored in a sealed cardboard box at about -25°C.
   d. When the time for marketing the roe arrives, then the roe glaze is removed by a freeze dryer immediately before thawing. This dehydrates the roe somewhat.
   e. Thaw the roe in still air at 5° to 10°C and market within 24 hours.

5. A similar method to the one above is suggested by Fukunaga (1974). The roe is added to a very cold low-pressure chamber and 10 percent of the water is extracted from the roe at .1 TORR (measure of vacuum in millimeters of Mercury: 1ML Hg = 1 TORR) during the freezing process. This is to minimize tissue damage during freezing. The roe is then dipped in clear water to form a glaze, packed in a paper box, wrapped in polyethylene film, and stored at -20°C. Just prior to marketing, the roe should be thawed at about 15°C.

Nordin and Kramer (1979) also tested different freezing methods with the following results.

Roe was drained thoroughly in a cold room overnight. Three layers of roe, separated by gauze were packed into a circular bamboo basket. A layer of salt was placed between each layer. The basket was placed over a plastic tub in a cold room for 6 to 12 hours, depending on roe size. The product remained cool or frozen. Salt prolonged its quality.

In another test, roe was cleaned and rinsed with a 3 percent salt solution. Male and female gonads were separated, placed in wooden boxes two layers deep, and frozen at -28°C for 7.5 months.

Roe was also brine soaked in 10 percent salt solution for 15 minutes and stored at -28°C for 7.5 months.

Salted roe obtained from the first process was placed in bags. Part were stored in a refrigerator at 2°C. The bottom roe layer was sampled after one day. The second layer was sampled after 1.5 months. The rest of the roe were stored in a freezer at -28°C. The bottom layer was sampled after one day and the middle layer after 1.5 months.

These samples were then served to a taste panel who rated the flavor, odor, and color: one (very poor) to five (excellent). Table 4 shows the results of these taste tests for each type of product. Even among a Japanese taste panel, the opinions on the quality of the roe varied a great deal. The only conclusive finding is that brine-rinsed and brine-soaked roe did not fare as well as the salted, frozen roe.

Baked Roe on Clam Shell

In this preparation method, the roe is washed in a solution of magnesium chloride and sea water to prevent dripping, then 70 grams of roe are placed on a clam shell and baked (Nordin and Kramer 1979). Similar methods are described by Kato (1972b).

Table 4. Ratings of sea urchin (S. franciscanus) under different methods of preparation

Sex of Gonads	Flavor Mean	Flavor Range	Flavor Number Panelists	Odor Mean	Odor Range	Odor Number Panelists	Color Mean	Color Range	Color Number Panelists
Brine rinse, less than one minute 3.5% salt solution, stored at -28°C for 7.5 months									
Male	3.3	1.5-4.3	6	3.2	1-5	6	3.2	2.7-4	6
Female	3.3	2-4.3	6	3.1	1-4	6	3.2	1-4.3	6
Both	3.3	1.5-4.3	6	3.2	1-5	6	3.2	1-4.3	6
Brine soak, 15 minutes in 10% salt solution, stored at -28°C for 7.5 months									
Male	3.1	2-4	6	3.0	1.5-5	6	2.9	2-3.5	6
Female	2.3	0.7-4	6	2.5	1-3.3	6	2.1	1-3	6
Both	2.7	0.7-4	6	2.7	1-5	6	2.5	1-3.5	6
Salted, refrigerated and stored for one day									
	3.9	3-5	8	3.3	2-4.3	8	2.9	2-4	8
1.5 months									
	2.4	1-4	8	3.3	1-5	8	3.0	2.3-4	8
Salted, frozen and stored for one day									
	3.7	2-5	7	3.4	2-4	7	2.6	2-3	7
1.5 months									
	4.2	3.3-5	8	3.1	1-4	6	3.3	2-4	8
3 months									
	3.7	2-5	10	3.8	2-5	9	3.3	2-5	10
6 months									
	3.1	2-4.3	7	3.9	3-5	7	4.0	3-4.7	7

SOURCE: Nordin and Kramer 1979.

THE ECONOMIC FEASIBILITY OF DIVER HARVESTING SEA URCHIN

In this section we will show you how to estimate your success in the urchin fishery. Using a "breakeven" analysis, you should be able to estimate the amount of money you will need to get into and operate in the fishery, the catch rate you will have to sustain, and the price you will have to receive for the urchin in order to avoid losing money in the fishery.

The "breakeven" point in any business is when the amount of money made (total revenue) is the same as the amount of money spent (total cost). In this analysis, if your final figure is negative, you will lose. If it is a zero, you will breakeven. If it is positive, you will make a profit, plus 15 percent on your investment. It will also allow you to see what things you will have to change in your operation in order to make a profit.

This analysis is for diver harvesting of urchin, because that is the most practical way to collect urchin for sale. The largest market for urchin is in Japan. Their buyers require a very high standard for urchin products. Diver harvesting assures the most careful handling possible.

This section consists of three parts: a discussion of some assumptions we have made about the urchin fishery; your estimates of stock abundance, catch rates, prices, operating costs and total revenues; and a comparison of your results with similar analyses we ran on 59 vessels in the salmon and herring fleet. Using the forms provided, you should be able to work through the analysis using your best estimates and a little math, and determine the best possible conditions under which to enter the fishery. At the end, you can compare your results with our results on similar boats, and get an idea of the high and low range of estimates.

If you do not wish to work through the analysis for yourself, follow the instructions under Comparing Your Results (pg.) for a boat in your size class with approximately the same costs. It might be helpful to skim through the analysis section if you are having trouble reading those tables.

At this point, skim the following forms and we'll begin with the first section, with Form 1, Assumptions.

ASSUMPTIONS

There is currently no consistently operating urchin fishery in Alaska. Therefore, we have no data from an actual fishery on which to base our estimates. Consequently we have used existing data to make the best possible estimates, based on current costs for the salmon and herring fleet, urchin abundance and distribution as indicated by the NMFS trawl surveys presented in Appendices A, B, and C, and the various catch rates and prices you are likely to receive for urchin. It is important to remember this is only an estimation and as such is only as dependable as the estimates you make on this form.

Under the first heading, Season Length, we have filled in all the blanks for you. We have assumed this to be an off-season fishery lasting four months

ASSUMPTIONS FORM 1

1. Season length

years	4
months	4
days	15
hours	5

2. Participation

A. Boat size

to 30 ft	
31 to 40 ft	
41 to 65 ft	

B. Crew

divers	
total crew	
crewshares	

C. Catch rate per diver

250 lbs/day		(1)
500 lbs/day		(2)
1,000 lbs/day		(3)
1,500 lbs/day		(4)

D. Price per pound

$.10/lb		(1)
.20/lb		(2)
.30/lb		(3)
.40/lb		(4)

E. Boat type

hand troll		(1)
power troll		(2)
gillnet		(3)
purse seine		(4)

TR	
NPV	

over four years for about half of each month. Because the maximum diving time is about five hours, that is the length of time per day spent fishing.

We have assumed that you will give the investment time to pay off, and planned a four-year fishery. You may alter these figures, but keep in mind these are the numbers we have used in our analysis when you get to that section of the report.

Under Participation, we have again made a few assumptions. For boat size, we made three size classes. Simply mark the one that applies to your operation. Under divers, we have assumed that boats to 30 ft will have one, boats 31 to 40 ft will have two, and boats 41 to 65 ft will have three. Total crew members would include all aboard, including the skipper. If the skipper is also a diver, include him in the diver count. The number of divers will be used to count the catch. The number of crew members will be used to calculate costs and crew shares. There are no one-man crews. Diving operations require at least two people: one diver and one tender. Under crewshares we have assumed that 80 percent of the profits will be divided among the crew and 20 percent will be paid to the boat.

There are several factors that can drastically affect your chances of success, and the next two items are among the biggest. There is really no way to know for sure what sort of catch rates and prices to expect until the fishery starts. Using what you know about the distribution and availability of urchin, the possibilities of finding buyers, and prices you are likely to receive, you must at this point make your best guess of which catch rates and prices to expect. If there is a great deal of interest in the fishery, you will have to take into account more competition for available stocks and buyers. Also, the affect of fishing on the urchin population is not known. Increased pressure could mean depressed stocks.

The numbers in parenthesis after your choice of catch rate and price will be used in the tables allowing you to compare your results with those of similar operations. For example, if you marked 500 lbs per day (2) and $.30 per lb (3), you would be interested in table column headings with 23 in them. A table heading TR23 would list beneath it total revenues (TR) for boats catching 500 lbs/diver/day and receiving $.30/lb. The table heading NPV23 would show net present value (NPV), how much money you would make or lose for those rates. Refer to Table 5 for a detailed explanation of these parenthetical numbers.

Finally, select the type of vessel you operate under Boat Type. These are not really important to your chances in the fishery, since our analysis indicates the type of boat doesn't affect catch. However, the number in parenthesis is the way boat types are referred to later. Let's assume a hypothetical case. The boat is a 40 ft hand troller, so it will have two divers. In this case, the skipper is not diving. We expect a 500 lb/day/diver catch rate and will get $.20 per pound for the urchin. The form will look like the one in Table 6.

From the instructions I know that I will be interested in results for boats between 31 and 40 ft long with total revenues and net present values listed under the headings TR22 and NPV22. Write your number for future reference in the box provided at the bottom of the sheet.

Table 5. Explanation of TR and NPV notations

TRØØ = Total revenue derived from the following combinations of catch rates and ex vessel prices.

	Catch Rate	Ex Vessel Price/lb		Catch Rate	Ex Vessel Price/lb		Catch Rate	Ex Vessel Price/lb
TR11	250 lbs.	$.10	TR21	500 lbs	$.10	TR31	1000 lbs.	$.10
TR12	250 lbs.	$.20	TR22	500 lbs.	$.20	TR32	1000 lbs.	$.20
TR13	250 lbs.	$.30	TR23	500 lbs.	$.30	TR33	1000 lbs.	$.30
TR14	250 lbs.	$.35	TR24	500 lbs.	$.35	TR34	1000 lbs.	$.35

	Catch Rate	Ex Vessel Price/lb
TR41	1500 lbs.	$.10
TR42	1500 lbs.	$.20
TR43	1500 lbs.	$.30
TR44	1500 lbs.	$.35

NPVØØ = Net present value, over four years derived from the following combinations of catch rates and ex vessel prices.

	Catch Rate	Ex Vessel Price/lb		Catch Rate	Ex Vessel Price/lb		Catch Rate	Ex Vessel Price/lb
NPV11	250 lbs.	$.10	NPV21	500 lbs.	$.10	NPV31	1000 lbs.	$.10
NPV12	250 lbs.	$.20	NPV22	500 lbs.	$.20	NPV32	1000 lbs.	$.20
NPV13	250 lbs.	$.30	NPV23	500 lbs.	$.30	NPV33	1000 lbs.	$.30
NPV14	250 lbs.	$.35	NPV24	500 lbs.	$.35	NPV34	1000 lbs.	$.35

	Catch Rate	Ex Vessel Price/lb
NPV41	1500 lbs.	$.10
NPV42	1500 lbs.	$.20
NPV43	1500 lbs.	$.30
NPV44	1500 lbs.	$.35

These variables are not listed on a case by case basis to preserve the anonymity of the respondents. Maximums and minimums could not be given for vessels from 46 to 65 feet.

