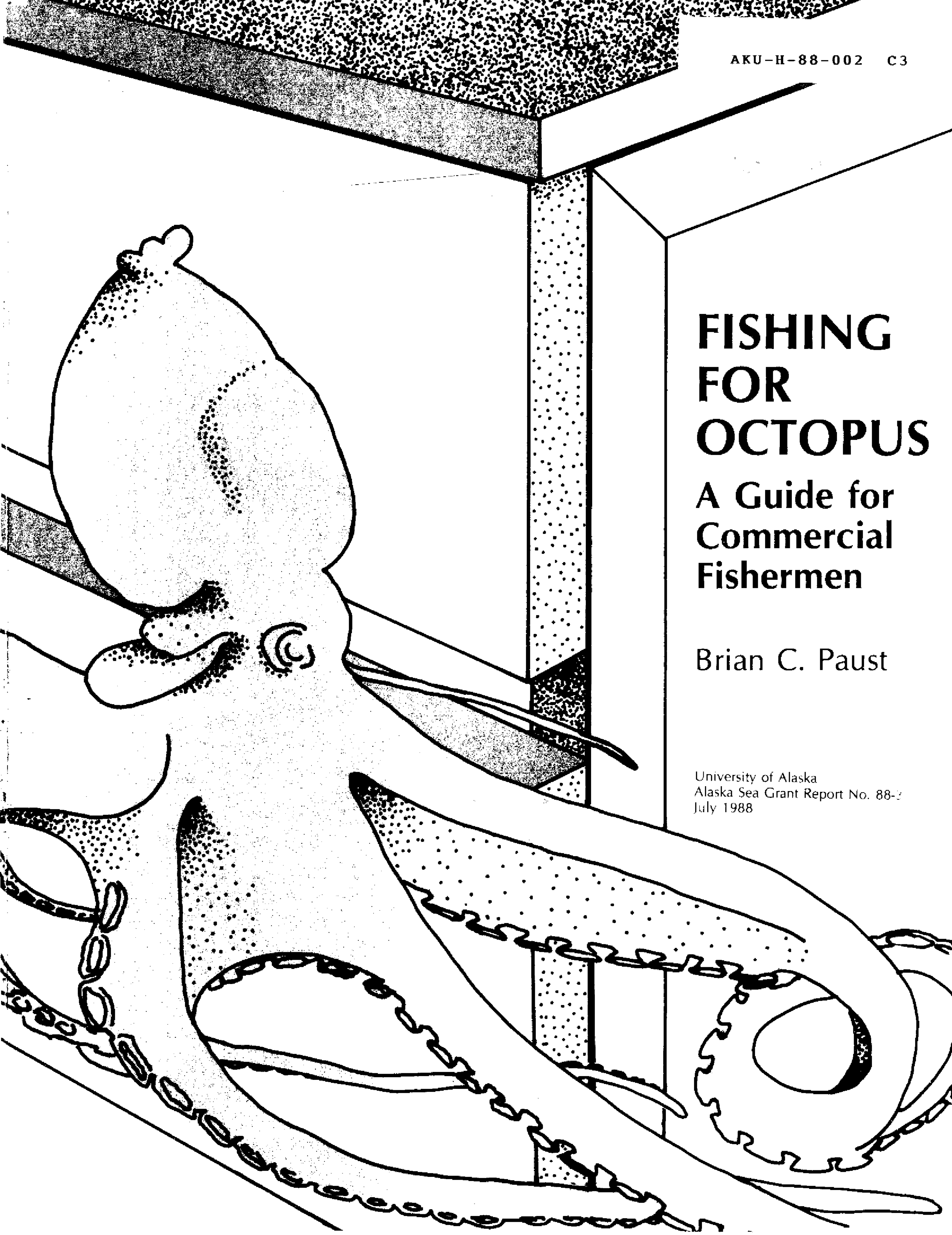

FISHING FOR OCTOPUS

A Guide for Commercial Fishermen

Brian C. Paust

University of Alaska
Alaska Sea Grant Report No. 88-3
July 1988

FISHING FOR OCTOPUS
A GUIDE FOR COMMERCIAL FISHERMEN

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INTRODUCTION

This report presents a review of practical fishing and biological information about *Octopus dofleini*, the giant Pacific octopus, which is of interest to commercial fishermen. This is one of several octopods found in Alaskan waters and the best known of these species.

Information in this report was generated through a project initially funded by the Alaska Office of Commercial Fisheries Development. The project also received funding from the Alaska Fisheries Development Foundation and individual fishermen. This project is the most recent and successful of several octopus development efforts attempted in state waters since the early 1960s. The author has several unpublished reports discussing the structure of this project available upon request (Paust 1982, 1985, 1986).

Many octopus development projects have been funded along the West Coast of the United States and Canada. There are several major motivations for recent octopus projects:

* Very few fishermen are currently engaged in octopus fisheries.
* Most of the octopus harvested in this region are incidentally captured in shellfish pot and trawl fisheries.
* Octopus find ready local and regional markets.
* Various West Coast regions have significant populations of octopus species including *Octopus dofleini*.
* Octopus pot or trap fishing, after perfection of practical techniques, would constitute a valuable supplemental fishery.
* The development of octopus fisheries would provide needed diversification for traditional fisheries now at the point of saturation or decline.
* It is commonly believed that local octopus fisheries can be developed with relatively small initial investments.
* Small- and medium-sized fishing vessels can be used with only limited conversion costs.
* The world demand for food-grade octopus is expanding, opening the door to potentially profitable export markets.
* Demand is increasing for high quality octopus used as halibut bait.
* The techniques for small-scale octopus harvesting are generally well known and foreign harvesting technology, with only minor modification, can be put into immediate use along the West Coast.

As we shall see, several of these considerations are not well-founded for a variety of social, economic and biological reasons. Most development projects have failed to develop viable commercial fisheries for octopus.

OCTOPUS HARVEST AND USE WORLDWIDE

Food-grade octopus currently finds only limited domestic markets in the Unted States and Canada where it is purchased largely by people of Chinese, Japanese, Spanish, Portuguese, Italian and Greek descent. Some hope exists that the octopus market will expand, parallelling the steady growth in seafood consumption in this country (OSU 1983). However, the major U.S. market for octopus is for use as halibut bait.

Octopus is the basis for extensive fisheries pursued by Japan, Korea, Spain, Portugal, Italy and Australia. These nations produce a variety of octopus species, *Octopus vulgaris* being the most notable. This species does not occur in Alaska. However, the giant Pacific octopus forms a significant portion of the harvest in Japan and Korea. Overfishing of some Japanese octopus stocks has made that nation increasingly dependent upon imported octopus, particularly *Octopus vulgaris*.

Octopus in Alaska, as mentioned, is best known as halibut bait. It is also an important item in some subsistence economies. In other parts of the world it is a valuable food species. Octopus has a number of characteristics that make it attractive as a food species (OSU 1983; Hartwick 1984; Paust 1985):

* white meat,

* firm texture and flavor characteristics similar to squid,

* lack of bones, fins, scales and other hard parts with the exception of mouth parts,

* 80 to 85 percent meat recovery rate (80 percent for small octopus, 85 percent for large),

* relatively large size, and

* fast growth and high fecundity permitting high sustainable fisheries yields.

Octopus is particularly important in Oriental and Mediterranean cooking. How it is used often depends on the animal's size. For example, the specific uses for various size ranges of *Octopus vulgaris* in the Orient include:

* 1 to 7 lb dressed weight: spiced and boiled octopus,

* 7 to 15 lb: pickled octopus, and

* 15 lb or more: utility or bait.

The food demand for very large octopus is limited and Japan annually exports several thousand tons. A sizable portion of this export grade octopus is shipped to the United States and Canada for use as halibut bait. The development of a stable octopus fishery in Alaska depends on this bait market. In the past, attractive bait markets have existed for octopus 15 lb and larger. Currently, octopus as small as 8 lb can be sold as halibut bait.

Information concerning the culinary preparation of octopus meat is available from a number of sources including ANWPC 1984; Coggins 1975; McClane and deZanger 1977; and Price 1979.

REVIEW OF OCTOPUS BIOLOGY FOR FISHERMEN

General Biology

The octopus is a highly advanced invertebrate and a member of phylum Mollusca. Within this group of mollusks (which also includes clams and snails), the octopus is called an octopod because of its eight arms. The octopus is also commonly referred to as a cephalopod, meaning "head footed," because of the unusual configuration of its arms, trunk and head or "mantle." The latter structure is a muscular envelope that encloses the visceral mass. A related group of marine organisms, squid and cuttlefish, are termed decapods, meaning "ten-armed," because of their eight arms and two tentacles. The octopus has no hard, bony parts except for its chitinous beak. The octopus body is divided into three sections (see Fig. 1):

* head or mantle, enclosing the visceral mass;

* the trunk, containing eyes and central nervous system; and

* arms.

Unlike vertebrates, which have red, iron-based blood, the octopus has blue, copper-based blood. The octopus' blood has a relatively low affinity for oxygen, predisposing the animal to rapid exhaustion. The complex body plan of the octopus includes highly developed nervous and circulatory systems. Various other aspects of octopus biology are described in several references: Boyle 1983; High 1976; Hochberg and Fields 1980; Mottet 1975; Roper, Lu and Hochberg 1983; Roper, Sweeney and Naven 1984; Wells 1978.

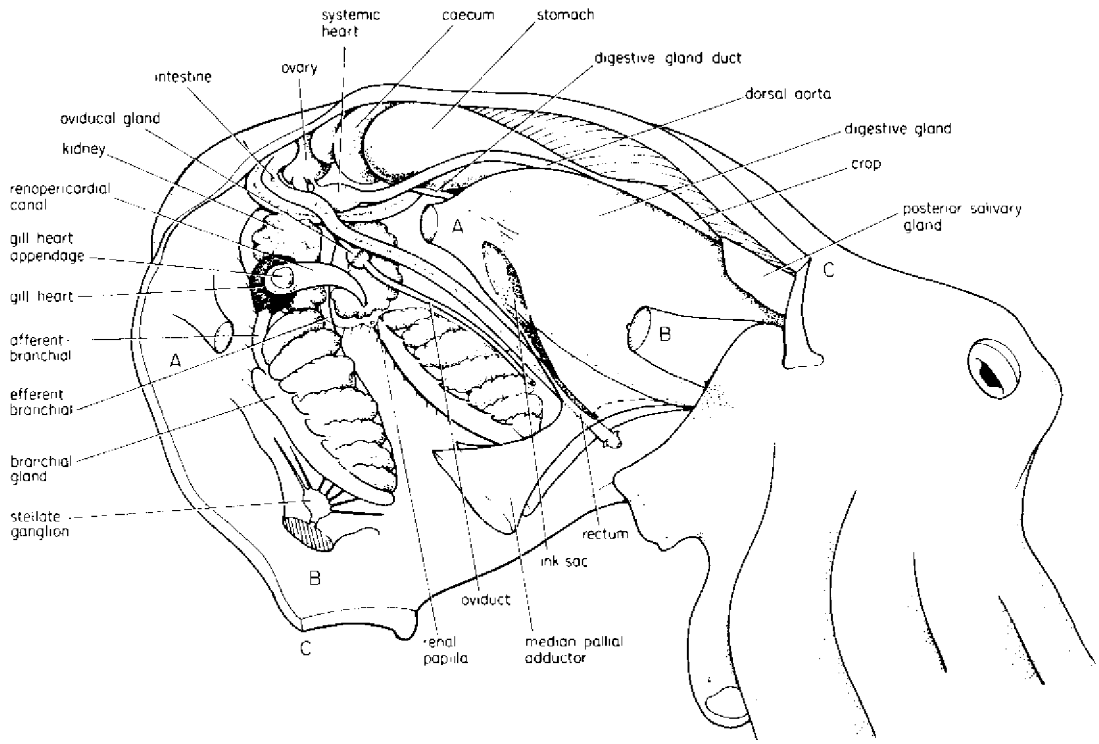

Fig. 1. A lateral view of the contents of the mantle cavity. The mantle has been split along the mid-dorsal line and folded down. Muscles suspending the guts from the mantle sides and roof have been cut through at AA and BB (Wells 1988).

Additional information on octopus natural history and fisheries can be found in Paust 1985, which reviews selected West Coast and Pacific Rim octopus projects, practical fisheries biology, indicator organisms, selection of soaking times and economic feasibility.

Distribution of Alaskan Octopus

Approximately 150 species of octopus are currently known (OSU 1983). These species range in size from 2 in. between outstretched tentacle tips to more than 30 ft between them. Octopus species present in Alaska include:

* *Octopus dofleini*: weigh more than 115 lb, used for both food and bait;

* *Octopus leioderma*: weigh less than 1 lb, used for food;

* *Octopus rubescens*: weigh less than 5 lb, used for food;

* *Benthoctopus* sp.: small, known to occur off British Columbia, suspected to be present in deep waters off Southeast Alaska.

Giant Pacific octopus occupy a range extending from the coastal waters of Northern California through the Gulf of Alaska and westward to the Aleutians, Japan and Korea. Octopus within this range are believed to represent three distinct subspecies. The depth of occurrence ranges between the low intertidal zone and 200 fathoms. Octopus are best known in waters less than 100 fathoms deep. *Octopus dofleini*, is most abundant in the northeastern Pacific from shallow water to approximately 50 fathoms (Hartwick 1982).

Behavior of Octopus

Octopus are solitary animals and are highly territorial. Dens can be made in a variety of natural and man-made cavities. Octopus will occasionally dig dens in sand and firm mud. An octopus den provides protection from numerous predators and is often close to concentrations of food organisms. Entrances to dens are commonly small and inconspicuous. The best indication of an occupied den is an accumulation of bivalve and crab shell fragments at the entrance.

Octopus can move their bodies through small holes. It is frequently reported that an octopus can slowly pass through a hole that is only slightly larger than its beak. Escape behavior of this type presents special problems to commercial fishermen attempting to hold octopus alive.

In addition to these aspects of defensive behavior, the octopus is also well known for its florid skin color displays and camouflage abilities. Octopus skin contains three types of organs responsible for color change. Two of these serve as mirrors to reflect environmental colors in proximity to the octopus. A third type of color organ, the chromatophore, is a colored disc capable of displaying one of four colors. Coordinated use of these skin organs enables octopus to make rapid and elaborate skin color displays that are part of various reflex behavior patterns (such as reproductive and defensive reflexes).

The octopus has many natural predators. In southeastern Alaska, common predators include lingcod, dogfish, wolf eel, halibut, rockfish, sea otter, sea lion, seal, mink, land otter and diving birds. Octopus defense strategies include camouflage, arm sacrifice, ink release and rapid escape using the jet action characteristic of cephalopods. Healthy octopus can regenerate arms lost to predators.

Life History of Octopus

It is easy to determine sex in octopus. The third arm on the right side of the male octopus (counting from the front) does not have suction cups at the tip. This portion of the arm is spoon shaped and is technically known as a hectocotylus. Female octopus have a non-specialized third arm (Fig. 2).

Male *Octopus dofleini* mature at a smaller size than females (Hartwick 1982). Typical longevity in this species is three to five years. Peak mating occurs during the fall and winter. Reproduction activity begins with breeding over a single season and ends with the parents dying before the eggs are hatched. The male typically impregnates six to seven females, moves to deeper water, become senescent and dies within nine months of mating. The females lay approximately 50,000 eggs (numbers range from 35,000 to 100,000), become senescent and die shortly before the eggs hatch.

Octopus commonly lay eggs on the walls of the maternal den. It can take 15 days for the female to deposit all her eggs. The incubation period can extend five to six months, depending on water temperature. In Alaska, the peak period for octopus egg laying is between April and May. Females can store sperm for several months before fertilization takes place. The female tends the developing eggs during the incubation period. Japanese octopus fisheries are enhanced by installing earthenware breeding pots on local fishing grounds to serve as artificial maternal dens.

Eggs hatch to produce free-swimming planktonic larvae. After approximately four to six weeks, the larvae metamorphose and become rapidly growing adults that settle on the ocean bottom (Kyte 1983).