Table 6. Assumptions form example

1.	Season length	years	4	
		months	4	
		days	15	
		hours	5	
2.	Participation			
	A. Boat size	to 30 ft.		
		31-40 ft.	x	
		41-65 ft.		
	B. Crew size	divers	2	
		total crew	3	
		crewshares	80% total revenue	
	C. Catch rate	250 lbs/diver/day		(1)
		500 lbs/diver/day	x	(2)
		1,000 lbs/diver/day		(3)
		1,500 lbs/diver/day		(4)
	D. Price per pound	$.10/lb		(1)
		$.20/lb	x	(2)
		$.30/lb		(3)
		$.35/lb		(4)
		TR	22	
		NPV	22	
	E. Boat type	hand troller		(1)
		power troll		(2)
		gillnetter		(3)
		purse seine		(4)
		TR	22	
		NPV	22	

Now move on to Total Revenue, form 2. From the formula at the bottom you will be able to tell how much you will make in the fishery. For items 1 and 2, use your answers from the assumption page. From our example, we see that the catch rate is 500 lbs/diver, and the price per pound is $.20. From the answers under assumptions, we also know that there will be 15 fishing days in each month, the season will last four months and we will have two divers. Now simply multiply the numbers together: as indicated in the example in Table 7.

At these rates, expected total revenue is $12,000.

Now, it is time to figure out how much it will cost to enter this fishery and operate it over the season. Use form 3, Total Operating Costs. Remember, we are assuming that you do not have to borrow money to get into the fishery. If you do, follow the special instructions for borrowers when you get to the net present value section.

Items 1 and 2 are the same as before. Items 3, 5, and 6 are estimates you must make based on your average usual costs. If you don't know how much you spend in these areas, we have included a table to help. Table 8 shows the range of answers we got when we polled the fleet for another study. You can use the mean values if you don't know your own. For those of you that know your cost, you might want to look at the table and compare your costs with the fleet average, high, and low responses. That way you can tell if your costs are rather low or high compared with other vessels your size.

To calculate your insurance cost per day, simply divide your cost by 365. The added insurance figure is 25 percent of your regular payment (.25 x regular payment). We have added this on to your regular cost to cover diver insurance.

Using the formula at the bottom, calculate your total operating costs. Our example boat looks like Table 9 when we use fleet averages for costs.

Now you should know the total operating cost and the total revenue for one season. Keep in mind that in order to make the most of your investment, you should fish for more than one season. This allows you to take into account appreciation of the investment, depreciation of the equipment, and possible increases in catch rate and price as your experience in the fishery increases. That brings us to the final section, form 4, Net Present Value.

Looking at the form, you can see that the components of net present value are fairly simple. You can also see that should your total operating costs or revenues change, your answer could be quite different.

Your answer from the equation will be positive if, based on your estimates, you will make money; it will be a zero if you breakeven; and it will be negative if you lose money. These figures are projections over a four-year involvement in the fishery. If your number is positive, it includes not only covering bills, payments to the crew, and payments to the boat, but also a 15 percent return on investment.

Fill in the blanks using your earlier answers. For the fixed cost referred to in items 1, 5 and 9, look at Tables 10, 11, and 12. Each of these show the

TOTAL REVENUE FORM 2

		VAR
1.	Catch rate per 5 hr dive day	_____ = A
2.	Price per pound	_____ = B
3.	Days fishing	_____ = 15
4.	Months fishing	_____ = 4
5.	Divers	_____ = D
	A x B x 15 x 4 x D	_____

Table 7. Total revenue form example

1.	Catch rate/day/diver	500 lbs = A
2.	Price/lb	$.20 = B
3.	Days fishing	15 = C
4.	Months fishing	4 = D
5.	Divers	2 = E

A x B x C x D x E = 500 x .20 x 15 x 4 x 2 = (100) x (60) x 2 = 6000 x 2 = 12,000

TOTAL OPERATING COST FORM 3

			VAR
1.	Days fished	_____	15
2.	Months fished	_____	4
3.	Daily fuel cost	_____	DFUELCST
4.	Daily food cost	_____	DFOODCST
5.	Daily other costs	_____	DOTHCST
6.	Daily insurance	_____	DINSUR
7.	Added insurance due to divers (.25 x regular insurance)	_____	ADDINSUR
8.	Fixed cost of diver outfitting	_____	C

15 x 4(DFUELCST + DFOODCST + DOTHCST + ADDINSUR) =

subtotal _____

.80 x [TR - 15 x 4(DFUELCST + DFOODCST + DOTHCST)] + C =

subtotal _____

Add the results

TC = _____

Table 8. Fleet average daily operating costs during the salmon and herring season[1]

Boats to 30 ft	Average	Minimum	Maximum
Days fished in season	28.20	8.00	90.00
Daily fuel consumption (gal)	28.45	30.00	16.6
Daily food cost (dollars)	27.8	25.00	20.00
Daily other costs (dollars)	17.76	0	35.1
Daily insurance costs (dollars)	22.93	0	15.55
Boats 31-45 ft			
Days fished in season	39.45	3.00	123.00
Daily fuel consumption (gal)	40.96	37.5	60.16
Daily food cost (dollars)	37.39	12.66	44.71
Daily other costs (dollars)	22.68	0	45.52
Daily insurance costs (dollars)	50.24	0	60.97
Boats 46-65 ft[2]			
Days fished in season	30.50		
Daily fuel consumption (gal)	213.11		
Daily food costs (dollars)	62.29		
Daily other costs (dollars)	34.42		
Daily insurance costs (dollars)	163.93		

[1]Figures do not reflect number of crew.

[2]Only averages were used since the analysis was based on two boats.

Table 9. Total operating cost form example

1.	Days fished	15	
2.	Months fished	4	
3.	Daily fuel cost	41.08	DFUELCST
4.	Daily food cost	37.39	DFOODCST
5.	Daily other costs	22.68	DOTHCST
6.	Daily insurance	50.25	DINSUR
7.	Added insurance	12.56	ADDINSR

Do the calculation in two parts:

A. 15x4 (DFUELCST + DFOODCST + DOTHCST) + DINSUR + ADDINSR =

60(41.08 + 37.39 + 22.68) + 62.81

60(101.15) + 62.81

6069 + 62.81 = Subtotal 6131

[1]B. .80 [Total Revenue 15x4 (41.08 + 37.39 + 22.68)]

.80 (12,000 - 6069) = Subtotal 5931

Add the subtotals: Total = 12,062

[1]In Section B, note that total revenues is multiplied by .80, representing the 80 percent crewshare assumed on Form 1.

NET PRESENT VALUE FORM 4

		VAR
Fixed cost of entering fishery (Tables 10, 11, 12)	____	C
Total revenue	____	
Total cost	____	
1.15^n	____	
Salvage value for diver budgets (Tables 10, 11, 12)	____	

$$= -C + \frac{TR-TC}{(1.15)^1} + \frac{TR-TC}{(1.15)^2} + \frac{TR-TC}{(1.15)^3} + \frac{TR-TC}{(1.15)^4} + S = \underline{\quad\quad}$$

Table 10. One diver budget

	New Cost	Total Capital Life	Annual Depre-ciation	Salvage Value End of 4 Years
Water Jet Assembly 1.5" outlet, 275 gallon/minute, high volume, low pressure impeller with industrial/commercial Briggs & Stratton 8 h.p. engine. One unit @ $465.00	$465.00	8 yrs.	.25	$190.46
Nozzle Assembly with shut-off valve One unit @ $40.00	40.00	8 yrs.	.25	16.39
Water Hose, 1.5" 200 ft. @ $.65/foot	130.00	5 yrs.	.40	33.84
Low pressure, second stage hookah regulator One unit @ $70.00	70.00	10 yrs.	.20	33.76
Back-up set Two back-up tanks (2250 PSI) fitted with k valves plus 1 two stage regulator with type "J" first stage, and pressure meter, plus one backpack. One set @ $600.00	600.00	10 yrs.	.20	289.35
Exposure Suit (Unisuit) Worn with protective outer clothing and well maintained One unit @ $700.00	700.00	4 yrs.	.50	138.27
Undergarment One unit @ $165.00	165.00	5 yrs.	.40	42.95
Full Face Masks Two units @ $78.00	156.00	4 yrs.	.50	30.82
Holding Boxes for Catch 24" x 18" x 12" 50/diver @ $8.00/crate	400.00	5 yrs.	.40	104.13

Table 10 (con't.)

	New Cost	Total Capital Life	Annual Depre-ciation	Salvage Value End of 4 Years
Messenger Line With 40" bouy and dive flags, 150', 1/2" polypropylene rope and 1 mushroom anchor One unit @ $70.00	$ 70.00	4 yrs.	.50	$ 13.83
Hookah Compressors & Assembly Keene Model 263-G belt drive with 3 h.p. Briggs & Stratton air displacement: 5 CFM @ 1 ATM or 3 CFM @ 100 PSI One unit @ 469.00 5 filters @ $115/piece	469.00 575.00	8 yrs.	.25	192.10 .00
Air Hose Keene AH1, yellow, floating 3/8" vinyl/nylon construction for use with 1/4" couplings. 200 feet @ $64.95/100 ft.	129.90	5 yrs.	.40	33.82
Fittings at Compressor & Regulator ends including Harnesses One unit @ $100.00	100.00	8 yrs.	.25	40.96
Davitt and Winch One unit @ $300.00	300.00	15 yrs.	.13	183.99
Catch Sacks (Goodie bags) Two bags/diver @ $25.00/bag	50.00	4 yrs.	.50	10.00
Mask, fins, snorkel weight belt, knife, basic & advance text (advanced text: U.S. Navy Dive Manual), water-proof dive tables & course tuition for diver training. One pkg @ $415.00	415.00			
TOTAL OUTLAY & SALVAGE VALUE	$4834.90			$1354.67

Table 11. Two diver budget

	New Cost	Total Capital Life	Annual Depre-ciation	Salvage Value End of 4 Years
Water Jet Assembly 1.5" outlet, 275 gallon/minute, high volume, low pressure impeller with industrial/commercial Briggs & Stratton 8 h.p. engine. One unit @ $465.00	$465.00	8 yrs.	.25	$190.46
Nozzle Assembly with shut-off valve Two unit @ $40.00	80.00	8 yrs.	.25	32.77
Water Hose, 1.5" 400 ft. @ $.65/foot	260.00	5 yrs.	.40	67.68
Low pressure, second stage hookah regulator Two unit @ $70.00	140.00	10 yrs.	.20	67.52
Back-up set Two back-up tanks (2250 PSI) fitted with k valves plus 1 two stage regulator with type "J" first stage, and pressure meter, plus one backpack. Two sets @ $600.00	1200.00	10 yrs.	.20	578.70
Exposure Suit (Unisuit) Worn with protective outer clothing and well maintained Two sets @ $700.00	1400.00	4 yrs.	.50	276.54
Undergarment Two unit @ $165.00	330.00	5 yrs.	.40	85.90
Full Face Masks Four units @ $78.00	312.00	4 yrs.	.50	61.63
Holding Boxes for Catch 24" x 18" x 12" 50/diver @ $8.00/crate	800.00	5 yrs.	.40	208.25

Table 11 (con't.)