Short life spans are typical for octopus. The life span of *Octopus dofleini* is relatively long (three to five years) when compared with that of other octopus species (approximately two years). Most octopus species can grow rapidly. *Octopus vulgaris*, an important commercial species not found in Alaska waters, can grow from 1 lb to 7 lb in 7 weeks. Rates of growth and size are variables closely related to food supply and not necessarily to age. Giant Pacific octopus will weigh approximately 2 lb after the first year. At the end of the second year, they can weigh 22 lb. *Octopus dofleini* will commonly mature within a weight range of 30 to 40 lb (3 to 4 years old). Again, the maximum life span is believed to be five years (Hartwick 1984).

During the free-swimming planktonic stages, larval octopus can grow 1 to 3 percent of body weight per day. Following transformation to benthic existence, an immature octopus grows at a rate of 0.5 to 2 percent of body weight per day (Kyte 1983). Transformation from planktonic to pelagic life commonly occurs at a weight of 3 to 5 g. Rapid growth, as mentioned, is largely a product of intense feeding activity (Hartwick

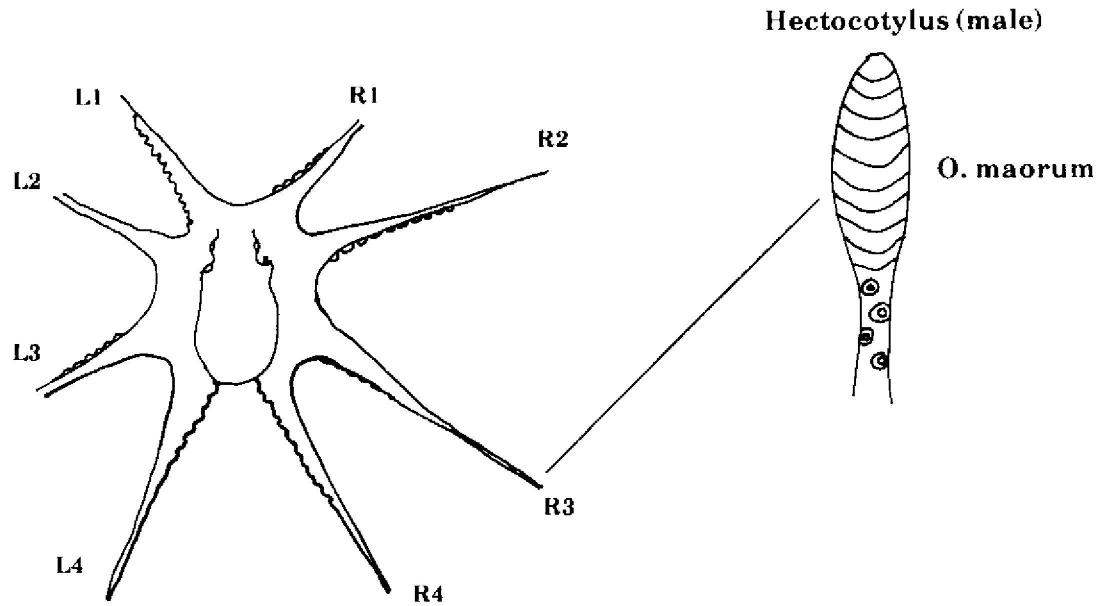

Fig. 2. Example of the hectocotylus, shown here on male *Octopus maorum* (NZFIB 1981).

1984). Because of their high fecundity, rapid growth rates and relatively short life spans, octopus of various species are being considered for large-scale aquaculture production.

Weights attained by *Octopus dofleini* approach 60 to 70 lb. Exceptional weights greater than 200 lb have been anecdotally recorded but not officially confirmed. The heaviest verified weight is approximately 115 lb (High 1976). A 70 lb *Octopus dofleini* will typically have a 15 ft arm span.

Octopus Feeding Habits

Most octopus are highly opportunistic feeders, preferring a variety of live prey. Giant Pacific octopus favor crab species including Dungeness, red rock, tanner and king crabs. In Puget Sound, octopus have been observed to consume Dungeness crab at a rate of one crab every one to three days. The basic feeding strategy is to conduct nocturnal hunts and return to the den to consume the captured prey (Kyte 1983). Waste fragments are discarded at the entrance to the den.

Other favored prey items include bivalves, snails, abalone, sea cucumber, fish, fish eggs, shrimp and other octopus. Octopus will characteristically entrap prey, bore a hole into the victim with its tongue-like radula and inject poisons and salivary juices. Injected juices partially liquefy animal tissues. The poison of *Octopus dofleini* is not known to cause serious toxic reactions in humans. However, venom from one Australian octopus species can be fatal. Octopus can also use their siphons to excavate clams by washing away surrounding sediment. Octopus are considered pests by shrimp pot fishermen, and in southeastern Alaska, shrimp pot fishermen have noticed the octopus' pronounced preference for spot shrimp.

Octopus Migration

The migratory behavior of *Octopus dofleini* within its natural range is poorly known. However, most field workers suspect that octopus are highly and regularly migratory. Halibut longlines positioned along passes in southeastern Alaska frequently produce large octopus catches (D. Sarff, 1984 personal communication). Some evidence suggests that a two-way annual migration may occur along the U.S. West Coast. A general migration into deeper offshore water is believed to occur during the fall with a return of numerous octopus to shallower waters in the spring (Kyte 1983). Observed migratory behavior is believed to be related to seasonal changes in water temperature and the movement of prey species. Octopus catch patterns in oceanic waters adjacent to Vancouver Island, British Columbia suggest that offshore migrations occur during late winter (February to March) and possibly late summer. Corresponding inshore movements occur between April and July and between December and January (Hartwick 1982). This is in agreement with complex migratory patterns reported by Mottet (1975) for octopus in Japanese waters. Hartwick (1982) verified migratory movements by dive sampling, commercial dive harvest and inshore trapping.

A clear understanding of octopus migrations cannot be deduced from statistics generated by this project. A general pattern is apparent, however. The most productive octopus fishing experienced in this project occurred on either tanner crab or spot shrimp grounds. Octopus movements tended to follow the seasonal migrations of these indicator species. The success of a commercial octopus fishery will depend on a clear understanding of octopus migration in terms of regularly fluctuating biophysical variables and the movement of indicator organisms.

THE ALASKA OCTOPUS FISHING INVESTIGATION

BACKGROUND INFORMATION

This project was shaped by a variety of legal, biological and economic preconditions present in Alaska. A summary of these provides useful background information.

The complete cooperation of the Alaska Department of Fish and Game (ADF&G) was required for successful completion of the project. The octopus project was recognized as an experimental fishery and participating fishermen were assigned permits Z09B or Z91B (statewide permit for miscellaneous pot gear), the actual designation depending on vessel size. Alaskan fishermen seeking octopus fishing management information should contact Tim Koeneman, shellfish biologist; ADF&G; P.O. Box 667; Petersburg, AK; 99833; (907) 772-3801.

The primary assumption underlying this effort is that octopus are present in sufficient quantities to support viable fisheries in the Gulf of Alaska. Octopus remain plentiful in Alaska, as evidenced by the high incidental capture rate in several demersal fisheries. Some of these octopus populations, particularly those in southeastern Alaska, are not necessarily available for harvesting in a pot fishery. The northern Gulf of Alaska, on the other hand, appears to harbor an abundant octopus resource that can be harvested with traditional pot fishing.

The generally negative results of octopus fisheries in the Southeast region were apparently caused by the rapid deterioration or loss of wooden pots, high replacement costs and poor capture efficiencies of the pots used. It was considered mandatory that our project use lair pots of proven design that were resistant to marine borers. To satisfy this project's objective of diversifying Alaska fisheries and because the study depended on volunteer labor, the pots were placed in the hands of conscientious participants. Much of our success is attributable to distributing the pots among several people.

Another pivotal assumption was that several groups of fishermen could participate in an octopus fishery that could in turn be integrated into and fished at the same time as traditional primary fisheries. Many fishermen are interested in a financially rewarding octopus fishery. However, the high gear loss we experienced seems to discourage part-time participation. The soak times are usually longer than six days, inviting unacceptable loss to vandalism, theft, barge traffic and other causes. Although this observation is tentative, it appears that participation in a supplemental octopus fishery will require vigilant attention to the fishing gear. Daily monitoring seems to be the only alternative in some areas. This problem is best described in Guilmet et al. (1986). An Alaskan octopus fishery, if developed, will most likely be a full-time, off-season fishery. As stated by Johnson (1983a), no one should have an illusion about octopus becoming the next big fishery bonanza.

Although the octopus fisherman has a number of potential marketing outlets, the most secure market is that for high-quality halibut bait. The current supply of octopus from Alaskan sources is greatly overshadowed by the demand for bait octopus. However, it can be assumed that small numbers of octopus will move into domestic and export food markets.

In return for their voluntary services, participating fishermen were given legal ownership of the ceramic pots at the end of the project. This arrangement turned out to be expensive for fishermen. In most cases, the high vessel costs associated with this type of exploratory project curtailed efforts. Fortunately, several fishermen had extensive prior knowledge of octopus distribution or the distribution of indicator species (spot shrimp, tanner crab and others) and could make maximum use of the limited time, greatly contributing to this project's success. Future projects should increase the subsidy to participating fishermen if the range and duration of test fisheries is to be increased.

Project results indicate with considerable certainty that a financially rewarding commercial fishery for *Octopus dofleini* using unbaited pots is possible when proper gear and strategies are employed. However, this fishery will require pot designs with volumes sufficient to harvest 15 lb and larger octopus.

Problems associated with shipworm damage to the original wood pots precipitated the choice of the ceramic Octopot as the standard experimental pot. The successful performance of wooden pots in the northern Gulf of Alaska, however, clearly indicates the utility of traditional wooden gear in developing a commercial octopus fishery. Octopus fisheries on certain current-swept ground may require continued use of self-ballasting ceramic pots.

It was originally assumed that an effective wooden pot would have to be constructed of red cedar. Project results indicate that a number of wood species can be used. Consult the appendix of this report for ways to treat wood against shipworm damage. Comparative statistics concerning the fishing efficiency of pots made from different wood species are not available. Inexpensive octopus pots can be constructed from Alaska forestry products. The use of quality galvanized nails or other non-deteriorating fasteners is essential.

Finally, it was hoped that this project would develop methods and strategies that could be easily transferred to other Alaska regions. Project participants are gratified that this has already begun to occur.

OCTOPUS FISHING STRATEGIES AND GEAR

Incidental Harvest of Octopus in Alaska

Fishermen will no doubt be interested in what has been learned about octopus fishing through incidental catches. There is a substantial incidental octopus fishery in Alaska. For 1984, official records indicate a statewide harvest of more than 76,000 lb (average ex vessel price was $0.77 per lb, ranging from $0.50 to $1.07 per lb). This harvest figure is undoubted grossly understated, the probable harvest being several times this figure.

The majority of this octopus is incidentally harvested in crab and shrimp fisheries. In several regions, octopus can be especially abundant in spot shrimp (prawn) pots. This incidental occurrence may include the small *Octopus rubescens* in addition to much larger *Octopus dofleini*, as noted from British Columbia (Hartwick 1982). Although Octopus dofleini is known primarily as a solitary creature, several exceptional incidents have been reported in which as many as three mature octopus (weighing more than 50 lb) have been captured in a single king crab pot (A. Otness, 1982 personal communication).

Shrimp pot fishermen from many regions report frequent encounters with octopus. Circumstantial evidence suggests that octopus are attracted to shrimp pots either by bait scent or by trapped spot shrimp. Pots containing empty shrimp shells are frequently reported. Evidently, shrimp pots do not serve as lairs, but as sources of food. The same is probably true for Dungeness, tanner and king crab pots, all of which harvest large numbers of octopus. Traditional king crab pots have been particularly effective in capturing octopus.

This information on capturing octopus incidentally was collected during the octopus project and is helpful to prospective octopus fishermen:

* Shrimp fishermen typically place their pots on rocky slopes. The depth fished varies with season (shallower in summer) and with region. In southeastern Alaska, flat muddy bottoms produce very few spot shrimp and even fewer octopus. (S. Tuttle, 1984 personal communication.)

* Octopus can be particularly numerous in current-swept passes in association with commercial concentrations of spot shrimp. Similar occurrences of octopus with concentrations of sidestripe shrimp have not been noted with the same frequency. When spot shrimp are present in commercial quantities, the incidental capture of octopus is commonly in the range of 3 to 17 percent (soak time is usually 6 to 12 hr). Occasionally, two octopus have been found in a single pot (the pot had a 3 in. eye, or pot opening). On one occasion, three small octopus were caught in one shrimp pot.

* A shrimp fisherman from Prince William Sound has noted that longer shrimp pot soaking times (two days instead of one) not only increase the number of large shrimp caught in his area, but also increase the number of trapped predators, including octopus (D. Clemens, 1985 personal communication).

* An octopus will characteristically move along a section of groundline, cleaning out each shrimp pot as it goes. It is common to find a series of cleaned-out pots followed by a pot containing an octopus (Anderson 1983). Crab fishermen have also reported this type of behavior. It is not surprising that the occurrence of octopus, particularly in large numbers, will lead to drastic downturns in crab and shrimp catch rates. (D. Sarff, 1984 personal communication).

* The incidental capture of octopus in shrimp pots has been reported to be as high as 54 percent on certain productive shrimp grounds (L. Phillips, 1986 personal communication). Dungeness crab fishermen have reported the occasional occurrence of octopus on or in 50 percent of their pots.

* Typically 3 to 17 percent of shrimp pots contain octopus (D. Sarff, 1984 personal communication; H. Medalen, 1984 personal communication). One shrimp fisherman reports that the incidental capture of octopus increases substantially through the spring to late summer period. This increased capture rate may indicate inshore migrations to warmer, shallower water. In late summer, the incidental capture of octopus can be high. It appears that increased octopus numbers are directly correlated with increased shrimp concentrations (B. Neely, 1984 personal communication).

* Octopus "typically" harvested in shrimp pots (3 in. ring) range from 6 to 10 lb. A typically, captured octopus can weigh 20 lb and on rare occasions have been known to approach 50 lb. Fishermen reportedly keep an average of 30 to 100 lb of octopus per trip. Pots fished in deeper water tend to catch larger octopus.

* A last bit of anecdotal information indicates the importance of precise pot placement. A Petersburg fisherman used 20 ceramic octopus pots together with 15 SAK Industries round, three-tunnel shrimp pots (volume approximately 4.3 cu. ft) in a single set. The ceramic pots were inadvertantly placed together on a mud bottom at 100 fathoms (depth indicated by the amount of mud in the pots) with the remaining shrimp pots on rock bottom sloping to approximately 90 fathoms. The 20 ceramic pots caught no octopus and contained mud. The 15 shrimp pots contained 11 octopus weighing between 3 and 10 lb (S. Cahoon, 1985 personal communication). Octopus were caught in 73 percent of the shrimp pots. The author has been told of similar occurrences. All suggest that extensive knowledge of the fishing ground is mandatory for anyone hoping to be successful in an octopus fishery.

Researchers Willing to Help Fishermen

Researchers are available to assist fishermen and others in interpreting biological information pertaining to octopus and related species. This list of contacts should provide a good start for those needing additional information.

Lynn Goodwin
Washington Department of Fisheries
Point Whitney Shellfish Laboratory
600 Point Whitney Road
Brinnon, WA 98320
(206) 754-1498

Scott Harrington
Washington Sea Grant
Fishermen's Terminal (Bldg. C-3)
Seattle, WA 98119
(206) 543-1225

Dr. Brian Hartwick
Simon Fraser University
Burnaby, B.C. V5A 1F6
Canada
(604) 291-4802

Dr. Gilbert Voss
School of Marine Science
University of Miami
400 Rickenbacker Causeway
Miami, FL 33149
(305) 350-7312

Dr. Fred Hochberg
Santa Barbara Museum of Natural History
2559 Puesta Del Sol Rd.
Santa Barbara, CA 93105
(805) 682-4711

Michael Kyte
Andrea Enterprises
P.O. Box 2602
Lynnwood, WA 98036
(206) 334-7720

Hank Pennington
Alaska Marine Advisory Program
202 Center St., Suite 204
Kodiak, AK 99615
(907) 486-3599

Fishing Strategies Used in the Alaska Octopus Project

The project organizer devised a listing of octopus fishing strategies for participating fishermen to use (Paust 1982). Some of the more important of these basic fishing strategies follow:

* Octopus pots should not be placed on rockpiles or reefs or close to natural denning sites. Artificial lair pots cannot compete with natural dens.

* Pots fish more efficiently with use and must be well seasoned before full production can be expected.

* A number of chemical substances are believed to be noxious to octopus and will decrease catching efficiency if used in conjunction with octopus pots. The repellant effects of most substances to octopus remains unknown. The ceramic Octopot was chosen partially because clay is a natural substance free of distracting chemicals (see Appendix). In spite of this, the catching efficiency of most octopus pots is probably due to the correct placement of the pot on the bottom. Volume, shape and water circulation characteristics also play important roles in the overall success of a particular pot.

* It is not essential to bait pots and, in most cases, it may be counterproductive. Baited octopus pots frequently attract unwanted pest species such as snails and starfish. The presence of these species and/or the presence of rancid bait may adversely affect overall fishing efficiency. Chemicals released by some marine invertebrates attracted to baited pots are believed to repel octopus.

* The octopus is an opportunistic carnivore with a decided preference for certain prey species such as Dungeness crab, tanner crab and spot shrimp. An octopus fisherman should use these potential prey as indicator species. Octopus fishing gear should be concentrated on grounds known to be inhabited by preferred prey species.

* Octopus are nocturnal and catching efficiency will decrease if the pots are pulled during the night.

* When fishing on current-swept bottoms, stabilize the octopus pot. It is believed that a "rocking" pot will have a low catching efficiency.

A great many additional strategies were gleaned from a variety of sources. It is now only too obvious that several of the strategies are of far greater importance than imagined. Large-volume pots like the wooden Puget Sound slat pot appear to be essential for the development of this fishery. Of even greater importance is fishing on open grounds that lack obvious natural denning sites and contain an abundance of indicator species. Experimental fishing on unobstructed tanner crab grounds is encouraged. Parallel strategies include restricting seasonal octopus fishing efforts to depths, water temperatures and habitats known to favor selected prey species (Hartwick, 1983 personal communication). A summary of additional or expanded strategies can be found at the end of this section.

Selecting Fishing Gear

The project organizer considered a variety of traditional octopus fishing gear before selecting the ceramic pot and later helped develop the Kodiak wooden pot. It was not possible to use several gear types in parallel experiments because of funding limitations. Also, the use of certain specialized gear types, such as claw hooks and tangle gear, was not seriously considered because they either required extensive knowledge of octopus behavior or they involved unusual operational complexity. Pots were considered to be a better developmental investment. Consequently, we proceeded with the development of an experimental pot fishery.

The project, as previously stated, was only one of a long series of similar octopus projects that have been attempted along the West Coast. Our operational strategies were similar to those used previously. The Alaskan project was carefully built upon the results of past Canadian and U.S. projects. The major administrative strategy was to allow for rapid geographic extension of the project. Close cooperation among project participants allowed rapid technology transfer. The project was easily redirected and improved strategies were quickly implemented. The development of the Kodiak pot is an important part of this extended project. The decision to use wooden pots on open tanner crab grounds adjacent to Kodiak Island was based on the advice of a resourceful Kodiak-based fishing family. We appreciate their participation.

Table 1. Basic pot specifications for gear used in the Alaska octopus project.

Type	Material	Volume (ft^3)	Length (in.)	Width (in.)	Weight (lb)
Kodiak wood	of several species	2.2	26	12	60
Octopot	unglazed ceramic	0.5	15	10	23
Tube	white PVC pipe	0.7	24	8	11
Japanese Urn	black plastic	0.1	12	8	3

Four types of lair pots were eventually used in this project with ceramic and wooden pots predominating. Basic pot specifications are as in Table 1.

If production goals had not been reached in the northern Gulf of Alaska, the project would probably have moved to the passes of the eastern Aleutian Islands.

Creating the Experimental Ceramic Pot

The search for the ideal octopus pot began when further use of wooden pots was abandoned in 1981. The local construction of 1,000 to 2,000 red cedar slat pots had originally been envisioned. However the prospect of reporting to the Office of Commercial Fisheries Development that their pots were destroyed by shipworms in five months was too much for us. A more certain alternative was needed.

A number of contacts were made in several Pacific Rim nations concerning the rational development of an Alaskan octopus fishery. Detailed information provided by Dr. Brian Hartwick of Simon Fraser University, Burnaby, British Columbia, provided much additional information. Hartwick conducted an extensive octopus fishery development project near Tofino, British Columbia, shortly before the initiation of the Alaska project (Hartwick 1982). A considerable body of information was gained concerning the practicalities of a pioneering fishery both from that study and from other sources. In addition, much useful information was received from the following companies:

Hakodate Seimo Sengu K.K.
17-14, Suehiro-cho
Hakodate City
Hokkaido, Japan 040

Toyo Buro Company
644 Okadama-Cho, Higashi-Ku
Sapporo City
Hokkaido, Japan 065

The purchase and importation of pottery and plastic Uroko-type pots was considered but ultimately rejected because of cost or biological inappropriateness (as determined by production failures in past projects). Several promising octopus fishing techniques were rejected because of legal and technical complexities. Without further deliberation, the decision was made to proceed with the development of a ceramic pot.

Bids for pots of a modified Japanese design were solicited from Japan, Mexico, U.S. and Canada. In most cases, the returned bids indicated prices of $45 to $50 per pot when ordered in lots of several hundred. Most U.S. and Canadian manufacturers indicated that the design was most similar to the oil and water containers produced in previous centuries, which were the product of now unfamiliar technology. Current mass manufacturing methods favored the production of much smaller clay vessels (J. Peterson, 1981 personal communication). The two major production alternatives were to either hand-throw pots on potter's wheels or to produce them in special molds, both at major cost (H. Hayers, 1981 personal communication). The pots were eventually manufactured in molds by Susan Payne of Petersburg, Alaska. The technical aspects of this production process have been reported in the fisheries literature (Johnson 1983a; 1983b).

The design of a pottery octopus pot involves seven basic considerations. They are:

* Color—A dark color was preferred but could be obtained only by adding metallic coloring agents to the clay mix or by using an expensive layer of glaze. We selected a product without coloring agents or glaze to reduce costs and eliminate the chance of introducing irritants.

* Amount of porosity that can be tolerated—Higher porosity would involve lower temperatures and lower costs. One alternative was to add glaze, a major extra cost. Non-glazed pots were selected to reduce costs. Increased porosity will predispose the pots to cracking or flaking during frozen storage.

Table 2. Characteristics of the three Octopot designs considered for the Alaska octopus project.

Variation	Ht (in.)	Width (in.)	Wt (lb)	Volume $ft^3(m^3)$	Probable wt octopus[1](lb)
Regular Octopot	15	10	23	0.53 (.015)	9.4
Nr.2	22	15	70	1.6 (.045)	17.2
Nr.3	24	15	78	1.8 (.051)	18.2

[1]Projected from Hartwick (1982).

* Ability to withstand frozen storage

* A compromise between strength and weight

* Producing a pot with a specific internal volume

* Cost

Pot volume corresponds directly to the size of octopus that can be enticed to inhabit the artificial lair. Three Octopot variations were eventually considered (Table 2).

Octopot design decisions were made in 1981. The estimated size of octopus was calculated from the graph indicated in Figure 3. The final configuration of the standard octopus pot is shown in Figures 4 and 5. The local potter was reimbursed at the rate of $12 per fully rigged pot. The ceramic pot was thought to be adequate for 15 to 18 lb octopus. The projections presented by Hartwick proved to be quite accurate, since the octopus captured in these pots ranged in size between 3 and 20 lb. The average was approximately 11 lb when fished in Kodiak Island waters. Hartwick's projection indicated an expected size of approximately 9.4 lb.

The pot was to be wrapped in heavy trawl web to increase durability before distribution to the participating fishermen. The cost of applying the web was $3 per pot in material. Additional funds were not available. The unwrapped pot was found to be quite durable. Consequently, an alternative method was borrowed from the Japanese. The pot manufacturer used 3/8 in. poly rope to apply a barrel hitch (see Figure 5). Knots were tied in the gangion at 6 in. intervals to facilitate handling.

The Kodiak Wooden Lair Pot

The Kodiak wooden lair pot (Fig. 6) is slightly smaller than the traditional Puget Sound slat pot (36x12x12 in. or 3 ft^3) from which it was derived (Fig. 7). In spite of this it consistently yielded substantial catch rates and weighs significantly less than the larger slat pot.

The wooden pot is also quite inexpensive. The Kodiak lair pot can be constructed from rough, unfinished lumber. Each pot requires approximately 10.7 board feet of 1 in. thick lumber (various combinations of 1x4, 1x5 and 1x6 lumber can be used). Inexpensive, rough-cut lumber is available throughout this region. Typical prices prevailing at the time the Kodiak pots were constructed were:

Southeast Alaska		Seattle/Tacoma	
spruce	$0.30 per bd ft	Douglas fir	$0.20 per bd ft
red cedar	$0.35	red cedar	$0.25
yellow cedar	$0.40		

The cost of a typical wooden Kodiak pot fabricated from these sources of dimensional lumber was as follows (cost does not include nails, waste lumber, transportation of lumber or labor):

Spruce	$3.22
Red cedar (Alaska)	$3.75
Red cedar (Seattle)	$2.68
Yellow cedar	$4.29
Douglas fir	$2.14

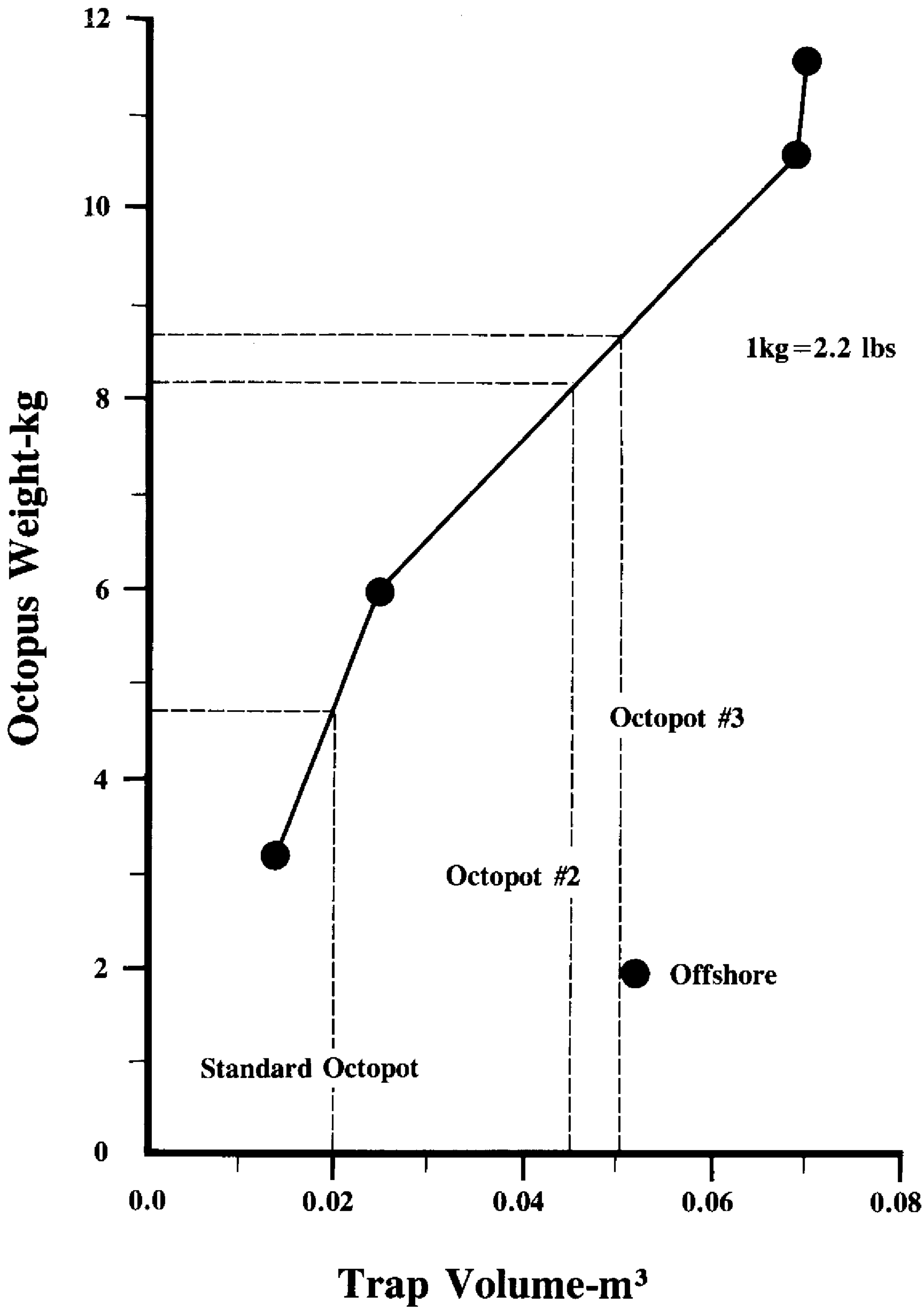

Fig. 3. Relationship between octopus weight and pot volume (modified from Hartwick 1982).

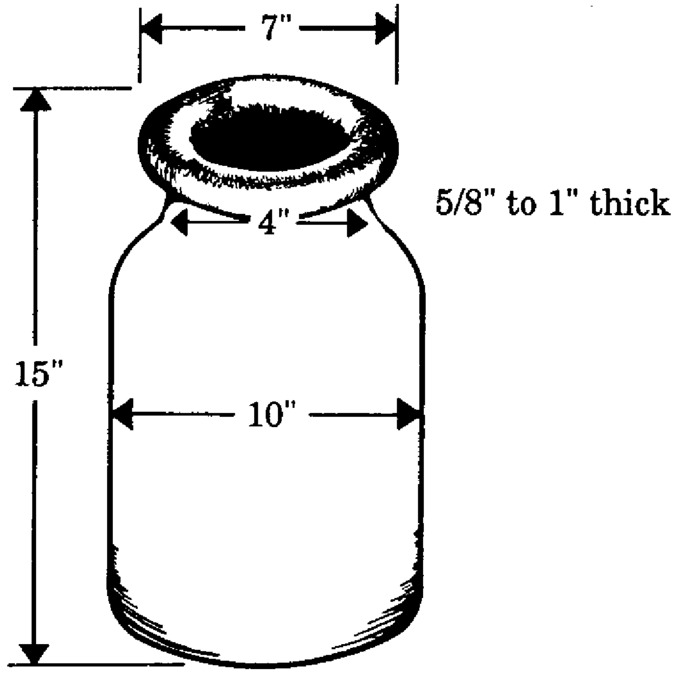

Fig. 4. Octopot dimensions (drawing by Susan Payne).

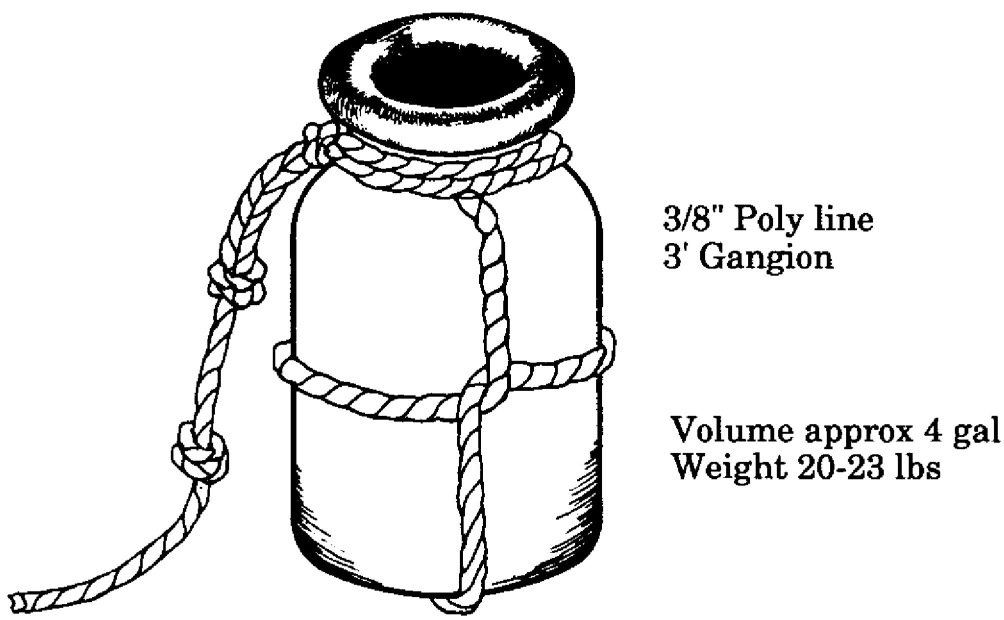

Fig. 5. Octopot rigging (drawing by Susan Payne).