	New Cost	Total Capital Life	Annual Depre-ciation	Salvage Value End of 4 Years
Messenger Line With 40" bouy and dive flags, 150', 1/2" polypropylene rope and 1 mushroom anchor Two unit @ $70.00	$140.00	4 yrs.	.50	$ 27.65
Hookah Compressors & Assembly Keene Model 265-6: 2 5 CFM compressors mounted to 5 h.p. Briggs & Stratton engine w/recoil starter One unit @ $799.00	799.00	8 yrs.	.25	327.27
5 filters @ $115/piece	575.00			.00
Air Hose Keene AH1, yellow, floating 3/8" vinyl/nylon construction for use with 1/4" couplings. 400 feet @ $64.95/100 ft.	259.50	5 yrs.	.40	67.63
Fittings at Compressor & Regulator ends including Harnesses Two unit @ $100.00	200.00	8 yrs.	.25	81.92
Davitt and Winch One unit @ $300.00	300.00	15 yrs.	.13	183.99
Catch Sacks (Goodie bags) Four bags/diver @ $25.00/bag	100.00	4 yrs.	.50	19.75
Mask, fins, snorkel weight belt, knife, basic & advance text (advanced text: U.S. Navy Dive Manual), waterproof dive tables & course tuition for diver training. Two pkg @ $415.00	830.00			
TOTAL OUTLAY & SALVAGE VALUE	$8190.80			$2277.66

Table 12. Three diver budget

	New Cost	Total Capital Life	Annual Depre-ciation	Salvage Value End of 4 Years
Water Jet Assembly 1.5" outlet, 275 gallon/minute, high volume, low pressure impeller with industrial/commercial Briggs & Stratton 8 h.p. engine. Two unit @ $465.00	$930.00	8 yrs.	.25	$389.93
Nozzle Assembly with shut-off valve Three unit @ $40.00	120.00	8 yrs.	.25	49.15
Water Hose, 1.5" 600 ft. @ $.65/foot	390.00	5 yrs.	.40	101.52
Low pressure, second stage hookah regulator Three unit @ $70.00	210.00	10 yrs.	.20	101.27
Back-up set Two back-up tanks (2250 PSI) fitted with k valves plus 1 two stage regulator with type "J" first stage, and pressure meter, plus one backpack. Three sets @ $600.00	1800.00	10 yrs.	.20	868.05
Exposure Suit (Unisuit) Worn with protective outer clothing and well maintained Three sets @ $700.00	2100.00	4 yrs.	.50	414.81
Undergarment Three unit @ $165.00	495.00	5 yrs.	.40	128.85
Full Face Masks Six units @ $78.00	468.00	4 yrs.	.50	92.44
Holding Boxes for Catch 24" x 18" x 12" 50/diver @ $8.00/crate	1200.00	5 yrs.	.40	312.37

Table 12 (con't.)

	New Cost	Total Capital Life	Annual Depre-ciation	Salvage Value End of 4 Years
Messenger Line With 40" bouy and dive flags, 150', 1/2" polypropylene rope and 1 mushroom anchor Three unit @ $70.00	$210.00	4 yrs.	.50	$ 41.48
Hookah Compressors & Assembly Keene Model 265-6: 2 5 CFM compressors mounted to 5 h.p. Briggs & Stratton engine w/recoil starter One unit @ $799.00	799.00	8 yrs.	.25	327.27
5 filters @ $115/piece	575.00			.00
Duo Fast oil free unit w/20 gallon tank driven by 6.25 h.p. Kohler Engine 4.5 CFM @ 50 PSI	550.00	8 yrs.	.25	225.28
5 filter @ $115/piece	575.00			.00
Air Hose Keene AH1, yellow, floating 3/8" vinyl/nylon construction for use with 1/4" couplings. 600 feet @ $64.95/100 ft.	390.00	5 yrs.	.40	101.44
Fittings at Compressor & Regulator ends including Harnesses Three unit @ $100.00	300.00	8 yrs.	.25	122.88
Davitt and Winch One unit @ $300.00	300.00	15 yrs.	.13	181.84
Catch Sacks (Goodie bags) Two bags/diver @ $25.00/bag	150.00	4 yrs.	.50	29.63
Mask, fins, snorkel weight belt, knife, basic & advance text (advanced text: U.S. Navy Dive Manual), waterproof dive tables & course tuition for diver training. Three pkg @ $415.00	1245.00			
TOTAL OUTLAY & SALVAGE VALUE	**$12807.00**			$3479.21

cost for outfitting divers in your operation. Table 10 is for one diver, Table 11 for two and Table 12 for three. This is what we consider to be the basic outfit, however, there is probably as much variety in diving gear as there is in fishing gear. You may be interested in other kinds or brands. You might also want to check these prices with a local dealer, since inflation has no doubt increased them. At the end of each table, we have totaled the amount required and estimated the salvage value of the equipment after four years. If you change the total amount, be sure to alter the salvage figure as well.

The 1.15^n in item 4 reflects net present value, the factor by which future returns on your present investment are discounted. The sum of all discounted returns over the four years represents the net present value. Net present value is a way to measure the value of investment. It will also tell you how much future returns on invested money are worth at the time you invest, and whether in the future those returns will compare favorably with other investments. Let's say you plan to invest $10,000 in urchin fishing and, as our analysis indicates, you will get a 15 percent return on investment if your calculated net present value is 0. That money will increase by $1,500 over the four years we have planned for investment. If you know that you can invest that same $10,000 in home improvements instead, and increase the resale value of the house by 20 percent, that $10,000 becomes worth $2,000 more. Since the home improvements might take only a year, you would have that money in less time than the 15 percent which requires four years of investment. The net present value of the $10,000 invested in the house is greater. In this case, home improvement is clearly the better investment.

If you borrowed money, you will also have to consider the cost of paying back the loan. You should double the net present value figure you get here in order to account for the loan.

Now substitute your figures into the formula at the bottom of the page. Finishing our example analysis looks like Table 13.

Follow the instructions in the following paragraphs for boats your size.

Vessels to 30 ft

We analyzed 15 boats in this size category. Table 14 shows cost information for each variable, just as your total cost section does. Locate a case with costs similar to yours.

Next, refer to the Participation section of your form. Locate the box you marked for catch rate and price per pound showing the numbers appearing to the right of the blanks. Tables 15, 16, 17, and 18 show total revenues (TR) and net present values (NPV). Find the table with your number in the column headings. For our example, that's Table 16, with TR22 and NPV22. Then compare your TR and NPV with that of the case you chose. This will give you an idea of what the low and high values for the analysis are.

Summary of Success

By looking at the total revenue and net present value figures, you can easily see that boats making money are catching at higher rates and receiving

Table 13. Net present value form example

1.	Fixed cost of entering the fishery	8190.80 (C)
2.	Total revenue	12,000 (TR)
3.	Total operating cost	12,062 (TC)
4.	1.15^n	1.15^n
5.	Salvage value	2277.66 (S)

$$NPV = -C + \frac{TR-TC}{1.15^1} + \frac{TR-TC}{1.15^2} + \frac{TR-TC}{1.15^3} + \frac{TR-TC}{1.15^4} + 2277.66;$$

$$8190.80 + \frac{62}{1.15^1} + \frac{62}{1.15^2} + \frac{62}{1.15^3} + \frac{-62}{1.15^4} + 2277.66 =$$

$$8190.80 + [-53.69 + -40.79 + -35.43 + -30.85] + 2277.66 =$$

$$-8190.80 - 160.56 + 2277.66 = \underline{-6073.70}$$

Table 14. Vessel operating costs for 15 boats to 30 ft long

CASE-N	BOATYP	BOATSZ	DFUELCST	DFOODCST	DOTHCST	ADDINSU
1	1.	30.	12.	17.	13.	169.
2	1.	30.	16.	6.	49.	0.
3	1.	30.	8.	3.	1.	83.
4	3.	30.	52.	17.	8.	0.
5	3.	30.	18.	9.	16.	200.
6	3.	30.	12.	3.	9.	0.
7	3.	30.	66.	12.	35.	200.
8	3.	30.	52.	12.	17.	350.
9	3.	30.	59.	20.	4.	137.
10	3.	30.	42.	6.	17.	213.
11	3.	30.	45.	17.	25.	238.
12	3.	30.	49.	5.	6.	250.
13	3.	30.	110.	22.	0.	175.
14	3.	30.	92.	17.	33.	238.
15	3.	30.	34.	8.	25.	175.

Table 15. Total revenues and net present values for boats to 30 ft long catching 250 lbs/diver/day and receiving $.10/lb, $.20/lb, $.30/lb, or $.35/lb

CASE-N	TR11	NPV11	TR12	NPV12	TR13	NPV13	TR14	NPV14
1	1500.	-5099.	3000.	-4242.	4500.	-3386.	5250.	-2957.
2	1500.	-5281.	3000.	-4424.	4500.	-3568.	5250.	-3139.
3	1500.	-3403.	3000.	-2546.	4500.	-1690.	5250.	-1261.
4	1500.	-5822.	3000.	-4966.	4500.	-4109.	5250.	-3681.
5	1500.	-4960.	3000.	-4103.	4500.	-3247.	5250.	-2819.
6	1500.	-3583.	3000.	-2726.	4500.	-1870.	5250.	-1442.
7	1500.	-7484.	3000.	-6627.	4500.	-5771.	5250.	-5343.
8	1500.	-6803.	3000.	-5946.	4500.	-5090.	5250.	-4661.
9	1500.	-6526.	3000.	-5669.	4500.	-4813.	5250.	-4384.
10	1500.	-5625.	3000.	-4768.	4500.	-3912.	5250.	-3483.
11	1500.	-6905.	3000.	-6048.	4500.	-5192.	5250.	-4763.
12	1500.	-5569.	3000.	-4712.	4500.	-3856.	5250.	-3427.
13	1500.	-8401.	3000.	-7545.	4500.	-6688.	5250.	-6260.
14	1500.	-8737.	3000.	-7880.	4500.	-7024.	5250.	-6596.
15	1500.	-5704.	3000.	-4848.	4500.	-3991.	5250.	-3563.

Table 16. Total revenues and net present values for boats to 30 ft long catching 500/lbs/diver/day and receiving $.10/lb, $.20/lb, $.30/lb, or $.35/lb

CASE-N	TR21	NPV21	TR22	NPV22	TR23	NPV23	TR24	NPV24
1	3000.	-4242.	6000.	-2529.	9000.	-816.	10500.	40.
2	3000.	-4424.	6000.	-2711.	9000.	-998.	10500.	-142.
3	3000.	-2546.	6000.	-833.	9000.	880.	10500.	1736.
4	3000.	-4966.	6000.	-3253.	9000.	-1540.	10500.	-683.
5	3000.	-4103.	6000.	-2390.	9000.	-677.	10500.	179.
6	3000.	-2726.	6000.	-1013.	9000.	700.	10500.	1556.
7	3000.	-6627.	6000.	-4914.	9000.	-3201.	10500.	-2345.
8	3000.	-5946.	6000.	-4233.	9000.	-2520.	10500.	-1664.
9	3000.	-5669.	6000.	-3956.	9000.	-2243.	10500.	-1387.
10	3000.	-4768.	6000.	-3055.	9000.	-1342.	10500.	-486.
11	3000.	-6048.	6000.	-4335.	9000.	-2622.	10500.	-1766.
12	3000.	-4712.	6000.	-2999.	9000.	-1286.	10500.	-430.
13	3000.	-7545.	6000.	-5832.	9000.	-4119.	10500.	-3262.
14	3000.	-7880.	6000.	-6167.	9000.	-4454.	10500.	-3598.
15	3000.	-4848.	6000.	-3135.	9000.	-1422.	10500.	-565.

Table 17. Total revenues and net present values for boats to 30 ft long catching 1,000/lbs/diver/day and receiving $.10/lb, $.20/lb, $.30/lb, or $.35/lb

CASE-N	TR31	NPV31	TR32	NPV32	TR33	NPV33	TR34	NPV34
1	6000.	-2529.	12000.	897.	18000.	4323.	21000.	6036.
2	6000.	-2711.	12000.	715.	18000.	4141.	21000.	5854.
3	6000.	-833.	12000.	2593.	18000.	6019.	21000.	7732.
4	6000.	-3253.	12000.	173.	18000.	3599.	21000.	5312.
5	6000.	-2390.	12000.	1036.	18000.	4462.	21000.	6175.
6	6000.	-1013.	12000.	2413.	18000.	5838.	21000.	7551.
7	6000.	-4914.	12000.	-1488.	18000.	1938.	21000.	3651.
8	6000.	-4233.	12000.	-807.	18000.	2619.	21000.	4332.
9	6000.	-3956.	12000.	-530.	18000.	2896.	21000.	4609.
10	6000.	-3055.	12000.	371.	18000.	3797.	21000.	5510.
11	6000.	-4335.	12000.	-909.	18000.	2517.	21000.	4230.
12	6000.	-2999.	12000.	427.	18000.	3853.	21000.	5566.
13	6000.	-5832.	12000.	-2406.	18000.	1020.	21000.	2733.
14	6000.	-6167.	12000.	-2741.	18000.	685.	21000.	2398.
15	6000.	-3135.	12000.	291.	18000.	3717.	21000.	5430.

Table 18. Total revenues and net present values for boats to 30 ft long catching 1,500/lbs/diver/day and receiving $.10/lb, $.20/lb, $.30/lb, or $.35/lb

CASE-N	TR41	NPV41	TR42	NPV42	TR43	NPV43	TR44	NPV44
1	9000.	-816.	18000.	4323.	27000.	9462.	31500.	12031.
2	9000.	-998.	18000.	4141.	27000.	9280.	31500.	11849.
3	9000.	880.	18000.	6019.	27000.	11158.	31500.	13727.
4	9000.	-1540.	18000.	3599.	27000.	8738.	31500.	11308.
5	9000.	-677.	18000.	4462.	27000.	9601.	31500.	12170.
6	9000.	700.	18000.	5838.	27000.	10977.	31500.	13547.
7	9000.	-3201.	18000.	1938.	27000.	7077.	31500.	9646.
8	9000.	-2520.	18000.	2619.	27000.	7758.	31500.	10327.
9	9000.	-2243.	18000.	2896.	27000.	8035.	31500.	10604.
10	9000.	-1342.	18000.	3797.	27000.	8936.	31500.	11505.
11	9000.	-2622.	18000.	2517.	27000.	7656.	31500.	10225.
12	9000.	-1286.	18000.	3853.	27000.	8992.	31500.	11561.
13	9000.	-4119.	18000.	1020.	27000.	6159.	31500.	8729.
14	9000.	-4454.	18000.	685.	27000.	5824.	31500.	8393.
15	9000.	-1422.	18000.	3717.	27000.	8856.	31500.	11426.

higher prices. By comparing the percentage of successful boats at each catch and price rate, this pattern becomes apparent.

Price Per Pound	% Success 250 lbs	% Success 500 lbs	% Success 1,000 lbs	% Success 1,500 lbs
$.10	0	0	0	13.3
.20	0	0	60	100
.30	0	13	100	100
.35	0	26.7	100	100

By looking at the tables, you can see the greatest loss is for case 14 at 250 lbs/day for $.10 per lb. The greatest profit is for case 6 at of the highest catch rate and price (44). Proportionally, the gillnetters (type 3) and the trollers (type 1) seem to do equally well.

Overall, case 3 is the most successful boat. A look at costs for that boat from Table 14 explains why: low fuel, food, and other costs. Case 14, the most consistent loser, has very high costs, making success more difficult.

Vessels 31 to 45 ft

We used 42 vessels, or cases, in this size class: two hand trollers, six trollers, 20 gillnetters, and 14 purse seiners. Turn to Table 19 and find a vessel with costs similar to yours. For an example, let's say case 21 resembles your costs.

Next, refer to the Participation section of your form and look at the choices you made for catch rates and price per pound. Use the numbers you listed in the box for Total Revenue (TR) and Net Present Value (NPV) to locate the table showing results for boats at that catch rate and price. For example, let's say you performed the analysis for 1,000 lbs/day (3) and expected $.20 per pound (2). You would look through Tables 20, 21, 22, and 23 to find the column headings TR32 and NPV32. Table 22 lists the results for TR32 and NPV32. Find case 21 in the first column and follow it over to the TR32 and NPV32 columns. We find a total revenue of $24,000 and a net present value of $6,360. Comparing this with your own figures should give you an idea of the range of your estimate.

General Summary of Results

By comparing the percentage of success in each category, we can see where the boats start to make money at each price and catch rate:

Price Per Pound	% Success 250 lbs	% Success 500 lbs	% Success 1,000 lbs	% Success 1,500 lbs
$.10	0	0	4.8	57.1
.20	0	4.8	71.4	95.2
.30	0	57.1	95.2	97.6
.35	0	66.7	95.2	97.6

From this, we can see that the earliest opportunity to make a profit comes at 500 lbs/diver/day and $.20 per pound. Even then the margin of success is

Table 19. Operating costs for 42 vessels from 31 to 45 ft long

CASE-N	BOATYP	BOATSZ	DFUELCST	DFOODCST	DOTHCST	ADDINSU
1	1.	3145.	10.	3.	0.	0.
2	1.	3145.	15.	4.	6.	120.
3	2.	3145.	14.	9.	6.	375.
4	2.	3145.	63.	5.	0.	750.
5	2.	3145.	12.	5.	0.	418.
6	2.	3145.	54.	1.	4.	250.
7	2.	3145.	24.	8.	3.	0.
8	2.	3145.	49.	7.	40.	1500.
9	3.	3145.	17.	4.	6.	188.
10	3.	3145.	74.	33.	33.	500.
11	3.	3145.	41.	10.	20.	75.
12	3.	3145.	52.	42.	156.	150.
13	3.	3145.	17.	14.	30.	138.
14	3.	3145.	51.	29.	67.	750.
15	3.	3145.	11.	7.	11.	0.
16	3.	3145.	23.	5.	23.	150.
17	3.	3145.	203.	42.	500.	875.
18	3.	3145.	7.	3.	12.	0.
19	3.	3145.	35.	1.	28.	188.
20	3.	3145.	51.	13.	10.	125.
21	3.	3145.	8.	4.	8.	150.
22	3.	3145.	58.	4.	48.	1000.
23	3.	3145.	45.	10.	0.	158.
24	3.	3145.	37.	9.	14.	0.
25	3.	3145.	36.	12.	7.	500.
26	3.	3145.	51.	6.	17.	750.
27	3.	3145.	63.	71.	0.	103.
28	3.	3145.	190.	24.	31.	188.
29	4.	3145.	10.	2.	8.	950.
30	4.	3145.	111.	4.	0.	0.
31	4.	3145.	23.	9.	111.	625.
32	4.	3145.	41.	8.	33.	473.
33	4.	3145.	29.	17.	11.	379.
34	4.	3145.	61.	9.	28.	525.
35	4.	3145.	38.	11.	8.	41.
36	4.	3145.	81.	14.	10.	1875.
37	4.	3145.	66.	17.	22.	1463.
38	4.	3145.	58.	14.	29.	1250.
39	4.	3145.	190.	21.	19.	1500.
40	4.	3145.	55.	3.	19.	425.
41	4.	3145.	52.	7.	6.	495.
42	4.	3145.	193.	25.	255.	1416.

Table 20. Total revenue and net present value for 42 vessels from 31 to 45 ft long catching 250 lbs/diver/day and receiving $.10/lb, $.20/lb, $.30/lb, or $.35 lb

CASE-N	TR11	NPV11	TR12	NPV12	TR13	NPV13	TR14	NPV14
1	3000.	-4890.	6000.	-3177.	9000.	-1464.	10500.	-607.
2	3000.	-5680.	6000.	-3967.	9000.	-2254.	10500.	-1397.
3	3000.	-6896.	6000.	-5183.	9000.	-3470.	10500.	-2614.
4	3000.	-9052.	6000.	-7339.	9000.	-5626.	10500.	-4770.
5	3000.	-6322.	6000.	-4609.	9000.	-2896.	10500.	-2040.
6	3000.	-7014.	6000.	-5301.	9000.	-3588.	10500.	-2732.
7	3000.	-5944.	6000.	-4231.	9000.	-2518.	10500.	-1661.
8	3000.	-12203.	6000.	-10490.	9000.	-8777.	10500.	-7921.
9	3000.	-5950.	6000.	-4237.	9000.	-2524.	10500.	-1667.
10	3000.	-12740.	6000.	-11027.	9000.	-9314.	10500.	-8457.
11	3000.	-7547.	6000.	-5834.	9000.	-4121.	10500.	-3264.
12	3000.	-16038.	6000.	-14325.	9000.	-12612.	10500.	-11756.
13	3000.	-7576.	6000.	-5863.	9000.	-4150.	10500.	-3293.
14	3000.	-13358.	6000.	-11645.	9000.	-9932.	10500.	-9075.
15	3000.	-5682.	6000.	-3969.	9000.	-2256.	10500.	-1399.
16	3000.	-6694.	6000.	-4981.	9000.	-3268.	10500.	-2411.
17	3000.	-35049.	6000.	-33336.	9000.	-31623.	10500.	-30766.
18	3000.	-5131.	6000.	-3418.	9000.	-1705.	10500.	-848.
19	3000.	-7015.	6000.	-5302.	9000.	-3589.	10500.	-2732.
20	3000.	-7919.	6000.	-6206.	9000.	-4493.	10500.	-3636.
21	3000.	-5631.	6000.	-3918.	9000.	-2205.	10500.	-1349.
22	3000.	-11036.	6000.	-9323.	9000.	-7610.	10500.	-6754.
23	3000.	-7208.	6000.	-5495.	9000.	-3782.	10500.	-2926.
24	3000.	-6863.	6000.	-5150.	9000.	-3437.	10500.	-2581.
25	3000.	-8335.	6000.	-6622.	9000.	-4909.	10500.	-4052.
26	3000.	-9218.	6000.	-7505.	9000.	-5792.	10500.	-4935.
27	3000.	-13991.	6000.	-12278.	9000.	-10565.	10500.	-9708.
28	3000.	-14816.	6000.	-13103.	9000.	-11390.	10500.	-10533.
29	3000.	-7767.	6000.	-6054.	9000.	-4341.	10500.	-3485.
30	3000.	-8442.	6000.	-6729.	9000.	-5016.	10500.	-4160.
31	3000.	-11476.	6000.	-9763.	9000.	-8050.	10500.	-7193.
32	3000.	-8935.	6000.	-7222.	9000.	-5509.	10500.	-4653.
33	3000.	-8426.	6000.	-6713.	9000.	-5000.	10500.	-4144.
34	3000.	-9680.	6000.	-7967.	9000.	-6254.	10500.	-5398.
35	3000.	-7049.	6000.	-5336.	9000.	-3623.	10500.	-2767.
36	3000.	-14151.	6000.	-12438.	9000.	-10725.	10500.	-9869.
37	3000.	-13172.	6000.	-11459.	9000.	-9746.	10500.	-8890.
38	3000.	-12198.	6000.	-10485.	9000.	-8772.	10500.	-7916.
39	3000.	-17740.	6000.	-16027.	9000.	-14314.	10500.	-13458.
40	3000.	-8215.	6000.	-6502.	9000.	-4789.	10500.	-3932.
41	3000.	-8268.	6000.	-6555.	9000.	-4842.	10500.	-3985.
42	3000.	-26189.	6000.	-24476.	9000.	-22763.	10500.	-21907.