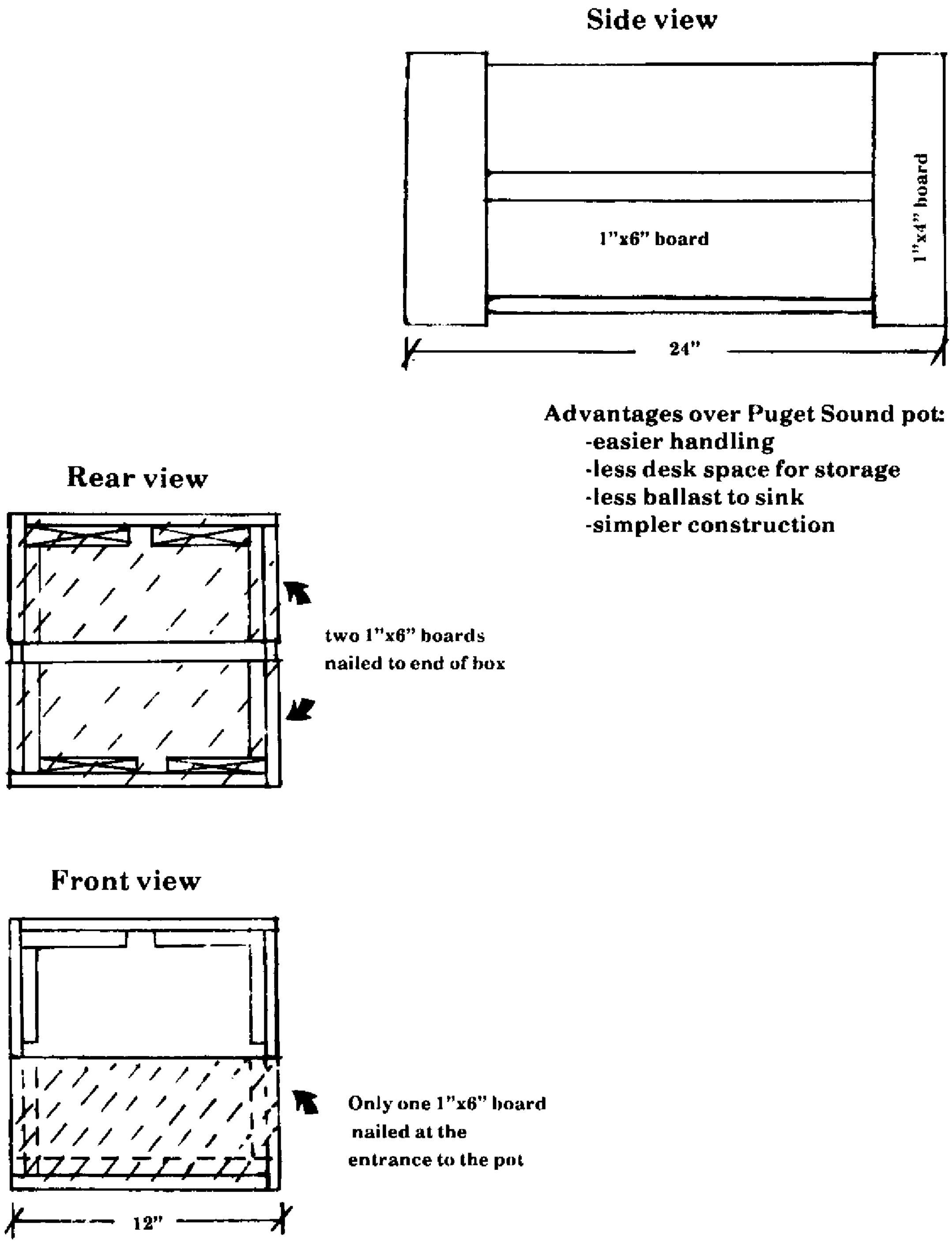

Fig. 6. Kodiak wooden lair pot (Guilmet et al. 1986).

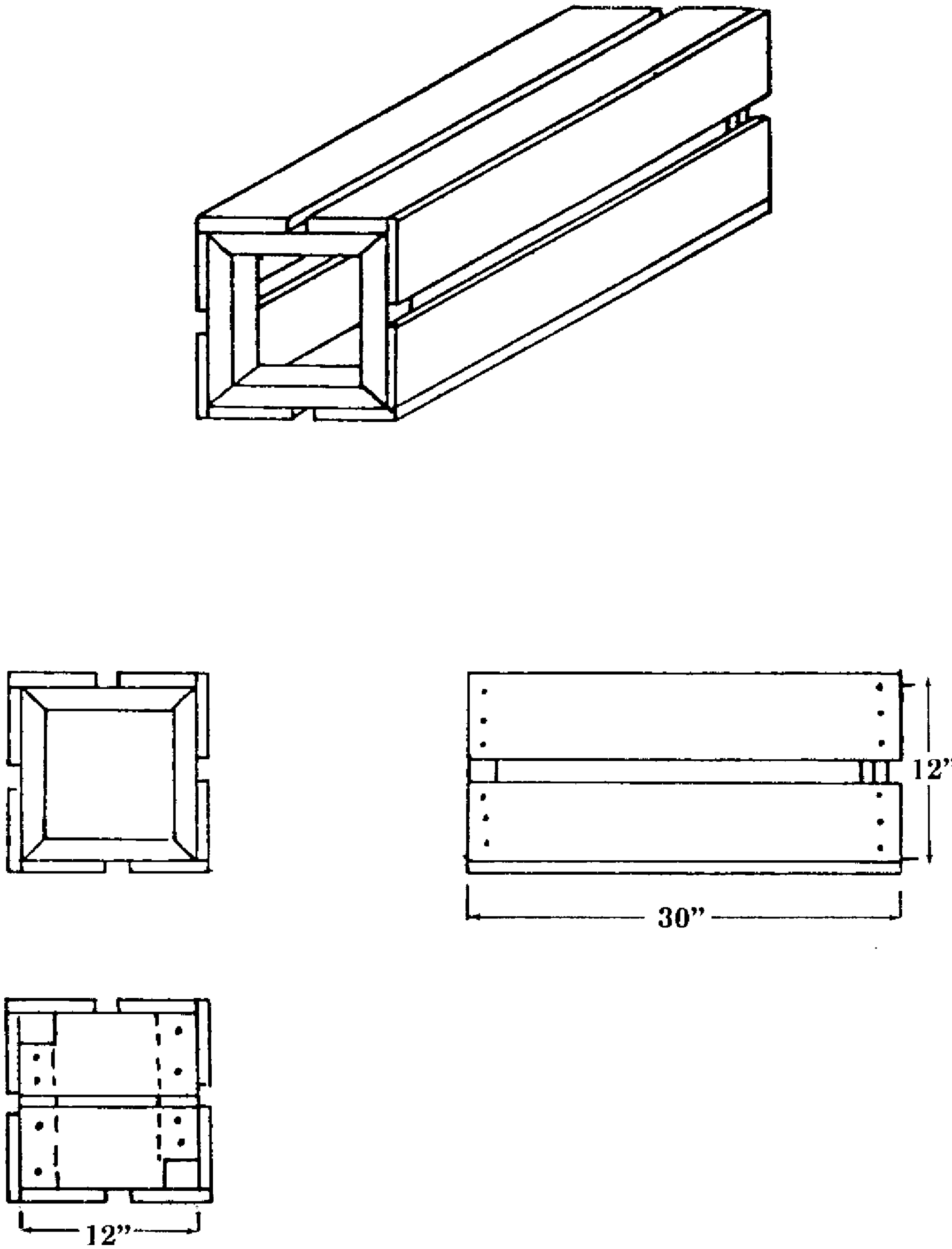

Fig. 7. Puget Sound slat pot (Clifton 1980).

Low construction costs, the relative ease of construction and repair and superior fishing performance make the wooden Kodiak lair pot or other variations of the Puget Sound slat pot the logical first choice of future octopus fishery development efforts. The use of the Octopot and Japanese plastic pots may be favored in certain specialized fishing situations. The PVC tube pot proved to be unproductive and is not further discussed in this report.

Chronology of Project

1979-1980 Information gathering

1981 Initial testing of wooden octopus pots by John Jensen, Petersburg, Alaska

1982 Acceptance of formal project proposal by State of Alaska

1983 Delivery of pottery octopus pots to five Petersburg fishermen (Phase I)

1984 Extension of project to Sitka and Ketchikan (Phase II)

1985 Extension of project to Kodiak, Alaska, using supplemental financial assistance provided by participating fishermen (James and Marilyn Guilmet) and the Alaska Fisheries Development Foundation (AFDF) (Phase III)

1986 Continued test fishing of remaining pots at Kodiak, Kake and other locations (Unofficial Phase IV)

The project officially concluded on March 15, 1986. Projects involving gear refinements and examination of specific regional octopus resources will be proposed in the future.

The project leader (B. Paust) received 1,200 ceramic octopus pots in March 1983. These pots were fished from March to October 1983 by the first group of cooperating fishermen. These individuals agreed to fish fully rigged ceramic octopus pots. The grant from the State of Alaska covered the cost of the pots. All other expenses were carried by the fishermen. This was the uniform financial pattern for all phases of this project. The cost to the state was $14,400.

Fishermen and Gear Used in Study

The fisherman first involved in the exploratory phase of this project was:

John Jensen — (F/V *Summer Breeze* - gillnetter)
P.O. Box 681 — small number of red cedar pots
Petersburg, AK 99833
(Coverage: eastern Frederick Sound)

Fishermen involved with the first phase of the official project were:

Dale Bosworth — (F/V *Leslie Ann* - longliner)
P.O. Box 45 — 200 ceramic pots
Petersburg, AK 99833
(Coverage: northern and western Frederick Sound)

Bill Connor — (F/V *Carolyn Ann* - multiple gear)
P.O. Box 1124 — 200 ceramic pots
Petersburg, AK 99833
(Coverage: southern Frederick Sound)

John Martin — (F/V *Fin* - gillnetter)
P.O. Box 825
Petersburg, AK 99833
(Coverage: central Frederick Sound)

Audi Mathisen | (F/V *Symphony* - multiple gear)
P.O. Box 413 | 200 ceramic pots
Petersburg, AK 99833
(Coverage: Wrangell Narrows)

Alan Otness | (F/V *Commander* - multiple gear)
P.O. Box 317 | 400 ceramic pots
Petersburg, AK 99833
(Coverage: northern Frederick Sound)

In the spring of 1984, the majority of the Petersburg pots were transferred to fishermen operating in more oceanic areas for the second project phase. Fishermen during this period were:

Dale Bosworth (continuing)

Audi Mathisen (continuing)

Bruce Anderson | (F/V *Casino* - pot shrimper)
P.O. Box 3218 | 200 ceramic pots
Sitka, AK 99833
(Coverage: west side of Prince of Wales Island)

Dick Bishop | (F/V *Isis* - pot shrimp)
P.O. Box A-15 | 200 ceramic pots
Ward Cove, AK 99928
(Coverage: Dixon Entrance, Cordova Bay and Clarence Strait)

Peter Hassemer | (College researcher)
Biology Department | 338 ceramic pots
Sheldon Jackson College | 70 Japanese plastic pots
P.O. Box 479 | 20 plastic tube pots
Sitka, AK 99835
(Coverage: Sitka Sound)

A grant received from AFDF in early 1985 paid for transporting the ceramic octopus pots to Kodiak (Phase III). The AFDF representative and fishermen were:

Michael Broili
Alaska Fisheries Development Foundation
805 West Third Avenue
Anchorage, AK 99501

James and Marilyn Guilmet | (F/V *Trinity* - crabber)
P.O. Box 3472 | 140 ceramic pots
Kodiak, AK 99615 | 600 wooden pots
333 Japanese plastic pots
(Coverage: Crab grounds adjacent to Kodiak Island)

The project continued with an unofficial fourth phase. Participating fishermen included:

Nick Davis | (multiple gear)
P.O. Box 234 | 30 ceramic pots
Kake, AK 99830
(Coverage: western Frederick Sound)

Paul Demmert | (multiple gear)
P.O. Box 274 | 30 ceramic pots
Kake, AK 99830
(Coverage: western Frederick Sound)

Additional transfers will be made until the pool of available pots is exhausted.

PROJECT RESULTS

The production goal established for this project was 21 percent occupancy by keeper octopus (greater than 9 lb) following a seven-day soak. This level of production was calculated to provide the typical small-vessel fisherman with sufficient incentive to remain in the fishery (based on ex vessel price of $0.75 per lb). Occupancy rates lower than 21 percent were believed to be inadequate to sustain interest. The figures used to calculate this production goal were:

* Type of vessel: longer than 45 ft (multi-fishery involvement)
* Cost of operation: $250 per day (including all costs)
* Dependence on octopus fishery: part-time, integrated with primary fishery
* Number of pots: 200 (400 for vessels in seiner category)
* Average weight of octopus: expected to be 15 lb (actual figure should have been 11 lb)
* Occupancy rate: 21 percent
* Ex vessel price of octopus: $0.75 per lb in 1983 (ex vessel prices now in the range of $1.25 to $2.00 per lb)
* Gross income: $947.10 per seven day fishing cycle or a gross daily supplement of $135.30 per day provided by harvested octopus (adjusted for current conditions)

Financial returns are treated in greater detail in "Calculation of Costs and Financial Returns," a later section of this report. Making certain broad assumptions, project guidelines support the statement that a properly directed octopus fishing operation can be financially rewarding, particularly when large numbers of pots (more than 200) are involved.

The catch records of most pots used in this project proved disappointing. Although valuable fisheries information was gained, development of a viable commercial fishery in southeastern Alaska has temporarily eluded us. Detailed studies of crab grounds in the northern portion of the region may reverse this finding. The situation is quite different in the northern Gulf of Alaska, where catch statistics are far more positive.

In southeastern Alaska, the ceramic Octopot did not meet the 21 percent production goal except in two isolated sets (21 percent and 23 percent occupation rates) following seven-day soaks. The occupancy rates attained by the Octopot in this region were typically in the range of 1 to 5 percent. In the northern Gulf of Alaska, the Octopot attained an average occupancy rate of 12 percent (11 lb per average octopus). The Kodiak wooden pot attained an average occupancy rate of 18 percent (22 lb per average octopus).

The Petersburg Quintet

The first phase of this effort consisted of five established Petersburg fishermen. Four of these individuals used traditional fishing vessels ranging from 37 to 47 ft in length. Each of these fishermen were supplied with 200 ceramic octopots. The fifth fisherman used a limit seiner (58 ft) and 400 pots. All vessels were equipped with hydraulic pulling gear and standard electronics packages.

Without exception the pots were longlined in sets of 20 to 100 pots. In most cases standard halibut groundline was used, although a variety of other line was successful when tested. Pot spacing ranged from 20 to 140 ft. Depths fished ranged from 10 to 200 fathoms. The pots were not baited.

A summary of catch statistics and comments from Petersburg fishermen follows.

* Catch rates were consistently from 1 to 5 percent. This production level cannot support a commercial fishing operation.

* The catch statistics did not indicate significant seasonal variations.

* Results verified the Canadian conclusion that shallow water fishing (less than 40 fathoms) is relatively unproductive. Hartwick (1982) reported catch rates of less than 6 percent at this depth range during the winter. One fisherman reported a consistent catch rate of 3.5 percent (3 to 5 lb octopus) in water of 5 to 20 fathoms in northern Frederick Sound (D. Bosworth, 1986 personal communication). For a short period of time another participant reported a 19 percent occupancy rate (12 lb average) at a depth range of 10 to 20 fathoms (B. Connor, 1984 personal communication). The informal nature of reported results makes the interpretation of these catch statistics difficult. The highest sustained rate reported by any of the Petersburg fishermen was 5.3 percent for the period from 3/83 to 10/83.

* It is apparent that octopus tend to be most numerous on current-swept rocky bottoms. It is also evident that these grounds are not often suited for a pot fishery. Artificial lair pots cannot compete with closely associated natural dens. Researchers have noted that the world's octopus pot fisheries tend to be most productive on sand, gravel and firm mud bottoms. This was found to be particularly true on bottoms lacking significant natural cover. The Petersburg fishermen found fishing on soft mud and sand unproductive. A California experimental fishery reported that when pots filled with silt or sand, the pots did not produce many octopus (Toole 1983). In southeastern Alaska the most productive fishing occurred on hard ground sloping up from a mud bottom. Highest catch rates occurred near the junction of mud and hard bottoms. Anecdotal accounts from spot shrimp and Dungeness crab fishermen on neighboring grounds reported high incidental catches of octopus in shrimp or crab pots. These incidental catch rates were usually several times the occupancy rates attained by the octopus pots. It soon became obvious that the octopus pots were not performing satisfactorily.

* Later in this project we learned the importance of tracking the movements of concentrations of indicator organisms, particularly Dungeness and tanner crab. Unfortunately, because of their distance from Petersburg, traditional crab grounds were not fished with Octopots during the first phase of the project. The productivity of tanner crab grounds in northern southeastern Alaska will be the subject of a future project.

* Vandalism and/or theft was the unexpected cause of significant gear loss during this phase of the project. During April 1983, 163 ceramic pots were lost to apparent vandalism. Barge traffic was responsible for the loss of additional gear. Approximately 25 percent of the pots were lost during the first phase of the project.

Although the catch rates obtained in the Frederick Sound region were higher than those from other projects in neighboring regions, overall production was far below desired levels. During October 1983, the majority of the ceramic pots were withdrawn from Petersburg and transferred to fishermen operating in more oceanic areas. These transfers initiated the second phase of the project. Unfortunately, logistical and timing problems prevented similar transfers to tanner crab and king crab fishermen operating in northern southeastern Alaska.

Richard Bishop (Ketchikan Shrimp Pot Fisherman)

A set of ceramic pots was moved to Ketchikan and fished in Cordova Bay and Felice Strait. Seven locations were fished between December 1983 and February 1984. Soak times ranged from 14 to 34 days. Most of the octopus fishing effort was concentrated in areas with bottom sediments composed of mud, rock and sand. The average occupancy rate was a disappointing 4.5 percent (7.2 lb average weight). Occupancy rates ranged between 0 to 18 percent per set. Depths fished ranged from 25 to 100 fathoms with the most productive fishing occurring at 50 to 70 fathoms between January 6 and February 10 of 1984. This location consisted of gully terrain with mud and rock substrate.

The participating fisherman experienced several significant problems with the ceramic octopus pots (R. Bishop, 1985 personal communication).

* The weight of the pot (23 lb) was considered excessive relative to pot volume.

* Overall pot volume was too small, selecting for smaller octopus.

* Ceramic pots were prone to breakage.

* Pots lacked sufficient drainage.

The pots fished by the Ketchikan fisherman were later transferred to Kodiak.

Peter Hassemer (Researcher, Sheldon Jackson College)

A large number of pots were transferred to Sheldon Jackson College in early 1984. The pots were of three types: ceramic pots (338), plastic tube pots (20) and Japanese plastic Uroko-type pots (70).

These pots were actively fished by university researchers from January to May 1984. The pots were fished in the usual manner using 1/4 in. groundline. The groundline only broke once. Pots were initially set in groups of 60 (100 ft spacing) with the number of pots per set later reduced to 20 in order to ease handling (distance between pots remained 100 ft). Standard halibut snaps were satisfactory connections to the groundline when used in conjunction with loops tied into the groundline.

All pots fished in the Sitka Sound area were unbaited. A small number of baited pots were tested once. The bait was quickly consumed by sand fleas (amphipods) and starfish. Those involved in the project do not believe it is practical to use baited octopus pots.

Sheldon Jackson College researchers confined their test fishing to three types of habitat within Sitka Sound. These test areas were:

* steep rocky slopes of large bays within a depth range of 50 to 90 fathoms,

* rocky island shorelines in depth range of 30 to 50 fathoms, and

* shallow gravel-rock bottom in depth range of 10 to 30 fathoms.

In spite of extensive effort, the catch rate averaged less than 1 percent in Sitka Sound. Numerous signs of octopus occupancy were observed, particularly in pots along rocky island shorelines (10 to 15 percent contained shell fragments) and on shallow gravel bottoms (indication of 20 percent occupancy). However, the only octopus harvested were immature males. The most productive fishing areas were along island shorelines at the junction of steep rocky slopes and adjacent, flatter, silt-covered bottom. This type of habitat proved difficult to fish because of the convoluted nature of the rocky slope-mud bottom junction. Precise placement of the pots was difficult on this type of terrain and the groundline frequently tangled with various obstacles projecting from adjacent slopes. In spite of these difficulties very little gear was lost. Although the Japanese plastic pots comprised only 7 percent of the total fishing effort, they produced 50 percent of the very limited octopus catch (P. Hassemer, 1985 personal communication).

Bruce Anderson (Sitka Spot Shrimp Fisherman)

A second Sitka fisherman actively fished 200 ceramic pots from November 1983 to May 1984. Approximately 4,000 pot hauls were made in the course of his efforts. The areas fished included lower Cordova Bay, Moira Sound and Ernest Sound.

For the most part, the Octopot sets were placed in close proximity to shrimp pots. The gear was arrayed in strings of 30 unbaited pots attached to 5/16 in. leaded polypropylene groundline with standard snaps. Soak times averaged five days (range three to fourteen days). The optimum soak time was in the range of three to eight days. Longer or shorter soak times resulted in negligible catch rates. Higher catch rates were observed when the pots were pulled during daylight.

Handling the pots aboard the fishing vessel was facilitated by putting a double layer of rubber foam mats where hauled pots were placed on the deck. Breakage was reduced and much of the work strain was removed. Pots were further examined or manipulated on a worktable positioned at normal working height. This further reduced strain, particularly when removing mud from the pots.

Approximately 20 percent of the gear was lost over the course of the experimental fishery. Most of these pots were lost when both buoy lines were lost from a single string of 30 pots.

This experimental octopus fishing effort was largely restricted to rocky cliff areas that produced good catches of spot shrimp. The most productive octopus grounds were in the depth range of 45 to 80 fathoms. Fishing at depths of 15 to 40 fathoms and deeper than 90 fathoms produced very poor results. The researcher concluded that harvestable octopus were found only in close association with spot shrimp concentrations.

In spite of extensive efforts, the Octopots (following the same pattern observed elsewhere) did not produce large numbers of octopus. The occupancy rate averaged 3 to 4 percent throughout the five-month fishing period. It is believed that the Octopot and other lair pots cannot compete with the numerous potential natural den sites found on typical spot shrimp grounds. This would tend to rule out using octopus pot fishing as a companion fishery supplementing shrimp potting. Octopus pot fishing did not prove financially viable in this situation. (B. Anderson, 1984 personal communication).

James and Marilyn Guilmet (Kodiak Multi-gear Fishing Family)

James and Marilyn Guilmet operate a fully equipped 52 ft fishing vessel designed for salmon trolling, longlining and other functions. The Guilmet's interest in developing an octopus fishery is much the same as that expressed by other interested Alaskan fishermen: its potential as a companion fishery to traditional or primary fisheries. Using the words of Marilyn Guilmet (1984 personal communication), "I believe octopus fishing is a very compatible fishery to blend with salmon trolling, halibut and black cod fishing. Because of the soak time, the gear can be fished between halibut openings or in conjunction with black cod fishing and trolling. The basic techniques for longlining halibut and black cod can be used with minor modification for setting and hauling octopus pots. This optional diversification provides the vessel with less non-fishing time due to weather and allows more efficient use of fuel and incurred expenses."

The major part of the Kodiak octopus explorations (the third phase of this project) was financed by the Alaska Fisheries Development Foundation and the Guilmets. Augmented funding for this part of the project allowed the participating Kodiak fishermen to use significant numbers of several traditional pots: 140 ceramic pots (Octopots), 300 red cedar and 300 spruce modified slat pots, and 333 Japanese plastic urn pots.

It was originally envisioned that a larger version of the Petersburg ceramic pot would be produced by the Kodiak participants. However, a number of logistical and cost problems intervened. This pot was to have a volume of approximately 2.25 cu ft (30 in. tall and 16 in. in diameter). Pot weight would have been in the range of 50 to 60 lb. This weight was considered excessive.

Much of the technical success of this project phase was because Kodiak fishermen adopted two key strategies:

* The Kodiak fishermen diverted much of their attention from ceramic pots to wooden pots because of the technical problems previously reported. They opted to use a modified Puget Sound slat pot.

* Tanner crab was used as the key indicator species. Other indicator organisms were considered as well, including clams and shrimp. Test fishing was largely restricted to areas with commercial tanner crab fisheries. The participants had extensive knowledge of productive crab grounds, crab migrations and the location of areas that lacked significant natural cover for octopus.

The wooden Kodiak pots were constructed using 1 in. thick spruce lumber. Additional pots were fabricated from red cedar. See Figures 6 and 7 for construction details. The pot's length was slightly shorter than the standard slat pot (26 in. instead of 30 to 36 in.). The Kodiak pot required 50 lb of rock or steel plate ballast during the initial fishing period (dry weight was estimated to be 60 lb). The amount of ballast was decreased by 50 percent as the wood became saturated with water.

Some caution should be taken when selecting ballast for wooden octopus pots. Poor pot performance has been attributed to the use of several ballasting materials, including cement (Nakada and Nakada 1981) and certain types of scrap metal. In one case near Ketchikan, sections of heavy electrical cable containing steel and copper were used and no octopus were ever caught in the pots. A galvanic reaction is believed to have occurred in this case. Large chain links, tractor tread sections and similar iron scrap are considered to be appropriate ballast, along with beach cobbles.

Table 3. Results from Kodiak Island segment of the Alaska octopus project.[1]

Catch Breakdown	Kodiak pots (untreated spruce)	Kodiak pots (treated spruce)	Ceramic pots	Japanese plastic	Red cedar pots
Overall pot occupancy (%)	17.5	18.3	11.8	7.7	3.2
Average weight of captured octopus (lb)	18.2	15.8	10.8	15.0	11.9
Depths fished (fm)	40-110	65-100	40-110	40-120	60-115
Most productive depth (fm)	90-110	80-90	50-90	90-120	95-100
Male (%)	56.5	95.5	61.4	55.5	76.2
Female (%)	42.4	4.5	38.6	33.3	14.3
Unknown sex (%)	1.1	0	0	11.2	9.5

[1]M. Guilmet, 1985 personal communication; Guilmet et al. 1986.

Each wooden pot was equipped with a 1/4 in. nylon rope bridle attached at two upper corners. The bridle was attached to the groundline with a heavy wire snap (0.13 in. diameter). This snap was also used on the ceramic pot bridle.

Approximately one-half of the Kodiak pots were treated with a chemical anti-foulant commercially known as Flex 10. Refer to the shipworm section of the Appendix and to Guilmet et al. (1986) for additional details and precautions. Although the treated pots attracted large numbers of octopus, the Guilmets and the author of this report cannot recommend continued use of anti-foulants that contain tri-butyl tin (TBT). This substance has been widely used in anti-foulants, but has since been found to pose serious environmental hazards.

The plastic, ceramic and wooden pots were set from a small platform at the stern of the fishing vessel. Several types of groundline were used, all generally 1/4 in. in diameter. Heavier line of 9/32 in. diameter was used later in the fishery to better accommodate the strain on the gear. The interval between pots was increased from an initial 40 to 60 ft. to a uniform 100 ft. The heavy wire snaps proved to be adequate (the use of loops in the groundline was abandoned). Soak time averaged seven days (range six to eight days).

The test fishing period extended from August 1984 to March 1986. The results are positive and are believed to represent productivity levels that can be expected from operations in which proper gear is used with appropriate fishing strategies. The results from the Kodiak Island segment of this project are shown in Table 3.

Throughout most of the initial testing period, various types of pots were alternated on the groundline. The statistics given in Table 4 apply to situations where side-by-side testing took place. Different types of pots were fished on the same groundline at approximately the same depth and at the same time. Pot separation was approximately 100 ft in most cases. Although the distribution of pots was not random, the arrangement does provide useful comparative statistics.

A summary of additional practical information resulting from the Kodiak portion of the project is as follows:

* The gear is set very rapidly. A variety of obstacles slow pulling to a much slower pace.

* **Groundline should be robust (at least 9/32 in.) and able to resist abrasion.**

* Although data is important, its collection can be very time consuming.

* A picking boom facilitated handling the pots during the pulling process.

* Weight of pots can be considerable. Ceramic and plastic pots occasionally accumulate mud. Wooden Kodiak pots quickly become waterlogged so that half of the ballast can be removed.

* Breakage of ceramic pots was limited, although 31 were destroyed during shipment by van to Kodiak.

* Some of the wooden pots required renailing.

Table 4. Results of side-by-side fishing of different pots.

Comparison	Overall pot occupancy (%)	Average weight of octopus (lb)
Treated wooden pots vs. untreated wooden pots	Treated = 18.3 Untreated = 15.6	Treated = 15.8 Untreated = 14.8
Untreated wooden pots vs. ceramic pots	Untreated = 17.3 Clay = 16.0	Untreated = 20.0 Clay = 10.5

* Considerable concern was expressed about the potential harmful effects of chemical anti-foulants. Fishermen should consider using untreated spruce pots in order to avoid personal and environmental contamination (Guilmet et al. 1986). Damage to wooden pots fished in areas with wood borers can be slowed by periodically air drying the pots.

* Pot intervals extended to 100 ft to lessen groundline tension.

* Catch statistics indicate that the optimal season for octopus pot fishing is the fall to early winter period. Significant improvements in catch rates and average weights of captured octopus were noted during the spring to early winter period (Table 5). Catch composition by sex is listed in Table 6.

* Catch data for the March to June period suggests that reproductive activities may be responsible for relatively low catch rates. Female octopus were largely absent from the catch during this period. This situation reversed after June and the pots returned to anticipated productivity levels.

* The harvesting efficiency of the red cedar pots was far below expected levels. Lower production was probably associated with the spring to early summer period. Other problems associated with red cedar (softness of material, tendency to split and relative high cost) make the use of locally produced spruce pots more attractive.

* Vandalism and/or curiosity resulted in significant loss of gear. In cases where curious fishermen pulled octopus pot sets, the groundline may have become frayed by rapid pulling, resulting in groundline failure and loss of gear. The only alternative may be to fish octopus as a full-time winter fishery.

The catch rates reported by the Guilmets were often above anticipated levels. Several extensive sets of treated and untreated wooden pots had production levels approaching 30 percent and produced very large octopus. Repeat setting on the same grounds did not initially produce significantly lower catch rates. Over the long-term, resetting pots on the same grounds resulted in significantly lower catch rates for most areas.

The Kodiak results suggest that cost-effective octopus fisheries are possible in selected areas. To further develop regional octopus fisheries, participants should carefully consider using wooden pots and the associated fishing strategies developed in this portion of the project.