Table 21. Total revenue and net present value for 42 vessels from 31 to 45 ft long catching 500 lbs/diver/day and receiving $.10/lb, $.20/lb, $.30/lb, or $.35/lb

CASE-N	TR21	NPV21	TR22	NPV22	TR23	NPV23	TR24	NPV24
1	6000.	-3177.	12000.	249.	18000.	3675.	21000.	5388.
2	6000.	-3967.	12000.	-541.	18000.	2885.	21000.	4598.
3	6000.	-5183.	12000.	-1757.	18000.	1669.	21000.	3382.
4	6000.	-7339.	12000.	-3913.	18000.	-487.	21000.	1226.
5	6000.	-4609.	12000.	-1193.	18000.	2243.	21000.	3956.
6	6000.	-5301.	12000.	-1875.	18000.	1551.	21000.	3264.
7	6000.	-4231.	12000.	-805.	18000.	2621.	21000.	4334.
8	6000.	-10490.	12000.	-7064.	18000.	-3638.	21000.	-1925.
9	6000.	-4237.	12000.	-811.	18000.	2615.	21000.	4328.
10	6000.	-11027.	12000.	-7601.	18000.	-4175.	21000.	-2462.
11	6000.	-5834.	12000.	-2408.	18000.	1018.	21000.	2731.
12	6000.	-14325.	12000.	-10899.	18000.	-7473.	21000.	-5760.
13	6000.	-5863.	12000.	-2437.	18000.	989.	21000.	2702.
14	6000.	-11645.	12000.	-8219.	18000.	-4793.	21000.	-3080.
15	6000.	-3969.	12000.	-543.	18000.	2883.	21000.	4596.
16	6000.	-4981.	12000.	-1555.	18000.	1871.	21000.	3584.
17	6000.	-33336.	12000.	-29910.	18000.	-26484.	21000.	-24771.
18	6000.	-3418.	12000.	8.	18000.	3434.	21000.	5147.
19	6000.	-5302.	12000.	-1876.	18000.	1550.	21000.	3263.
20	6000.	-6206.	12000.	-2780.	18000.	646.	21000.	2359.
21	6000.	-3918.	12000.	-492.	18000.	2934.	21000.	4647.
22	6000.	-9323.	12000.	-5897.	18000.	-2471.	21000.	-758.
23	6000.	-5495.	12000.	-2069.	18000.	1357.	21000.	3070.
24	6000.	-5150.	12000.	-1724.	18000.	1702.	21000.	3415.
25	6000.	-6622.	12000.	-3196.	18000.	230.	21000.	1943.
26	6000.	-7505.	12000.	-4079.	18000.	-653.	21000.	1060.
27	6000.	-12278.	12000.	-8852.	18000.	-5426.	21000.	-3713.
28	6000.	-13103.	12000.	-9677.	18000.	-6251.	21000.	-4538.
29	6000.	-6054.	12000.	-2628.	18000.	798.	21000.	2511.
30	6000.	-6729.	12000.	-3303.	18000.	123.	21000.	1836.
31	6000.	-9763.	12000.	-6337.	18000.	-2911.	21000.	-1198.
32	6000.	-7222.	12000.	-3796.	18000.	-370.	21000.	1343.
33	6000.	-6713.	12000.	-3287.	18000.	139.	21000.	1852.
34	6000.	-7967.	12000.	-4541.	18000.	-1115.	21000.	598.
35	6000.	-5336.	12000.	-1910.	18000.	1516.	21000.	3229.
36	6000.	-12438.	12000.	-9012.	18000.	-5586.	21000.	-3873.
37	6000.	-11459.	12000.	-8033.	18000.	-4607.	21000.	-2895.
38	6000.	-10485.	12000.	-7059.	18000.	-3633.	21000.	-1920.
39	6000.	-16027.	12000.	-12601.	18000.	-9175.	21000.	-7462.
40	6000.	-6502.	12000.	-3076.	18000.	350.	21000.	2063.
41	6000.	-6555.	12000.	-3129.	18000.	297.	21000.	2010.
42	6000.	-24476.	12000.	-21050.	18000.	-17624.	21000.	-15911.

Table 22. Total revenue and net present value for 42 vessels from 31 to 45 ft long catching 1,000 lbs/diver/day and receiving $.10/lb, $.20/lb, $.30/lb, or $.35/lb

CASE-N	TR31	NPV31	TR32	NPV32	TR33	NPV33	TV34	NPV34
1	12000.	249.	24000.	7101.	36000.	13953.	42000.	17379.
2	12000.	-541.	24000.	6311.	36000.	13163.	42000.	16589.
3	12000.	-1757.	24000.	5095.	36000.	11947.	42000.	15373.
4	12000.	-3913.	24000.	2939.	36000.	9791.	42000.	13217.
5	12000.	-1183.	24000.	5669.	36000.	12521.	42000.	15947.
6	12000.	-1875.	24000.	4977.	36000.	11829.	42000.	15255.
7	12000.	-805.	24000.	6047.	36000.	12899.	42000.	16325.
8	12000.	-7064.	24000.	-212.	36000.	6639.	42000.	10065.
9	12000.	-811.	24000.	6041.	36000.	12893.	42000.	16319.
10	12000.	-7601.	24000.	-749.	36000.	6103.	42000.	9529.
11	12000.	-2408.	24000.	4444.	36000.	11296.	42000.	14722.
12	12000.	-10899.	24000.	-4047.	36000.	2805.	42000.	6231.
13	12000.	-2437.	24000.	4415.	36000.	11267.	42000.	14693.
14	12000.	-8219.	24000.	-1367.	36000.	5495.	42000.	8911.
15	12000.	-543.	24000.	6309.	36000.	13161.	42000.	16587.
16	12000.	-1555.	24000.	5297.	36000.	12149.	42000.	15575.
17	12000.	-29910.	24000.	-23058.	36000.	-16206.	42000.	-12780.
18	12000.	8.	24000.	6860.	36000.	13712.	42000.	17138.
19	12000.	-1876.	24000.	4976.	36000.	11828.	42000.	15254.
20	12000.	-2780.	24000.	4072.	36000.	10924.	42000.	14350.
21	12000.	-492.	24000.	6360.	36000.	13212.	42000.	16638.
22	12000.	-5897.	24000.	955.	36000.	7807.	42000.	11233.
23	12000.	-2069.	24000.	4783.	36000.	11635.	42000.	15061.
24	12000.	-1724.	24000.	5128.	36000.	11980.	42000.	15406.
25	12000.	-3196.	24000.	3656.	36000.	10508.	42000.	13934.
26	12000.	-4079.	24000.	2773.	36000.	9625.	42000.	13051.
27	12000.	-8852.	24000.	-2000.	36000.	4852.	42000.	8278.
28	12000.	-9677.	24000.	-2825.	36000.	4027.	42000.	7453.
29	12000.	-2628.	24000.	4224.	36000.	11076.	42000.	14502.
30	12000.	-3303.	24000.	3549.	36000.	10400.	42000.	13826.
31	12000.	-6337.	24000.	515.	36000.	7367.	42000.	10793.
32	12000.	-3796.	24000.	3056.	36000.	9908.	42000.	13334.
33	12000.	-3287.	24000.	3565.	36000.	10417.	42000.	13843.
34	12000.	-4541.	24000.	2311.	36000.	9163.	42000.	12589.
35	12000.	-1910.	24000.	4942.	36000.	11794.	42000.	15220.
36	12000.	-9012.	24000.	-2160.	36000.	4692.	42000.	8118.
37	12000.	-8033.	24000.	-1182.	36000.	5670.	42000.	9096.
38	12000.	-7059.	24000.	-207.	36000.	6644.	42000.	10070.
39	12000.	-12601.	24000.	-5749.	36000.	1103.	42000.	4529.
40	12000.	-3076.	24000.	3776.	36000.	10628.	42000.	14054.
41	12000.	-3129.	24000.	3723.	36000.	10575.	42000.	14001.
42	12000.	-21050.	24000.	-14198.	36000.	-7346.	42000.	-3920.

Table 23. Total revenue and net present value for 42 vessels from 31 to 45 ft long catching 1,500 lbs/diver/day and receiving $.10/lb, $.20/lb, $.30/lb, or $.35 lb

CASE-N	TR41	NPV41	TR42	NPV42	TR43	NPV43	TR44	NPV44
1	18000.	3675.	36000.	13953.	54000.	24231.	63000.	29370.
2	18000.	2885.	36000.	13163.	54000.	23441.	63000.	28580.
3	18000.	1669.	36000.	11947.	54000.	22225.	63000.	27364.
4	18000.	-487.	36000.	9791.	54000.	20069.	63000.	25208.
5	18000.	2243.	36000.	12521.	54000.	22798.	63000.	27937.
6	18000.	1551.	36000.	11829.	54000.	22106.	63000.	27245.
7	18000.	2621.	36000.	12899.	54000.	23177.	63000.	28316.
8	18000.	-3638.	36000.	6639.	54000.	16917.	63000.	22056.
9	18000.	2615.	36000.	12893.	54000.	23171.	63000.	28310.
10	18000.	-4175.	36000.	6103.	54000.	16381.	63000.	21520.
11	18000.	1018.	36000.	11296.	54000.	21574.	63000.	26713.
12	18000.	-7473.	36000.	2805.	54000.	13083.	63000.	18222.
13	18000.	989.	36000.	11267.	54000.	21545.	63000.	26684.
14	18000.	-4793.	36000.	5485.	54000.	15763.	63000.	20902.
15	18000.	2883.	36000.	13161.	54000.	23439.	63000.	28578.
16	18000.	1871.	36000.	12149.	54000.	22427.	63000.	27566.
17	18000.	-26484.	36000.	-16206.	54000.	-5928.	63000.	-789.
18	18000.	3434.	36000.	13712.	54000.	23990.	63000.	29129.
19	18000.	1550.	36000.	11828.	54000.	22106.	63000.	27245.
20	18000.	646.	36000.	10924.	54000.	21202.	63000.	26341.
21	18000.	2934.	36000.	13212.	54000.	23490.	63000.	28629.
22	18000.	-2471.	36000.	7807.	54000.	18085.	63000.	23224.
23	18000.	1357.	36000.	11635.	54000.	21913.	63000.	27052.
24	18000.	1702.	36000.	11980.	54000.	22258.	63000.	27397.
25	18000.	230.	36000.	10508.	54000.	20786.	63000.	25925.
26	18000.	-653.	36000.	9625.	54000.	19903.	63000.	25042.
27	18000.	-5426.	36000.	4852.	54000.	15130.	63000.	20269.
28	18000.	-6251.	36000.	4027.	54000.	14305.	63000.	19444.
29	18000.	798.	36000.	11076.	54000.	21354.	63000.	26493.
30	18000.	123.	36000.	10400.	54000.	20678.	63000.	25817.
31	18000.	-2911.	36000.	7367.	54000.	17645.	63000.	22784.
32	18000.	-370.	36000.	9908.	54000.	20186.	63000.	25324.
33	18000.	139.	36000.	10417.	54000.	20695.	63000.	25834.
34	18000.	-1115.	36000.	9163.	54000.	19441.	63000.	24580.
35	18000.	1516.	36000.	11794.	54000.	22072.	63000.	27211.
36	18000.	-5586.	36000.	4692.	54000.	14970.	63000.	20109.
37	18000.	-4607.	36000.	5670.	54000.	15948.	63000.	21087.
38	18000.	-3633.	36000.	6644.	54000.	16922.	63000.	22061.
39	18000.	-9175.	36000.	1103.	54000.	11381.	63000.	16519.
40	18000.	350.	36000.	10628.	54000.	20906.	63000.	26045.
41	18000.	297.	36000.	10575.	54000.	20853.	63000.	25992.
42	18000.	-17624.	36000.	-7346.	54000.	2932.	63000.	8071.

quite small. We can also see, however, that once the 1,000 lbs/diver/day level is reached, success is much more likely. However, that is also probably an optimistic catch rate.