Summary of Additional Project Results Concerning the Ceramic Pot

The analysis of project results presented to this point has focused on octopus production and the comparative performance of octopus fishing gear and fishing strategies. A number of additional findings were also brought to light, particularly with regard to the ceramic Octopot. The ceramic pot is still of interest and may prove useful in some Alaskan situations. This is particularly true since this type of octopus pot is used extensively in several major world fisheries. A summary of remarks concerning the experimental ceramic pot follows:

* There can be little doubt that the ceramic pot was out-performed by the Kodiak wooden pot in the northern Gulf of Alaska test area during the third phase of this project. It is assumed, with some caution, that wooden pots used with appropriate fishing strategies will produce similar results in other areas. However, there are ways to improve the performance of the ceramic pot. Participating fishermen had several suggestions: Volume should be increased to accommodate larger octopus. Reconsider using a layer of trawl web around each pot to increase durability. Put more holes in the bottom and sides of the pot to increase water circulation when it is on bottom, to serve as octopus look-out ports and

Table 5. Catch rates by month for all pot types.

Month	Ave wt (lb)	Catch rate %
March	11.9	2.4
May	16.7	8.9
June	13.1	12.2
August	19.1	12.9
September	22.4	23.1

Table 6. Catch composition by sex.[1]

Month	Male %	Female %
March	76	14
May	88	4
June	90	5
August	32	59
September	33	66

[1]Remaining animals captured were of unknown sex.

to allow water to drain more rapidly when the pots are hauled. The shape should be changed from perfectly round to oval to increase the pot's stability on steep grounds.

* Although the ceramic pots are relatively heavy, their high density allows them to be self-ballasting. Additional anchoring devices are generally not needed (P. Hassemer, 1985 personal communication).

* Ceramic gear can be hauled very rapidly. It takes less than 30 minutes to haul and reset a string of 30 pots. At this rate it is feasible to handle an average of 500 pots per normal fishing day (16 hr) when individual strings are deployed in the same area (B. Anderson, 1985 personal communication).

* The problem of pot weight (ceramic or wooden) and potential vessel stability problems concerned several participating fishermen. Small deck loads were favored by most. Placing pots in holds and other below-deck storage spaces proved time consuming and invited pot breakage.

* Two pot thicknesses were apparent—thicker ones averaged 23 lb per pot, thinner ones averaged 18 lb per pot. Although the lighter pot was easier to handle, it was less durable (P. Hassemer, 1985 personal communication).

* The ceramic pots were durable. They were easy to stack on deck or in storage areas. Furthermore, these stacks were quite stable in stormy seas if properly secured. The primary source of ceramic pot damage was dockside handling. Several participants reported that when a full set of pots (200) was handled, two to four pots were usually damaged. Bruce Anderson (1984 personal communication) suggested that such loss may be partially due to an attitude problem. Most fishermen have grown accustomed to the durability of plastic, steel, nylon and other materials. American fishermen have had little experience with crockery (D. Bosworth, 1985 personal communication). Pots were most often damaged from contact with other ceramic pots. This damage was primarily confined to cracking the pot rim or lip. Pots did not generally break when they hit the vessel sides or decks. Setting a complete string of pots resulted in the average loss of one pot due to landing on rocks.

* Ceramic pots are not prone to hang on bottom obstructions.

* Onshore handling of ceramic pots can be rapid. A set of pots can be moved from storage area to vessel in one working day. Moving the pots on deck is also relatively easy.

* Many pots (ceramic or wooden) can be stored in a relatively small space.

* Pots exposed to weather during storage were not significantly damaged. In one case, pots were frozen to -30°F with no breakage (B. Anderson, 1984 personal communication). However, unglazed pottery stored in exposed areas over a wide temperature range will suffer surface flaking or exfoliation (Hamilton 1983). Ceramic pots will crack when exposed to rain or high tides and repeated freeze/thaw cycles.

Summary of Significant Fishing Strategies

Participating fishermen passed along other observations that should be carefully considered by prospective octopus fishermen. Most of the following observations constitute important fishing strategies.

The octopus fisherman must be familiar with the fishing grounds, the distribution of indicator species, the location of natural cover and the migration patterns of octopus and prey species. Efficient inshore octopus fishing seems strongly correlated with water temperature and relative abundance of prey species. A key indicator species in Canadian waters is the red rock crab (*Cancer productus*) (Hartwick 1982). Reports written by Clifton (1980) and Hartwick (1982) are essential reading for a prospective octopus fisherman.

Octopus migratory behavior is poorly understood. Consequently, many fishermen either fail to intercept significant numbers of octopus or fail to follow octopus along their migratory pathway once contact has been established.

Many fishermen do not use proper scouting procedures. Scout pots are placed at depths above and below the major group of pots. The scout pots are checked periodically to see if the major concentration of octopus is moving to other depths.

Most prospective fishermen are not aware of the proper scale for a commercial octopus fishing operation. To be financially viable, a boat may fish 2,000 to 3,000 pots, as in the Japanese industry. Only limited financial returns can be expected when using 100 or fewer pots.

Pot fishing for octopus on grounds with large amounts of natural cover, such as in most spot shrimp areas, appears futile. Octopus will be captured only incidentally in these areas. Other types of octopus gear (claw hooks, scuba harvesting, etc.) may be useful in areas with significant natural cover.

On some grounds the presence of abundant indicator species does not necessarily indicate a good location for octopus pot fishing. Other factors, such as significant natural cover, pot type and season may reduce the number of octopus caught in pots. One researcher states, "If you put traps near rocky areas, the octopus will choose the natural dens." In one area divers harvested 154 lb octopus per hour, but pots fished in the same area caught very few octopus (Blackburn 1984).

Dive harvesting may be a possible solution in some areas. Divers can harvest from 22 to 154 lb per hour depending on the location (Hartwick 1984).

This study shows that commercial octopus fishing is possible using large-volume wooden pots fished in relatively deep water. Highest occupancy rates occurred in the late winter. The use of large wooden pots is supported by the findings of several other researchers (Hartwick 1982; Kyte 1983; Clifton 1980).

Octopus caught in deep water tend to be larger than those in shallow water.

Octopus captured from deeper waters show more evidence of relatively high predation rates, such as missing arms and scars. According to Hartwick (1982), this suggests a shortage of protective denning sites in these areas.

This project indicated that a soak time of approximately six to eight days is nearly optimal. Proper soak times will probably be highly variable, depending on location of grounds and the season. The best soak time for deep areas off Vancouver Island is 10 to 12 days (Hartwick 1982).

This and other projects demonstrate with considerable certainty that larger pots attract larger octopus. However, as pointed out by Hartwick (1982), the size of octopus captured varies more with larger pots. Those seeking octopus for halibut bait will strongly favor the use of large pots (B. Anderson, 1984 personal communication). Minimum size for bait octopus is in the range of 15 to 18 lb, although much smaller octopus have been used with good results. Sales of bait octopus depend highly upon adherence to proper quality control measures.

Pots tested in this project were highly selective for males. It is not known if these octopus were post-reproductive males.

Although available statistics do not provide a clear picture of the effect of "night pulling," it is apparent that the incidence of "riders" increases with this practice. During daylight hours most captured octopus are inside the pots (M. Guilmet, 1986 personal communication).

Several fishermen stated that it would be helpful to have pot gangions long enough to allow unsnapping while the pot is still slightly submerged. Reduced tension on the gangion eases this operation and tends to keep the pot further away from the hull (P. Hassemer, 1985 personal communication). Several fishermen also had problems with octopus adhering to the hull, pulling themselves free of the pot and escaping. In apparent contradiction to this, another fisherman prefers very short gangions. If the pulling equipment is properly placed, the pot can be pulled from the water to the level of the rail with hydraulic power (B. Anderson, 1984 personal communication).

In an octopus operation involving 200 or more pots, two deckhands will be needed to manipulate the gear.

Several fishermen had to tie loops in the groundline, to which snaps were attached, to prevent the pots from slipping on the groundline during hauling. Others who used very heavy snaps found that no slippage occurred on unmodified groundline. No pot losses were reported with the use of heavy-duty snaps.

Heavy, abrasion-resistant groundline should be selected. Some pots were lost because of chafing and eventual failure of inappropriate (light-duty) groundline.

In some regions the annual rate of octopus gear loss has been 20 percent (Kyte 1983). A similar rate of gear loss was experienced in this project. Major sources of loss include vandalism, theft, lines cut by barges and conflicting fishing activities such as trawling. A possible solution to this problem is to use time-released links that keep buoys submerged until the end of the soak time.

Octopus pot fishing may not be a part-time effort after all. If large numbers of pots are soaked over extended periods (six to twelve days) the fishing area will probably have to be watched constantly (M. Guilmet, 1986 personal communication).

HANDLING OCTOPUS ONBOARD SMALL FISHING VESSELS

QUALITY CONTROL: BACKGROUND INFORMATION

Octopus production has been a minor industry in Alaska. Recent interest in developing local octopus fisheries is due primarily to the increased demand for octopus used as bait in the halibut fishery. Prior to the second 1986 opening in Southeast Alaska bait octopus sold for more than $1.60 per lb. These prices increased to approximately $2 per lb in the northern Gulf of Alaska prior to the May 1987 halibut opening. Increased bait prices are believed to have been caused by shortages of large octopus harvested by the major supplier (Japan) and strategies in the halibut fishery that use more octopus. The most discerning octopus predator is probably the Pacific halibut.

Octopus has not been an important source of income to most Alaskan fishermen and has in fact been considered a pest by some. Consequently, incidentally captured and retained octopus have frequently been subjected to abusive handling and storage. Octopus meat is fragile and prone to rapid quality deterioration. The development of rancidity is a serious problem. Rancid octopus is poor halibut bait and, with even limited deterioration, is believed to repel halibut.

Veteran halibut fishermen will check quality and reject bait octopus that is not top quality. Bait octopus rejection gained considerable attention in the early 1980s. Because poor quality octopus didn't sell, several major seafood processors refused to buy octopus incidentally captured in regional crab fisheries. Processors who purchased octopus accepted only live deliveries or product frozen onboard.

The first phase of this project called for the live delivery of octopus to Petersburg Fisheries Incorporated (Icicle Seafoods). Proper onboard handling is essential in the development of local octopus fisheries. Placing captured octopus in iced storage is not appropriate or acceptable handling. The exacting quality demanded by regional halibut bait marketers and users mandates the use of either onboard live-holding tanks or effective onboard freezing facilities. Some preliminary experimentation has been done with storing dressed octopus in plastic bags held in refrigerated and chilled seawater systems. These results, although positive, are tentative.

Basics of Onboard Handling

It is often reported that removing an octopus from a pot can be tedious. Some workers have suggested the use of dilute chlorine solutions, starfish extracts, other chemicals and cattle prods to accelerate the removal process. These procedures can damage the product as well as contaminate the pot, reducing fishing efficiency. Fishermen in this project found that *Octopus dofleini* was a cooperative animal. The normal procedure was to place the pot on its side and after a short time, approximately 15 min, the octopus would voluntarily exit the pot. The empty pot would then be included in the next string of gear.

If the octopus is disagreeable, it is usually when it leaves the confines of the pot. If the loose octopus is not contained in a checker or some other cool, temporary storage area, it will soon be lost overboard. The occupied octopus pot can be placed in a 20 gal garbage can. The octopus is later transferred to a larger container (B. Anderson, 1984 personal communication). The pot can also be placed in a closed checker area. Octopus that leave the pot are then placed in a large, burlap-covered tote with flowing seawater. The accumulated octopus are removed just prior to processing (freezing in this case) (M. Guilmet, 1986 personal communication). The short-term storage container used by one Puget Sound fisherman consists of a covered, burlap-lined plywood storage box (6 ft x 4 ft x 4 ft). The burlap lining prevents sucker adhesion so the octopus can't crawl out of the container.

Octopus are removed from these containers and are then either placed in a long-term, live-storage facility or are dressed, butchered, packaged and frozen.

Several medium and long-term, live-storage methods have been used along the West Coast at one time or another. Evaporative damp storage uses ice. In its simplest form, a 3 to 5 in. layer of ice is put down in the bottom of an insulated checker, hold, or tote. A layer of saltwater-saturated burlap is placed on ice (kelp fronds can be substituted for the ice and burlap). Live octopus are placed on the burlap, then saltwater-saturated burlap is placed over octopus. The burlap is covered with a 3 to 5 in. layer of ice and the entire mound is covered with an insulating blanket. This method can maintain octopus in viable condition for a maximum of 48 hr.

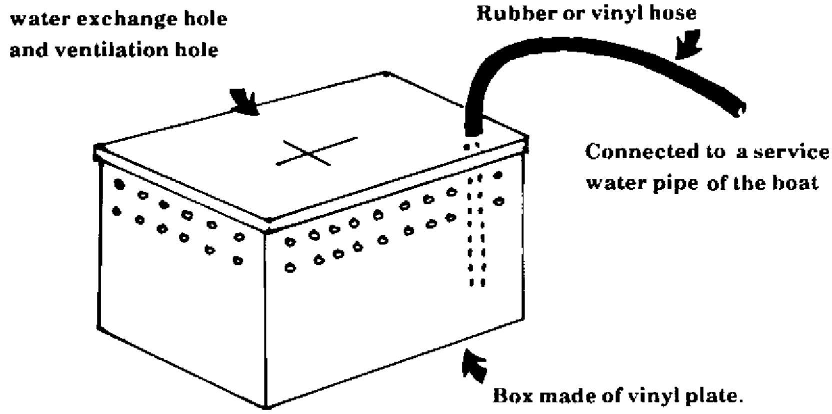

Fig. 8. Small octopus live storage box. The lid should be made of thick rubber and the aperture cut into a cross so that it can close automatically after an octopus is put inside (Yamaha 1981).

Figure 8 illustrates an Australian example of the flooded tote method. An upwelling circulation system is built into a large tote with 1/4 in. drain holes drilled along upper lip of container. Octopus are placed in onion sacks or other net bags and suspended in the tote. Octopus must not be allowed to pile up on bottom of tote, since rapid asphyxiation is the most probable result. Rapid circulation must be maintained, particularly when the tote is heavily packed with octopus. In low-density situations, bagging can be omitted, but cannibalism can become a problem. The lid must be securely fastened to hinder escapees. This method can hold octopus for at least seven days (water temperature is an important limiting factor).

The crab live-tank method is probably the most common holding procedure used in Alaska. The same general procedure as in the flooded tote method is used, but on a larger scale. Handling methods developed for this project called for placing octopus in onion bags secured to the hatch combing by a 3 to 5 ft gangion (actual length will depend on the size of the tank). Again, it is important that octopus not pile up on the bottom or in the corners of the tank because they will suffocate. Also, special precautions should be taken when crab or shrimp are carried in the same tank. High stress levels can lead to oxygen crisis, particularly if water circulation is interrupted. Again, the hatch must be securely fastened. Escaping octopus have produced some interesting stories, particularly when they come back for more crab. This method will hold octopus for seven or more days.

In the live pot method, net bags containing live octopus are placed in crab pots or similar containers and placed on hard bottom with adequate current. A similar method uses floating live boxes of the type used for storing Dungeness crab. This method was used years ago and its effectiveness is not precisely known. The latter method is somewhat similar to systems used in public aquaria and might hold octopus over the very long-term (months). In some cases, long-term storage will require implementation of a feeding schedule.

A number of these live-holding methods use onion sacks or similar net bags. The net bags used by the Petersburg fishermen were 50 lb capacity poly onion bags. Individual octopus are placed in each bag and the bag is then suspended in a live tank or similar facility. If two or more octopus are placed in one bag, they will usually cannibalize one another. Poly bags of this type are available from a number of sources including bag manufacturers. Bags used in this project cost $0.29 per 50 lb bag when purchased in lots of 1,000. The bags were ordered from:

Friedman Bag Company, Inc.
P.O. Box 13389
Portland, OR 97213
(503) 232-9181

New bags with printing errors can be obtained very inexpensively. Fishermen making orders should request "fused" bags. The web of these bags has been heat-treated and cannot be easily spread apart. Determined octopus can escape from non-fused bags by spreading the web and moving through holes. Nylon net laundry bags have also proven effective, but are quite expensive when purchased new.

The damp storage method is similar to a system being used in California to carry live octopus to market by truck. Octopus are placed in large plastic barrels and covered with saltwater-saturated packing material. The octopus remain alive over a 24 hr delivery period (Toole 1983).