If we compare this to the similar table for boats to 30 ft, it appears that the 31 to 45 ft boats have a slightly better chance for success. It also means a greater risk because of the higher operating costs involved. You must be sure you can find large enough urchin populations to keep two divers busy. Note that vessel 1 did very well in this analysis and that vessel 17's results were consistently poor. If you look at Table 19 you can see that case 1 had very low costs, while vessel 17 had very high costs. Both are probably unrealistic estimates. This points up just how important those initial estimates are to the results.

Vessels 46 to 65 ft

There were only two cases in this size class. All results are located in Table 24. If your boat is in this class, select from the costs section of the table the boat which has costs similar to yours. Then look under the Participation section of your form and find the numbers you marked in the box reflecting your catch and price per pound. For example, if you expected 1,500 lbs/diver/day and to receive $.30 per pound, your box has 33 beside Total Revenue (TR) and Net Present Value (NPV). Now look for the column heading which shows the results for TR33 and NPV33 for the case you chose. Compare this with your own figures to get an idea of the range of your estimates.

By comparing the cases, you can see that positive NPV's don't appear until the catch rates reaches 1,000/diver/day and prices are at least $.30 per pound.

CONCLUSIONS

Based on this analysis several things should be clear:

1. Do not expect to make money in the first few seasons.

2. Do not invest in diver harvesting unless you can bring in more than 250 lbs/diver/day and get more than $.10 per pound for it.

3. Vessels 31 to 45 ft seem to have a small advantage over vessels of other sizes.

4. Any vessel can be reasonably sure of success with a catch rate over 500 lbs/diver/day and a price of $.20 per pound or more.

5. These results hold true for vessels with low- to mid-range operating costs.

Table 24. Operating costs, total revenue, and net present value for two vessels from 45 to 65 ft long, at all possible catch and price rates

CASE-N	BOATYP	BOATS?	DFUELCST	DFOODCST	DOTHCST	ADDINSU
1	4.	4665.	203.	5.	40.	2000.
2	4.	4665.	276.	35.	9.	500.

CASE-N	TR11	NPV11	TR12	NPV12	TR13	NPV13	TR14	NPV14
1	4500.	-21462.	9000.	-18893.	13500.	-16323.	15750.	-15038.
2	4500.	-22734.	9000.	-20165.	13500.	-17595.	15750.	-16310.

CASE-N	TR21	NPV21	TR22	NPV22	TR23	NPV23	TR24	NPV24
1	9000.	-18893.	18000.	-13754.	27000.	-8615.	31500.	-6045.
2	9000.	-20165.	18000.	-15026.	27000.	-9887.	31500.	-7317.

CASE-N	TR31	NPV31	TR32	NPV32	TR33	NPV33	TR34	NPV34
1	18000.	-13754.	36000.	-3476.	54000.	6802.	63000.	11941.
2	18000.	-15026.	36000.	-4748.	54000.	5530.	63000.	10669.

CASE-N	TR41	NPV41	TR42	NPV42	TR43	NPV43	TR44	NPV44
1	27000.	-8615.	54000.	6802.	81000.	22219.	94500.	29927.
2	27000.	-9887.	54000.	5530.	81000.	20947.	94500.	28655.

WORLD TRADE OF SEA URCHIN

Our summary of sea urchin world trade is based on responses we received to a questionnaire. Countries that might be interested in the sea urchin trade were determined by consulting United Nations statistics in the FAO's Yearbook of Fishery Statistics. Using data for 1976 and 1977, and an elimination process described in Appendix B, we selected a number of countries to contact. The questionnaire went not only to government agencies, but also to companies interested in sea urchin.

Details on how the questionnaire was developed and a copy of it are contained in Appendix B. Essentially, it asked for two types of information:

1. General and topical data including descriptions of the fishing industry, which sea urchin species they preferred, and descriptions of harvesting and processing techniques.
2. Marketing data, including import and export information, used to construct a model showing every relevant dealer on the world market. This model eventually included Warsaw Pact countries, not explicitly contacted during research.

Fisheries ministers in each country were contacted and asked to supply the following information:

1. Production and value of harvest (defined or landed catch) from 1974 to 1977
2. Import value for 1977 (or 1976, if 1977 not available)
3. Export value for 1977 (or 1976, if 1977 not available)
4. Trade barriers against the U.S. (tariff and non-tariff)
5. Names and addresses of importers that might be interested in U.S. trade

This information is more fully detailed in Appendix B.

Processors, wholesalers and brokers were then sent a questionnaire to determine:

1. Interest in species offered by U.S. catches
2. Desired harvesting techniques
3. Desired processing techniques
4. If they could be contacted by English-speaking businessmen
5. Specific quality control requirements
6. Price quotes, buyer terms

This is more entirely detailed in Appendices C and D.

1977 AND 1978 WORLD TRADE PICTURE FOR SEA URCHIN

The information in Appendix C (Import and Export Statistics for Countries Reporting Trade in Sea Urchin) has been summarized in Figure 19. In this trade diagram, an arrow pointing to a country indicates that it imports from the country where the arrow originates. A double arrow indicates a cross

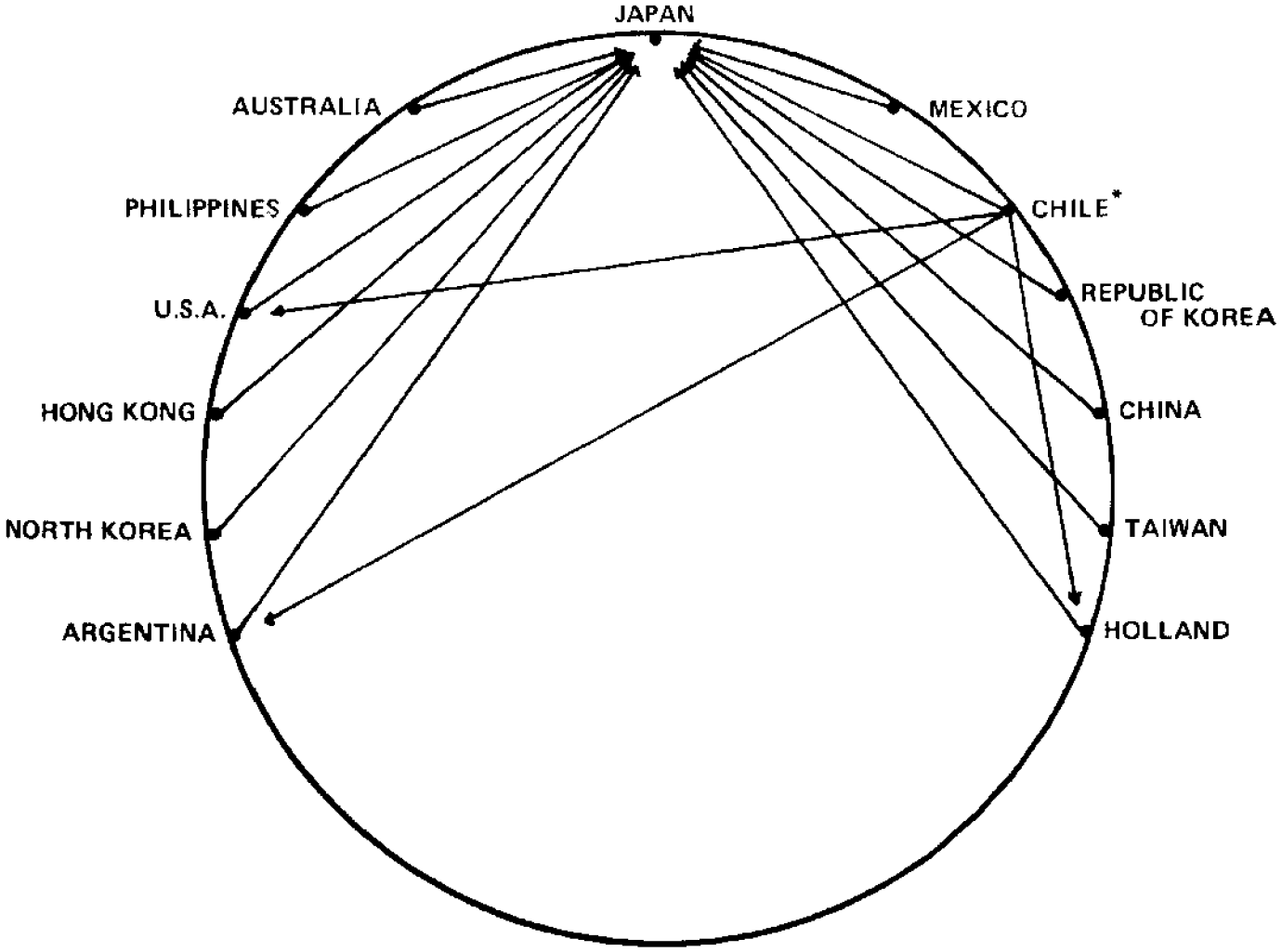

Figure 19. The 1977 world trade picture for sea urchin. (Republic of Korea 1977, Chile 1978, Japan 1977)

trade between two countries. Consult Appendix D to determine net trade flows.

Whole sea urchin and roe were traded by at least 13 countries in 1977 and 1978. There was a data gap from 1974 to 1977, so 1978 data was used to show trade flows. Note, the major importer of sea urchin is Japan. The major exporter, in terms of the number of countries it serves, is Chile.

Only one European country is shown in this trade diagram. Sales to Europe will be difficult. Shipping is difficult from most U.S. ports, especially those in the eastern states. Indications, at least for now, suggest Japan as the most likely target for exports.

COMPANIES THAT GAVE POSITIVE RESPONSES TO THE QUESTIONNAIRE

The extent of replies we received to the questionnaire varied. Some only answered the yes and no portion, others provided detailed information on processing and harvesting techniques. Because the form was rather complicated, we believe those who took the time to answer it were genuinely interested in possible U.S. trade.

Many of the companies contacted had not been considering an urchin market. Their responses were often based on equipment and species they were more familiar with. Tastes and preferences among the countries differed greatly.

The company names that follow are those which gave the most positive response to our inquiry. Each address is followed by a short synopsis of their responses.

Greece

Antiprosopeftilei, Ltd.
Commercial Company
Sofocleous 530
I.I. 113 Athens, GREECE
Tele: 311 420

This company expressed an interest in importing sea urchins. However, no other information was volunteered. Although they specified that they were not willing to deal in English, they answered an English questionnaire. This company is an import-export broker.

Veropoulos Bros S.A.
Orfeos & kifisson Str. - Egaleo
P.O. Box 878
Athens, GREECE

Although this company expressed an interest in sea urchins, no other information was volunteered. This group is a "multiple supermarket" (probably a chain). Inquiries in English and visits to the firm are invited.

France

Paul Coutau-Begarie
P.O. Box 22
33029 Bordeaux Cedex
FRANCE
Tele: (56) 48.55.17
Telex: 560 853 AFTOM

This import-export agent is interested in importing sea urchins. However, processing procedure and prices were not discussed. This firm will respond in English and welcomes visitors.

Japan

Co-Optrade Japan, Ltd.
Seikyo kaikan 1-13
4-Chome
Sendagaya
Shibuya-ku
Tokyo, JAPAN
ATTN: K. Miyasaka
Tele: 03-404-3251
Telex: J23393 COOPTR

This company, an independent processor, specified an interest in sea urchins. They are familiar with Strongylocentratus sp. and Polcherrimus sp. The company is willing to respond to requests in English and visitors are welcome. No other information was given.