Octopus destined for onboard freezing are usually dressed (gutted) soon after capture. Dressing is rapidly accomplished by turning the mantle inside-out and eviscerating. The process is sometimes known as "turning the cap." The mantle is separated from the visceral mass by either cutting it free with a knife or by placing the knee at the top of the mantle and tearing the mantle free of the viscera. The beak and eyes are usually removed at this point. Some food markets require retention of the ink sac with the carcass. The carcass is then freed of slime, the inner lining of the mantle is removed and the finished product is then inspected, packaged and refrigerated. A photographic description of the gutting process is found in Guilmet et al. (1986). Information concerning the preservation of octopus ink (marketed as sepia) is available from the author or Guilmet et al. (1986).

Slime removal is simplified by placing the carcass in a container of circulating sea water for several hours, although care should be taken to prevent meat from deteriorating because of thermal abuse. The eviscerated carcass may still have considerable nervous function. This activity can be terminated by crushing the nerve ganglia between the eyes (D. Clemens, 1985 personal communication). The carcass is then rinsed free of remaining slime, butchered, packaged and frozen. Care must be taken to prevent rancidity development during frozen storage. The use of closely adhering plastic packaging or water glazes is advised.

A superior product is more likely to be produced if the octopus is frozen immediately after dressing, resulting in a thawed product that has bright orange skin and white meat. A quality product does not have appreciable amounts of slime (M. Guilmet, 1986 personal communication). Contact icing produces an inferior product. Traditionally iced octopus produce foul ammoniacal odors within three days of capture.

ECONOMIC PROBLEMS FACING THE DEVELOPMENT OF AN ALASKAN OCTOPUS FISHERY

The octopus fisherman must cope with a variety of tactical and financial challenges. Some of these include:

* Successful integration of octopus fishing into an existing operation either as a companion or simultaneous fishery or as a secondary fishery to be fit in between primary fisheries
* Understanding of octopus biology, distribution and migratory behavior
* Development of adequate scouting techniques to track key indicator species and the location of main octopus populations
* Avoiding marginally productive areas and seasons
* Maintaining markets
* Making a reasonable profit

In addition to these, the prospective Alaskan octopus fisherman must maneuver through additional obstacles, some of which are unique to the developing commercial octopus fishery:

* Vandalism and unexplained disappearance of gear
* Vessel modification, including the need for hydraulic pulling equipment
* Stability problems associated with heavy deckloads of octopus pots and, in some cases, maintaining flooded live-storage facilities
* Development of effective octopus fishing strategies based partially on tracking indicator species
* Testing gear and exploring grounds without adversely affecting the financial viability of primary fisheries
* Establishing dependable markets, including planning for long-term storage of product prior to sale as halibut bait
* Establishing effective quality control procedures
* Preserving pot service life
* Calculating gear costs including annual loss rates
* Coping with resource problems associated with overfishing, area closures and adverse management decisions
* Establishing a proper scale for the proposed fishing operation

Accurately determining economic feasibility is complex even under the best conditions. It is not surprising that a close review of this project's operational assumptions has turned up some miscalculations.

* **Local octopus fisheries can be integrated into a number of traditional primary fisheries or otherwise fished on a part-time basis.** Realities: The shortened seasons for many primary fisheries make this difficult, perhaps impossible. Other constraints, including the unexpected problem of vandalism, mandate something close to full-time surveillance of octopus gear.

* **Tracking concentrations of several indicator species (spot shrimp, Dungeness crab and tanner crab) is an adequate strategy for locating octopus concentrations.** Reality: Although these species often serve as accurate indicators of octopus abundance, the octopus present may not climb into pots because of local conditions such as ground type or natural dens.

Table 7. Breakdown of 1984 octopus catch.

Fisheries area	Landed (lb)	Ex vessel price (dollars)	Value (dollars)
Ketchikan	1,916	1.07	2,052
Petersburg/Wrangell	365	0.85	311
Prince William Sound	154	0.75	116
Cook Inlet	56,698	0.76	42,920
Kodiak	12,974	0.73	9,456
Dutch Harbor	215	0.50	107
Bering Sea	698	0.75	523
	Total 73,020	Average 0.77	Total 55,485

* **Many markets are available to the octopus fisherman.** Reality: Domestic and foreign markets are subject to wide price fluctuations. This and associated export marketing complexities limit the options of the octopus fisherman. The halibut bait market is currently the major outlet for *Octopus dofleini* from Alaskan waters.

* **A significant supplemental income can be gained from using a few hundred octopus pots.** Reality: The development of a financially rewarding octopus fishing operation, particularly one in which full-time gear management is required, may require several thousand pots.

* **Many areas of Alaska have large octopus resources.** Reality: The necessary conditions for development of octopus pot fisheries may be found only in few isolated areas. Possibly because of this, the reported commercial harvest of octopus in Alaska is low. The breakdown of the 1984 catch is shown in Table 7.

The largest portion of this catch was harvested incidentally in crab, shrimp and trawl fisheries. Recent ex vessel prices paid for bait octopus have generally been in the range of $0.90 to $1.25 per lb (1986) and $1.25 to $2 per lb (1987). There are several reasons for the increased attention given to octopus in the bait market:

* High quality octopus is an effective halibut bait.

* Octopus is durable bait with a bait life of approximately 24 hr (bait life of herring is 4 hr and that of codfish is 10 to 12 hr).

* Shortened halibut fishing seasons, favoring durable baits.

* Octopus is a good bait for the modified halibut fishing strategies that have been generally adopted by the fleet, including use of additional skates of gear, decreased hook spacing and circle hooks.

* Octopus adheres to the hook better than softer baits such as herring.

* Quality octopus bait can be soaked two to three times, reducing rebaiting time and increasing fishing efficiency. For these reasons, many fishermen are willing to purchase bait octopus at premium prices. The demand for bait octopus in Alaska and from other sources is expected to remain stable.

As mentioned elsewhere, profitable octopus pot fisheries exist in several other parts of the world. These fisheries are successful primarily because ex vessel prices for food-grade octopus tend to be high and because the necessary fishing techniques have been adapted to local fishing conditions. In some areas, this process of adoption has taken several centuries. A third reason for the success of other octopus pot fisheries is that they are often very economical (Yamaha 1986). It appears likely that small-scale octopus pot fisheries supplying regional bait markets can be developed in Alaska.

Calculation of Costs and Financial Returns

The cost effectiveness of a hypothetical Alaskan octopus pot fishery operation is estimated in the following projection. The various calculations assume that:

Table 8. Annual gross income and cost calculations.

Type of operation	Ex vessel price/lb	Gross income (dollars)	Operational costs (dollars)
(A) Ceramic pots, 500 pots	0.90	12,678	48,000
(B) Ceramic pots, 500 pots	1.15	16,199	48,000
(C) Ceramic pots, 1,000 pots	0.90	25,355	51,000
(D) Ceramic pots, 1,000 pots	1.15	32,398	51,000
(E) Wooden pots, 500 pots	0.90	32,847	46,800
(F) Wooden pots, 500 pots	1.15	41,971	46,800
(G) Wooden pots, 1,000 pots	0.90	65,693	48,600
(H) Wooden pots, 1,000 pots	1.15	83,941	48,600

* season = 180 days (not continuous, but divided into several discrete seasons some of which may be fished simultaneously with primary fisheries)

* soak time = 7 days

* pots fished = 500 or 1,000

* meat recovery = 83 percent

* standard occupancy rates = ceramic pot: 12 percent; Kodiak wooden pot: 18 percent

* average weight of captured octopus = ceramic pot: 11 lb; Kodiak wooden pot: 19 lb

* ex vessel price for dressed octopus (conservative estimate): low = $0.90; high = $1.15

* projected pot service life (losses due to all hazards) = ceramic pot: 5 years; Kodiak wooden pot: 5 years

* projected support gear service life (groundline and other gear, including estimated losses due to all hazards): both gear types = 5 years

* vessel operating costs (assumed 45 ft multi-purpose vessel, all costs to be assigned to octopus fishing): both pot types = $250 per day

* cost of pots: ceramic pots, $20 each; Kodiak wooden pots, $8 each

* cost of support gear: both gear types, $10 per pot fished

* annual estimated cost of pot loss (averaged over 5 years): ceramic pots, $4 per pot fished; Kodiak wooden pots, 500 pots = $1.60 per pot fished

* annual estimated cost of support gear loss (averaged over 5 years): both gear types, $1 per pot fished

The major variables being considered in the projection are (Table 8):

* type of pot (ceramic or wood)

* ex vessel price ($0.90 or $1.15 per lb)

* number of pots (500 or 1,000 pots per operation)

The only operations predicted to be profitable are the ones using 1,000 wooden pots (G and H). The break-even points (where income equals costs) for operations G and H are 715 pots at $0.90 per lb and 560 pots at $1.15 per lb.

At an ex vessel value of $2 per lb, a typical vessel would be able to reach the break-even point using as few as 320 wooden pots. However, ceramic pots net marginal returns even at this elevated ex vessel value.

The most significant costs associated with vessels using wooden pots on optimal grounds are daily operating costs ($250), the cost of the wooden pots ($8 each) and estimated service life of the pots and gear (5 years). Improvements in these figures (lower operating costs, lower pot prices, and so on) will substantially improve the profitability of this operation.

Fishermen wishing to complete detailed break-even analyses of proposed octopus pot fishing operations should obtain a copy of "Financial Statements and Business Calculations for Commercial Fishermen," (Wiese 1982). This handbook is available at most Marine Advisory Program offices.

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APPENDIX
DEVELOPMENT OF THE ALASKA OCTOPUS PROJECT

This practical fisheries project originated from repeated inquiries made by a group of Petersburg fishermen searching for viable alternate fisheries. The intent was to integrate octopus pot fishing into primary as well as off-season fisheries that fishermen in this region could periodically draw upon. An octopus pot fishery was proposed as a part-time fishery that could be used simultaneously with traditional fall-to-spring fisheries such as shrimp and crab.

This attempt to develop an octopus fishery was originally limited to Southeast Alaska as part of a larger effort to diversify and stabilize traditional regional fisheries by establishing secondary fisheries. Originally, this project was to test techniques borrowed from octopus fisheries in other parts of the world. However, funding limitations and conservative management regulations focused the project on octopus lair pots made of plastic, wood or ceramics. The designs ultimately selected were of traditional pots that had been successfully used in commercial fisheries targeting giant Pacific octopus or similar species in Japan, British Columbia and Washington. The project was designed to harvest small- and medium-sized octopus that could be used in domestic and export marketing experiments, with emphasis on bait marketing.

The project was conceived in October 1981, following some pot testing at Petersburg. The responsible state officials were Kay Poland and Dick Reynolds of the Office of Commercial Fisheries Development, Department of Commerce and Economic Development, which was then known as the Division of Economic Enterprise, Office of Fisheries. The project used funds set aside for the development of underutilized fisheries resources (D. Reynolds, 1981 personal communication). The project contract called for the production of 1,200 ceramic pots at $12 each ($14,400).

Funding limitations mandated that only one type of pot could be used within a single fisheries region (general vicinity of Petersburg). A modified Japanese ceramic octopus pot was selected to harvest medium-sized octopus (15 to 20 lb). Five Petersburg fishermen were selected to participate in the experimental fishery. Petersburg potter Susan Payne was selected to produce the ceramic octopus pots. Payne dubbed the experimental lair pot the 'Octopot' and her company is formally known as the Octopot Company. A subsequent contract addendum from the Alaska Fisheries Development Foundation (AFDF) funded construction of wooden pots used in Kodiak and transfer of the ceramic pots to Kodiak.

This project developed in three discrete phases. Ultimately it was expanded into a large region of the Gulf of Alaska before it was completed in 1986. The first two phases of the project (1981-1985) did not develop into a successfully commercial fishery. But there is clearly promise of a productive fishery resulting from the third phase, which ended in March 1986.

The testing period for the first phase of this project was planned to extend from June 24, 1982 until June 30, 1983 with an option for time extensions to increase the effectiveness of the project. Unavoidable delays in pot construction moved the start date to February 1983 and the first phase (Petersburg area) testing was completed in April 1984. The second testing phase occurred around Sitka, Ketchikan and waters north of Petersburg. It began in May 1984 and concluded in August 1985. The third phase of the project was funded by the AFDF and began in Kodiak Island waters in May 1984 and extended until March 1986. The project is currently active with an unofficial fourth phase centered in the west Kupreanof Island area (Kake, AK). It was expected to remain active until all pots are lost to attrition. The official project termination date was March 17, 1986.

The official phases of the project were preceded by informal testing of red cedar pots in 1981 and early 1982. The wooden pots were tested in Frederick Sound north of Petersburg. Catch rates approached 20 percent over short soak times of four to seven days. However, damage caused by marine borers put a quick end to the idea of using wooden pots. The original Southeast Alaska wood pots were found to have an effective service life of only four to five months (J. Jensen, 1982 personal communication). Anti-foulants that are now available were not considered because they were not on the market during these experiments (1981) or were thought to be repulsive to the target species. Participants in the final phase of this project (Kodiak Island) successfully used wooden pots. Statistics clearly indicate the usefulness of wooden pots in capturing octopus in oceanic areas (M. Guilmet, 1985 personal communication).

Various other technical aspects of this project, including the description of the pot manufacturing process, have been reported by Johnson (1983a and 1983b) and others. Under a contract agreement among participating fishermen and the project organizer, pots actively fished by the fishermen became their personal property at the end of the project. A number of these fishermen volunteered to return their pots for use in the later project phases. Pot transfers ultimately contributed to the success of the project. Additional administrative details regarding this project are available upon request.

The Alaska project was intended to operate at approximately the same time as a Canadian octopus study. The results of the research in British Columbia have been reported by Hartwick (1982). Various aspects of the Canadian study are also described in this report and in Paust (1985).

PROJECT OBJECTIVES

This project was to have two major results:

1. evaluation of the commercial feasibility of harvesting octopus in Alaska; and

2. initiation of a production fishery that could develop into a model for other areas.

For the project to be successful, a number of smaller objectives have to be accomplished first:

1. Locate productive octopus fishing grounds

2. Identify optimal fishing seasons

3. Define appropriate fishing techniques and strategies

4. Quantify the effectiveness of several traditional lair pots

5. Refine handling and quality control procedures

6. Provide vessel conversion information

7. Stimulate development of an octopus fishery through distribution of practical fishing and marketing information

8. Generate a set of useful economic information

Originally, the project was to use several types of lair pots in a multi-strata sampling scheme. Several sets of standard pots were to be positioned at pre-set locations over a succession of different seasons. This experimental approach offered the advantage of flexibility, particularly with regard to refining fishing strategies to increase productivity. A design of this type also proved to be costly and was abandoned.

PROJECT DESIGN

An effort has been made to generate conclusions that are statistically valid and of practical value to commercial fishermen. The participating fishermen were asked to provide the following catch data:

1. date

2. location

3. depth

4. type of pot used

5. soak time

6. description of area and type of bottom where capture occurred

7. sex

8. size

Participants were given a prescribed set of fishing strategies. These techniques were individually refined as the project progressed. The original strategies were:

1. soak time of five to seven days

2. fishing restricted to 40 to 60 fathom zone during summer and 50 to 80 fathom zone during winter

3. whenever possible, the pots would be placed in association with known indicator organisms

4. pots would not be placed near natural denning sites (most commonly rock piles and similar structures)

5. fishing would not occur on mud bottoms and would be confined primarily to firm crab and shrimp grounds

6. when productive grounds were located, effective scouting strategies would be used to track movements of octopus

7. orthodox handling procedures would be used, including non-contact icing

8. captured octopus would either be retained for individual use or sold to local processors as halibut bait

A comprehensive list of octopus fishing strategies is available (Paust 1982).

GEAR RESEARCH: THE SEARCH FOR THE IDEAL OCTOPUS FISHING METHOD

The Alaska octopus harvest is currently limited to a very low tonnage. Virtually all the octopus is caught incidentally in trawl, crab and shrimp fisheries. Limited octopus pot fisheries are developing in this state and have existed for decades in adjacent regions (particularly Washington). Existing operations in other areas are primarily small-scale and use a variety of locally produced lair pots.