Hori Trading Company
Mitsui Seimei Building
2-3 Ohtemachi
1-Chome
Chiyoda-ku
Tokyo 100 JAPAN
ATTN: Mitsuharu Fujisawa
Tele: (214) 3981

This company simply expressed an interest in importing sea urchin roe, but gave no further description of the processing methods, nor did they specify price. They insist on supplying technical advisors to oversee the processing if particular packers can give them more specific information. This company claims that it is impossible to give an accurate account of parameters that affect quality.

Ito Yokado Co., Ltd.
5 Sanbancho
Chiyodaku
Tokyo, JAPAN
ATTN: S. Yoshimura, Trading Department (FOOD)
Tele: 03-264-2111
Telex: 23841

This company is both an independent processor and an import-export brokerage. English is spoken and visitors are welcome. Although this firm is interested in sea urchins, no specifications were given.

Kanematsu Gosho Ltd.
Central P.O. Box No. 141
Tokyo, 100-91
JAPAN TGS5

This company is an independent processor of seafood. Apparently, they process a wide variety of products. The company gave detailed information on everything but price. The response was written in excellent English. Visitors are welcome. For sea urchins, the respondent admonishes that extreme care must be taken when handling the roe, as it loses shape easily. The roe cannot be frozen, but may be fresh or salted. This company requires a specialist to oversee the processing and packaging of the roe. The principal criteria for grading are color and taste.

Nichiryo, Ltd.
No. 2-1, 2-Chome
Azabudai, Minato-ku
Tokyo, JAPAN
ATTN: K. Tanaka, Marine Products Section
Tele: (03) 584-0151
Telex: 242-2136 NICRYOJ

Although this trading (import-export) company is principally interested in making contact with crab, salmon and herring producers, they are also interested in trading sea urchin roe. Their letter of response was written in English and they indicated that visitors were welcome to their office. No other information was given. One interesting observation that must be made is that in their cover letter, they disavowed any interest in sea urchin roe, although on the questionnaire they indicated that they were.

Spain

CONSAJA, S.A.
P.O. Box 12
San Vicente dela Barguera
Santander
SPAIN
ATTN: Sr. Angel Aja M.
Tele: 710100
Telex: 35.884 AJA E

This processor and import-export agency responded in Spanish but they are willing to communicate in English. They welcome visitors to their office in Santander. Although they indicated an interest in importing sea urchins, no further information was given.

Robert Gordon Maple
Apartado 596
Seville
SPAIN
ATTN: R.G. Maple
Tele: 61 41 47

Mr. Maple is an American doing business in Spain. He is interested in obtaining supplies and suppliers from Alaska for all types of seafood. Some of his comments are revealing. Mr. Maple offers to act as an intermediary for sellers in Alaska for establishing customers in the U.S., as well as Spain. He suggests that he has customers in France and Spain for sea urchins, and invites inquiries from potential sellers.

PACKAGING FRESH ROE FOR SHIPMENT

The traditional Japanese method of marketing uni wholesale is to pack each unit in small wooden or plastic trays (Figure 20). The bottom plate of the wood box is constructed to allow drainage. These trays are wrapped in plastic or cellophane and sold in lots of 13, according to the quality of the pack. The net weight of each tray in the lot is about 200 g. Sales are by auction in one of the many wholesale markets in Japan, but the most important market is the Tokyo Wholesale Market.

One of the most important features of marketing uni in Japan is appearance. This traditional method of packing uni sometimes does not yield the best product if the tray packaging has been done in the United States for export to Japan. Because the trays are not readily integrated, roe may shift in shipping. An alternative to this method is bulk packing. This has been suggested by Kato (1979) as a way to reduce labor costs of packing small trays, and maintaining the quality and appearance of the roe when it arrives upon the Japanese markets.

The bulk-pack container may be obtained from the following two companies:

Plasticon
1810 So. Santa Fe
Compton, California 90221

South West Foam Moulding
12162 So. Woodruff Avenue
Downey, California 90241

The container may simply be referred to as a "sea urchin shipping container." This bulk pack container has 15 trays to the pack and each tray holds about one kilogram. A block of jell-ice is placed at the bottom, then stacked in the box. Another block of jell-ice is added to the top and the whole container is then sealed. The full container weighs about 50 lbs. This can be air freighted to Japan so that the product may arrive for the next day of trading. The total trip time from Anchorage should take between eight and ten hours.

SUMMARY

The two principal methods of urchin processing are boxing live urchins for shipping and roe extraction. The fisherman and processor are likely to be only peripherally involved in preparing specialty products, unless there is some sort of quality control by the buyer.

However, one major problem remains. Market demand in Japan and France is seasonal. In Japan, for example, summer is the poorest time of the year to export sea urchin roe. The price of roe plummets because of Japan's own production increases (Kato 1979). Harvesters and processors in Alaska

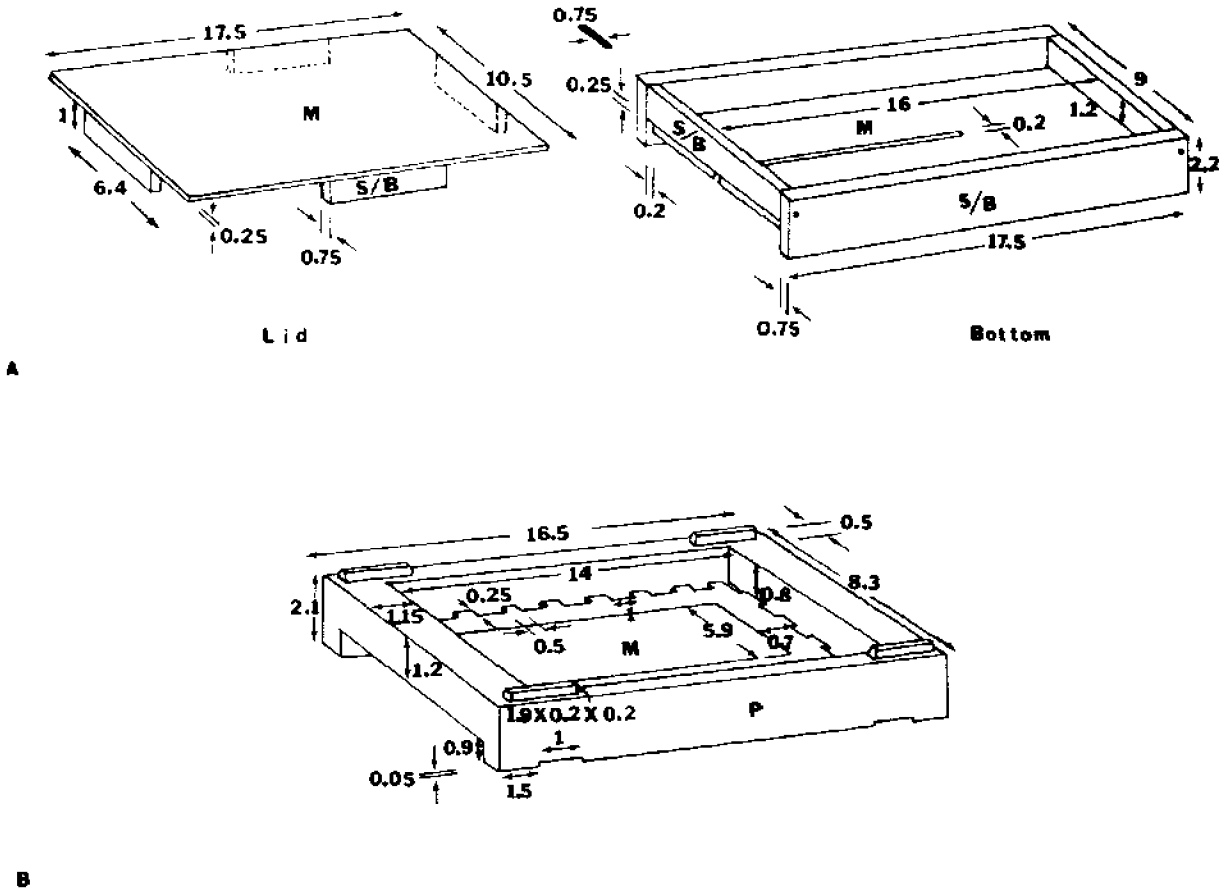

Figure 20. Typical sea urchin packing cartons with measurements (cm). A: box with lid and bottom, used by British Columbian and Japanese companies; B: box used in Japan to pack fresh roe. (Kramer and Nordin 1979)

should be active during the colder months. However, harvesting may be hampered due to weather.

Another factor to be considered is that roe extraction is a highly labor-intensive operation. An adequate supply of processing workers may present a problem in some Alaskan communities during the winter months. On the other hand, development of a sea urchin fishery could contribute to the development of a year-round stable labor force in Alaskan seafood processing. In any case, the labor cost is a prime factor in economic feasibility considerations related to sea urchin processing (Earl 1979).

SHIPPING THE PRODUCT

Surface Shipping

Surface shipping companies in Alaska indicate that there are only two specific routes that operate continuously: Alaska to Seattle and Alaska to Tokyo. This makes it difficult to estimate freight rates and routes without specific product weight, destination and frequency of shipment. Those interested in shipping information should contact shipping companies with specific information for estimates. The two major surface shippers in Alaska are American President Lines and Sea-Land, Inc. Some specific information on freight rates and packaging is included in Appendix H.

Neither of these companies has much experience shipping from Alaska to foreign countries other than Japan and Korea. Surface shipment to Europe has offered little incentive in the past because customer interest has been small. If shipping through an Alaskan company is possible, there are three things to consider:

1. Almost all frozen products going to Europe will go through Seattle. Another alternative is to ship by rail to the East Coast from Prince Rupert.
2. Companies which ship from the West Coast to Europe are almost exclusively California-based.
3. Truck and rail shipping routes to the East Coast are well established. From eastern ports, products can be placed on ships for travel to Europe.

Air Freight

Air freighting perishable foods is more expensive but may be the best way to insure product quality. Before deciding on how to send products, the following questions should be considered.[2]

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[2]The section on air freighting was developed after contacting representatives from Western Airlines, Japan Airlines, Northwest Orient Airlines, Flying Tigers, Air France and Scandinavian Airline System. Publications by Western Airlines, the Air Transport Association of America (1971) and the International Chamber of Commerce (1974) also proved useful.

1. How perishable is the commodity?

2. How valuable, by weight, is the commodity? Air freight rates are often quite high per pound, especially for small non-containerized shipments. If the CIF (customs, insurance, freight) quote agreed on by the buyer and seller is not substantial, the shipper may lose money on the margin to shipping costs.

3. What are the holding costs of the product? Because seafood is highly perishable and because finance charges on money lent to cover the cost of a transaction is often high in Alaska, the cost of handling and storage can be prohibitive.

4. How predictable is demand for the product? Successful trade with foreign countries requires assurance of a steady demand in large volume for a product. With a new or volatile consumer market, air freight may be a good alternative to surface transportation.

5. What is the total cost of distribution? The Air Transport Association of America (1971) suggests the following elements be considered:

    a. Transportation charges
    b. Cost of capital tied up in inventory
    c. Warehousing expense
    d. Packaging
    e. Insurance (considerably higher for perishable items, estimated at two times the cost for nonperishables)
    f. Spoilage losses
    g. Theft losses
    h. Inventory taxes

In addition, the backhaul charges must be considered, especially if one's own containers are being used. Most airlines will help a shipper determine the cheapest, most efficient way to send items. In most cases, they will also tell a shipper when air freight is too expensive.

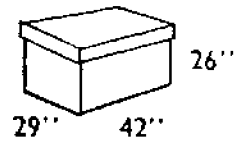
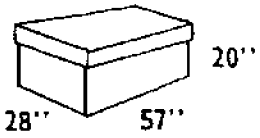
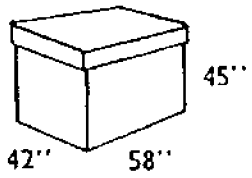
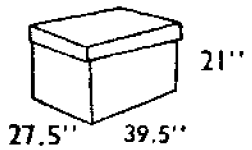
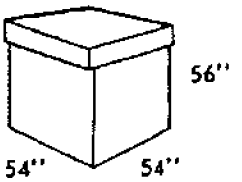
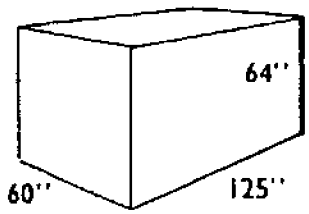
Packaging

Once method of transportation is determined, packaging should be considered. There are three general categories:

1. Unit packaging, no container
2. Unit packaging, shipper-owned containers
3. Unit packaging, carrier-owned containers

Unit packaging with no container is the highest priced shipping. Only large quantities get a price break, so only large volume orders can be sent this way without considerable expense.

Price breaks are available for shipper-owned containers that meet domestic and international air freight container regulations. Figure 21 shows the most commonly used containers. Types E, E-2, D, Q, and LN are corrugated cardboard and reusable. The D, E, E-2, and Q containers are collapsible, and entail backhaul charges. LN boxes are made of Fiberglas and also carry

CONTAINERS	AIRCRAFT	INTERNAL CAPACITY and DIMENSIONS	MAX. GROSS WT.	CONTAINER WEIGHT
TYPE E 	All aircraft	17 cu. ft. 40'' X 27.5'' X 25''	500 lbs.	18 lbs.
TYPE E-2 	All aircraft	17 cu. ft. varies	500 lbs.	18 lbs.
TYPE D 	DC-10	60 cu. ft. 56'' X 40'' X 41''	1200/2000 lbs.*	63 lbs.
TYPE Q 	All aircraft	12 cu. ft. 37.5'' X 26'' X 20''	400 lbs.	13 lbs.
TYPE LN 	DC-10 only	90 cu. ft. 51.5'' X 52'' X 52''	3100 lbs.	100 lbs.
TYPE L5 	DC-10 only	277 cu. ft. 121'' X 58'' X 60''	5000 lbs.	Actual Empty Wt.

The maximum gross wt. for the Type D container on a 707 or 720 aircraft is 1200 lbs.; 2,000 lbs. on DC-10 aircraft.

Figure 21. Shipper-owned containers with dimensions. (Western Airlines 1977)

a backhaul charge. The L5 container is so large it is used only by the airlines for the return trip. The original shipper is not charged backhaul fees. Varying discounts are given for packing large weights in the D, E, E-2, and Q boxes, for palleting small boxes and for loading or unloading at points other than the airport.

Using carrier-owned containers can lead to some savings. These are usually rented at a flat fee for both the container and the load. Each type (Figure 22) has a maximum weight for the fee charged, called a pivot weight. If this weight is exceeded, a surcharge is assessed by the pound, kilo or centiweight.

Generally, airlines provide night and day rates for containers, pick-up and delivery, and free time for loading and unloading freight. Container rates are also regulated by the Air Freight Container Tariff.

Airlines and some freight forwarders also have containers which can keep products cold with dry ice or refrigerator compresses. Self-contained refrigeration reduces the risk of loss if flight connections are delayed, but there are also substantial premium payments involved when using dry ice. Delays often occur because freight packed in dry ice is sometimes not compatible with other cargo.

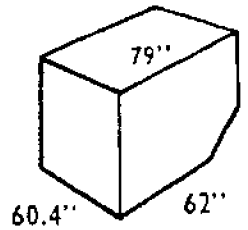
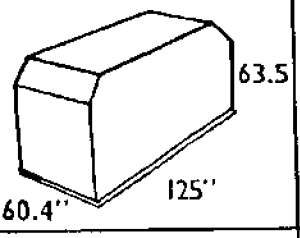
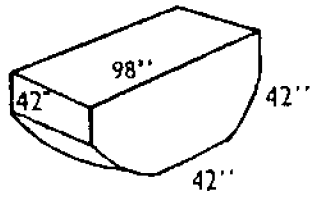
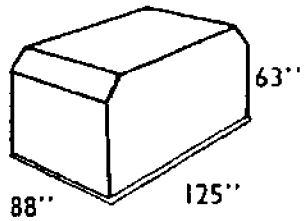
It may be best to consider a super-insulated container. This avoids the refrigeration problems of hookups and carbon dioxide build up. These containers are available through independent container dealers in Anchorage.

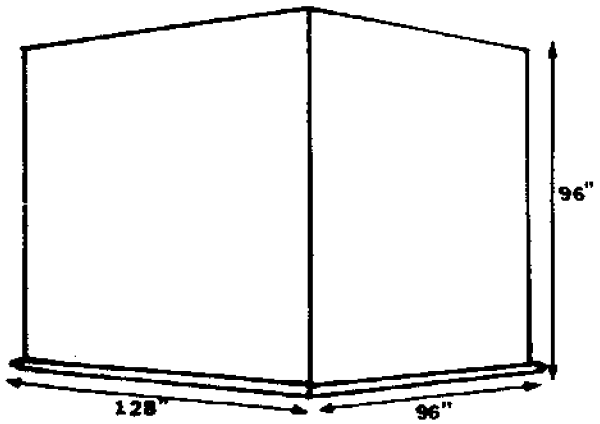
Freight Rates

Freight rates, like container rates, are controlled by both regional and international tariffs. Comparing freight charges might not be a good way to choose among airlines, but the following considerations may help with the decision:

1. Directness of flight
2. Pick-up, delivery and loading services offered
3. Storage space and conditions at layover points
4. Airline policy on lost, damaged or misdelivered freight
5. Allowing shipper to travel with order
6. Ability of airline to plan logistics for handling and delivery
7. Accurate tariff interpretation for weight and type of shipment
8. Favorable terms of payment and cities served

Freight rates are divided into four categories: general commodity shipments, exception rating, priority reserved flight, and specific commodity shipments. General commodity tariffs are based on net weight or weight and volume estimations. As the weight increases, the per pound rate decreases. Exception rates are percentage surcharges to the general commodity rate for shipments requiring special handling. Priority reserve flights is a special service that reserves space for a shipment that must be on a certain flight. Specific commodity rates are the most used rates for very high volumes of specific product between cities. There is, for example, a special rate for

CONTAINERS	AIRCRAFT	INTERNAL CAPACITY and DIMENSIONS	MAX. GROSS WT.	APPROXIMATE CONTAINER WEIGHT
L3* 	DC-10	140 cu. ft. 75"–58" X 58" X 60"	3,500 lbs.	370 lbs.
L11* 	DC-10	265 cu. ft. 115" X 58" X 58" *Has a separate pallet base that may be used for transporting shipments.*	7,000 lbs	400 lbs.
LW 	Boeing 720, 727 707	65 cu. ft. 96" – 40" X 40" X 40"	1,200 lbs.	180 lbs.
L7** 	DC-10	355 cu. ft. 115" X 58" X 81" *Has a separate pallet base that may be used for transporting shipments.*	10,400 lbs.	500 lbs.



The M-1 container and pallet are loaded onto the main deck of the 747 combi. The internal volume measures 600 cubic feet. The maximum gross weight is 15,000 pounds. The weight without cargo is 1,119 pounds.

Figure 22. Carrier-owned containers with dimensions. (Western Airlines 1977; Scandinavian Airline Systems 1979)

fish between Anchorage and Tokyo (Appendix E). These rates are nearly always lower than general commodity rates.

Appendix E gives an example of general commodity rates by division and weight from Anchorage to different destinations in Europe, Asia and South America. Five of nine airline contacts responded with discussions on rates. It is interesting to note the difference between special seafood rates offered by Northwest Airlines to Tokyo and Japan Airlines' general commodity rates for the same destination. It is also interesting to note the comparison between the general rates for container dimensions in the questionnaire and rates that apply to the carrier-owned containers. This signifies a considerable savings over loose cargo.

OTHER CONSIDERATIONS

Dimensional Rate Rule. For high volume, low weight shipments, the following rates are used:

1. For most domestic shipments, 1 lb = 250 in^3
2. For international shipments, 1 lb = 194 in^3

If dimensional weight exceeds measured weight, then rates are charged according to the dimensional rate.

Surcharge For Dry Ice Use. Almost all airlines give a flat charge for handling shipments packed in dry ice. A restricted article certificate is also required.

Compliance With U.S. Fish and Game Laws. Seafood must have a declaration for importation or exportation of fish or wildlife. This is U.S. Fish and Wildlife Department form 3-177.

Compliance With U.S. Export Laws. Export shipments must have two copies of the shipper's export declaration of shipments from the United States (form 7525-V). This declaration describes export district, port, city, transportation, name of carrier, exporters, agents, consignees, and the foreign port.

Shipping Arrangements. Arrangements with a carrier should be made well in advance of shipping date. You should discuss preservation (brine, ice, dry ice, self-contained refrigeration, ground cold storage), length of transit, rates for loading and unloading, terms of payment and so forth. If shipping to a foreign country, considerable lead time is required to determine the procedure for getting things into the country. Most important is knowing the buyer or his agent. Losses are often caused by a failure to have an agent available for the consignee, failure to give an agent power of attorney, or failure to notify the buyer that a shipment is on the way.

The buyer may also refuse shipment at the point of destination. As a foreign national, the seller has little legal recourse as the product spoils on site. It is a good idea to have an alternative plan for the product in case the buyer refuses shipment. For this reason it is also best, for the seller or his agent, to be with the shipment when it arrives until customers prove reliable.

Planning and confirming shipping logistics may prove profitable to many sellers, especially if they are able to use the plan many times. However, many sellers may find it is less expensive and more efficient to work through a broker, rather than setting up trade routes on their own.

Organizations. If you have more questions on the air freight industry, the following organizations should be able to help (Air Transport Association of America 1971):

International Air Transport Association of America (IAIA)
1155 Mansfield
Montreal, 2
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The Air Cargo Tariff (TACT) (international)
P.O. Box 7627
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The Netherlands

Airline Tariff Publishers, Inc. (domestic)
1825 K Street
Washington, DC 20006

Air Cargo, Inc. (ACI) (domestic and Canada)
1730 Rhode Island Ave., N.W.
Washington, DC

Official Airline Guide
P.O. Box 6710
Chicago, IL 60680

A Note About Financial Arrangements. There are quite a number of ways to arrange payment for the shipment which entail less risk to the seller than consignment (where payment is made shortly after arrival). One possibility is letters of credit, which are arrangements between the seller's and buyer's banks offering payment to the seller immediately upon presentation of evidence that the product has been shipped. This is often an agreement that must be filled even if the buyer rejects the shipment.

Other alternative methods of receiving payment have been compiled and explained by the International Chamber of Commerce (1974) and the National Marine Fisheries Service and can be obtained by writing for the following publications:

Uniform Customs and Practice for Documenting Credit
ICC Publication No. 290
United States Council of the International Chamber of Commerce
121 Avenue of the Americas
New York, NY 10036

Export and Domestic Market Opportunities for Underutilized Fish and Shellfish: Study Report

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National Marine Fisheries Service
NOAA, U.S. Department of Commerce
Washington, DC 20235

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