A wide range of octopus gear was reviewed during formulation of this project. Primary attention was given to the highly developed techniques used in Japan and countries bordering the Mediterranean Sea. Sources reviewed include Berg, FitzSimmons and Johnson (1980); Hamade (1982); Mottet (1975); Nedelec (1975); Nomura (1981); Nomura and Yamazaki (1975); Pennington (1979a and1979b); Wilson and Gorham (1982); and Yamaha (1981).

The tentative conclusion of this review favored lair pots or traps. The practical octopus fisheries literature is surprisingly extensive. Unfortunately many of the most valuable items are unpublished or in some other form of limited circulation. Contact a Sea Grant or Marine Advisory Program office for additional assistance.

Types of gear for octopus fishing that are legal in Alaska include gillnets, purse seines, trawls, trolling gear, pots or traps, longlines, jigging and diving (T. Koeneman, 1981 personal communication). Just because these methods are technically legal ways of taking octopus does not mean that using such gear is efficient or economically feasible. Many methods were considered before lair pots were decided upon. Note that the use of unorthodox gear for capturing octopus (or any other species) requires a permit issued by the Commissioner of Fisheries and the full approval of local management biologists.

A leading manufacturer of Japanese octopus pots was consulted during the earliest stages of this project. Their staff felt strongly that an Alaskan fishery for *Octopus dofleini* should not use pots and instead recommended tangle hook longlines as the most appropriate gear for Southeast Alaska (C. Gibson, 1981 personal communication). To get permission to use tangle hooks we would have to maneuver through a myriad of management regulations. Heavy loss of entangled octopus to natural predators would also have been involved. Consequently, tangle hooks were not considered.

A second type of gear believed to be potentially productive in Alaska waters was the drifting "claw" hook. Again a number of management concerns, most importantly incidental harvest of commercial species such as crab and halibut, would have to be resolved before this gear type could be used. Descriptions of the drift hook and associated fishing strategies can be found in Pennington (1979b) and Mottet (1975).

As mentioned, the project eventually settled on the use of lair pots for the following reasons:

1. pots of traditional design had proven productive in other octopus fisheries

2. lair pots could be made locally and are relatively inexpensive

3. lair pots promised reasonable service life

4. use of lair pots presented minimal regulatory problems

A variety of lair pots have been used in other octopus fishery projects in the northeastern Pacific region. These pots have included:

1. plastic tube pots

2. whole tire or tire segment pots

3. wooden box traps or pots

4. ceramic pots

5. various improvised plastic pots (buckets, oil containers, tubes, battery cases)

6. converted shrimp pots

7. converted Dungeness crab pots

Descriptions of these pots can be found in Hartwick (1982) and Paust (1985). The most successful of these experimental pots is the open, non-closing wooden box trap fabricated from lumber weighted with stones or other ballast (Kyte 1983). This pot is frequently called the Puget Sound slat pot.

The theoretical aspects of how lair pots work are simple. The giant Pacific octopus is a major predator of crabs, clams and other invertebrates. Major predatory activity in shallower waters occurs when it is dark. Lair pots are set unbaited and octopus use them as dens during most of the day. The pot provides protection from the octopus' many natural predators. The fisherman attempts to longline a string of octopus pots between natural denning sites (such as reefs and rock piles) and sites containing significant amounts of favored prey. The theory is that octopus will find the lair pot to be a convenient den closer to sources of prey than natural den sites. Other aspects of this process are explained in Hartwick (1982) and Clifton (1980). The fisherman, following an appropriate time interval, will lift the string of pots and claim the occupants. When pots are pulled during daylight hours, the occupants are inclined to stay within the artificial den. Pulling pots during darkness may reduce the catch rate and result in increased numbers of "riders" or octopus adhering to the exterior of the pot (M. Guilmet, 1986 personal communication). Although theoretically simple, capturing octopus in lair pots has proven to be complex in practice.

Creating the Experimental Ceramic Pot

Budgetary limitations mandated the selection of one pot to be fished within a single region using the voluntary services of participating fishermen. However, in addition to the pot we constructed, a smaller number of plastic tube pots and Japanese plastic pots were obtained from cooperating agencies for use during the initial phases of this project. Later financial involvement by AFDF made it possible to introduce wooden pots as the second major gear type.

During the planning phase, the lair pot was selected as the primary gear, a pot was designed, and the optimal number of pots to be carried by each boat in the experimental fishery was calculated.

A review of catch statistics from past octopus projects and analysis of current vessel operating costs indicated that the target catch rate would need to be 21 percent after a five- to seven-day dock period in order for the vessel operator to receive a reasonable return. The average size of octopus expected to be harvested in the experimental pot was estimated to be 12 lb. Calculations indicated that a small fishing vessel (gillnetter or troller for example) would require 200 pots while a medium sized vessel (such as a salmon seiner) should carry 400 pots. Project funding allowed for distribution of 1,200 pots to five vessels (four boats carried 200 pots and the other boat carried 400 pots).

The final selection of a specific lair pot design proved to be straightforward. A list of criteria for selecting the final pot design follows.

1. cost per unit of gear, including both pot and bridle
2. estimated service life including resistance to marine boring organisms
3. average size of octopus harvested
4. efficiency of gear (track record)
5. ease of handling
6. commercial availability or opportunity of local manufacture
7. ease of repair
8. storage characteristics
9. stability when carried by fishing vessels
10. ability to satisfy management concerns

The selection of a basic pot design involved consideration of the following materials:

1. Ceramic construction proved an attractive option because of its physical nature.

2. Concrete was not seriously considered since it was suspected that octopus are repelled by uncured aggregate (Nakada and Nakada 1981).

3. Wood, although considered to be nearly ideal, had previously been rejected because of its vulnerability to marine borer attack.

4. Plastic was recommended by many but was found to be expensive when used in the fabrication of large pots.

5. Modified shrimp pots, like wooden pots, were considered to be near-ideal but were rejected because of budgetary limitations.

Clay or ceramic pots with a volume of 0.02 cubic meters (appropriate for a 12 lb octopus) were selected for this project. There were several justifications for this decision. The pots would be resistant to marine borers. Clay is a natural material, and one that is not suspected of carrying contaminants that would repel octopus. Pottery pots had been successfully used in other parts of the world. Ceramic materials are strong and durable. The ceramic pots would be self-ballasting.

In 1981, the pot design was distributed to a number of commercial ceramics manufacturers in the United States, Canada and Mexico. Most returned bids were in the range of $30 to $45 per pot. Fabrication was ultimately turned over to Susan Payne, a Petersburg potter and artist. The contract price was $12 per pot, complete with rope harness. This pot is a slightly modified version of a highly productive pot used in Japan. Considerable care was taken to preserve the original design in order that an inexpensive pot of known usefulness could be employed.

We originally intended to wrap the pots in trawl web to augment their durability. There was some concern that U.S. fishermen not familiar with this type of gear might frown on using crockery. Using heavy trawl web proved to be expensive and time consuming. Each pot required 1 lb of web at a cost of $3 per pot. An alternate wrapping method was developed that used a single barrel hitch similar to the wrapping method used by the Japanese. Pots equipped with the barrel hitch were tested to destruction and found to be quite durable.

Wooden Octopus Pots: The Problem of Shipworm Damage

Wood submerged in sea water is subject to a number of hazards that can cause the rapid deterioration of wooden structures and fishing gear. Biological fouling organisms represent one group of hazards. Chemical and other anti-fouling methods have been developed over the years to reduce the economic losses caused by various fouling organisms. The use of chemical anti-foulants containing tri-butyl tin (TBT) compounds is being restricted or banned in many parts of the world.

Marine boring organisms presented this project with a major challenge. The original cedar box pots used in our experiments were destroyed by marine boring organisms within a short time. The use of chemical anti-foulants was rejected in the project from the very beginning. The prevalent opinion was that chemical additives would repel octopus, thus decreasing pot efficiency to unacceptable levels. This assumption proved to be incorrect. The resourceful actions of participating fishermen from Kodiak Island and researchers elsewhere (Smith 1982) have successfully resolved this problem.

The major wood boring organisms in the coastal waters of the northeastern Pacific are the deep penetrating shipworm, Bankia setacea, and the surface scavenging gribble, *Limnoria lignorum* (Figure A-1). *Bankia setacea* is the major shipworm found in Pacific Coast waters north of San Francisco. Shipworms are sometimes incorrectly referred to as teredos. The name teredo originates from a particular shipworm, *Teredo navalis*, found in the warm water of the mid-latitude regions. The shipworm species of interest to octopus pot fishermen in this region can grow to a length of 5 to 6 ft and a diameter of 0.88 in. (Helsing 1979). The gribble, although potentially very destructive, was not suspected to have caused the damage we observed on wooden octopus pots.

In many parts of the world, shipworm attack follows a somewhat irregular pattern. Under certain oceanographic conditions shipworm attack may not occur for several years. However, the simultaneous occurrence of optimal conditions can promote intense levels of attack (Kocher 1984). Levels of shipworm settling and attack were judged to be intense during the fall periods of 1982 and 1983. Untreated red cedar octopus pots test fished in 1981 and 1982 had effective service lives of only three to five months, primarily because of shipworm attacks.

In Southeast Alaska, immature *Bankia setacea* settle on wood surfaces and start boring at a water temperature of 55°F (13°C). Boring will continue until the surrounding water temperature declines below 45°F (7°C). Bottom temperatures in this region are seldom less than 43°F (6°C). Consequently, untreated wooden objects are exposed to shipworm attack throughout most of the year (BCRC 1963). For this reason, the use of untreated wooden octopus pots was initially rejected.

Traditional methods used to protect wooden fishing gear from shipworm attack include the following (FNI 1983):

1. removing gear from water and air drying

2. using non-wood materials

3. using naturally resistant woods such as Panamanian rosewood and certain cedars

4. halting fishing activities when immature shipworms are settling from their initial planktonic stage

Proper use of these methods can offer effective protection. However, they are time consuming and eventually result in lost income. Shipworms can also be extremely tenacious. *Bankia* present in wooden objects that have been hauled and placed in non-freezing winter storage can remain alive for 28 days. These shipworms resumed normal activity when the test objects were returned to the sea. Tests made at higher storage temperatures indicated high levels of shipworm mortality; however, 2 percent of the invading organisms remained alive after 28 days storage, enough to cause continued significant damage to the gear (BCRC 1963).

One option available to those using wooden octopus pots in this region is the anti-fouling chemicals that have appeared on the commercial market since the early 1980s. Pressure- treated lumber might also be considered. Participating Kodiak fishermen James and Marilyn Guilmet used a liquid preservative diluted in petroleum-based solvents before use. Wood is treated by dipping or spraying and must be dry for proper treatment. The solvent evaporates, leaving biologically active ingredients on the wood surface. If the wood

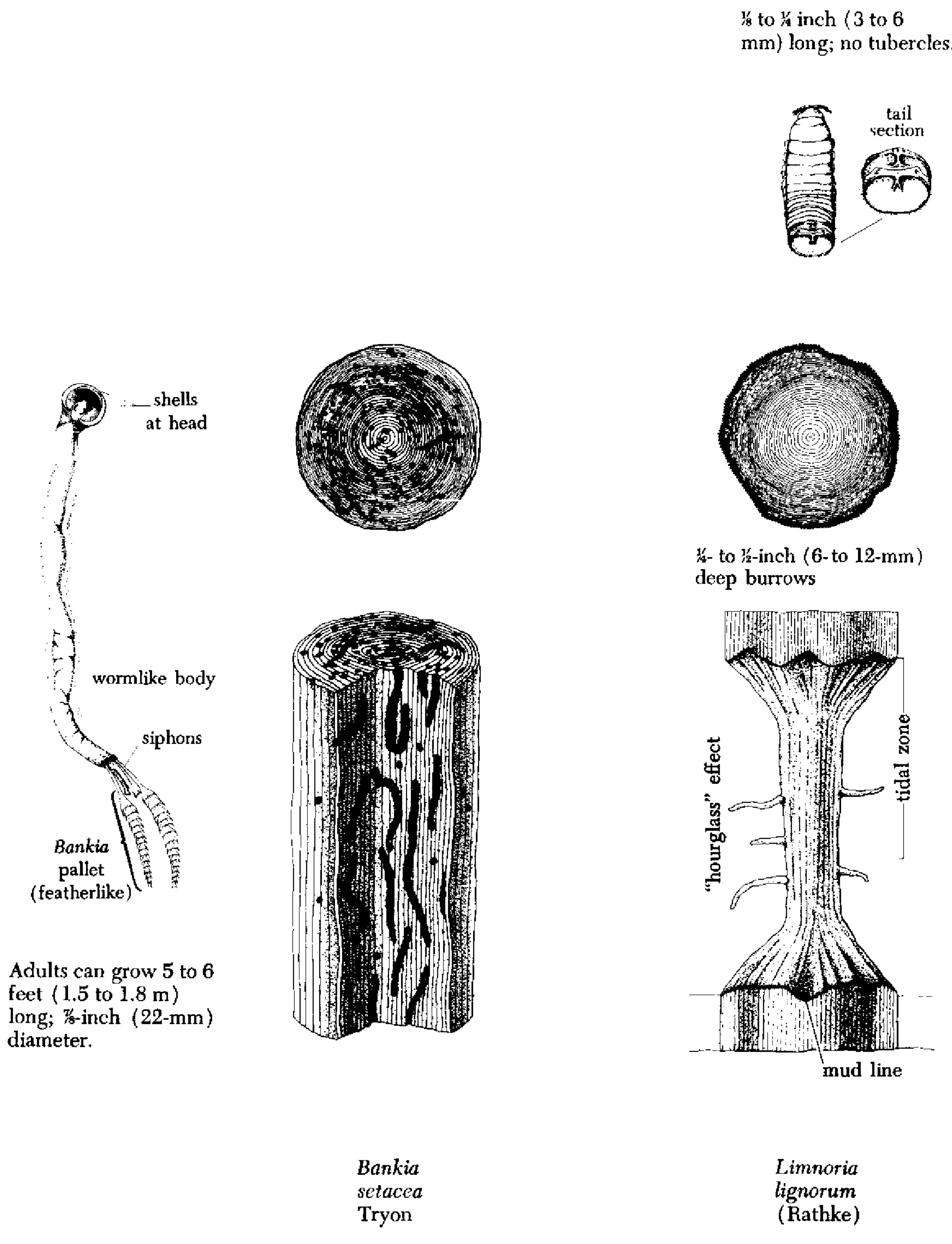

Fig. A-1. Wood borers *Bankia setacea* and *Limnoria lignorum* (from Helsing 1979).

is deeply immersed in water after drying, it is believed that the toxins are driven deep into the wood, increasing the duration of effective protection. When tested in East Coast fisheries, treated pots caught lobster two days after treatment. The amount and length of anti-fouling protection may ultimately depend upon accumulated immersion time and particular storage methods. The current trend is to treat crustacean pots once a year (Kocher 1984).

The anti-foulant used to treat the Kodiak pots contains an organic compound called tributyl tin oxide, which is toxic to marine invertebrates. This compound is now considered a major environmental contaminant and should not be considered. Other compounds that might be used as wooden pot preservatives include chromated copper arsenate (CCA) present in pressure-treated lumber (Smith 1982) and several surface "anti-grip" products. These products have similar functions, either discouraging larval shipworms from settling on treated surfaces or poisoning them once active boring has begun. Many of these products have been tested on crustacean pots and do not significantly affect fishing efficiencies.

The use of chemical anti-foulants requires careful consideration of application instructions provided by the manufacturers in order to avoid personal and environmental contamination. A wide variety of organic and inorganic anti-fouling treatments are now available in the United States. Several of these products have been implicated in the formation of abnormalities in certain marine species, including oysters. Because of a variety of personal health and environmental hazards associated with its use, the Kodiak participants declined to endorse the use of the chemical dip employed with their pots. The untreated spruce pots used in the Kodiak area were fished for a prolonged period of time without deterioration due to borer activity. Because rough-cut lumber tends to be available and inexpensive in most regions of Alaska, it is strongly suggested that regular replacement of pots be considered and that hazardous chemical dips not be used (M. Guilmet, 1986 personal communication). Additional information concerning anti-foulants is available from the Alaska Department of Environmental Conservation.