Lang, M. A. and F. G. Hochberg (eds.). 1997.
Proceedings of the Workshop on *The Fishery and Market Potential of Octopus in California.*
Smithsonian Institution: Washington. 192 p.

EXPERIMENTAL OCTOPUS FISHERIES: TWO CASE STUDIES

Clyde F.E. Roper
Department of Invertebrate Zoology - Molluscs
National Museum of Natural History
Smithsonian Institution
Washington, D.C. 20560 U.S.A.

Two completed octopus fishery projects are reviewed, one from Florida and the other from South Carolina. Results are analyzed and provide a basis for recommendations concerning future experimental octopus fishery projects. Factors that need to be considered when an experimental fishery is undertaken are discussed from the viewpoint of an international development organization.

Introduction

Around the world, *Octopus* species constitute an impressive by-catch in some trawl and trap/pot fisheries. Octopuses also prey intensively on trapped crustaceans, for example:

1. *Octopus vulgaris* predation on the lobster *Homarus vulgaris* in the English Channel (Rees and Lumby, 1954).
2. *O. vulgaris* predation on the stone crab *Menippe mercenaria* in Florida waters (Voss, pers. comm.)
3. *O. tetricus* predation on western rock lobsters (*Panulirus longipes cygnus*) off Western Australia (Joll, 1976, 1977).
4. *O. dofleini* predation on several species of crabs and shrimps (especially Dungeness, tanner and king crabs and spot shrimp) in the Alaskan pot fisheries (Paust, 1988).
5. *Eledone cirrhosa* predation on lobsters (*Nephrops norvegicus* and *Homarus vulgaris*) in Scotland (Boyle, this volume).

Such predatory behavior by octopuses clearly can have significant adverse effects on profitability for the fishermen. In some cases fishermen or fishery agencies have sought to turn this adversity into profit by developing a fishery for the octopuses.

Exploratory octopus fishery projects often begin with the assumption that there is a large enough population of octopuses to support a commercial fishery. This might not be an accurate assumption. Casual observations may suggest that there are "tons" of octopuses around. However, because every crab or lobster pot has one or two octopuses in it, does not guarantee that there are enough octopuses upon which to base a sustainable yield fishery. After all, octopuses seem to learn enough from experience to know that a captive lobster or crab is easier to catch than a free-ranging one.

In the Yucatan Peninsula region of the Gulf of Mexico, a baited-line artisanal fishery for *Octopus maya*, the Mexican octopus, yields nearly 10,000MT/yr. The baits, tied on lines drifted slowly along the bottom, are dead stone crabs or blue crabs (*Callinectes* sp.), normal prey for *O. maya*; interestingly, experiments show that traps or pots are not very effective in catching this species of octopus (Voss, 1988; Solís, 1991, this volume).

Therefore, ideally, before large-scale effort, funds, and public relations campaigns are expended, a solid survey of the natural population should be conducted by fisheries biologists who are knowledgeable regarding octopus biology and ecology and who can analyze the data objectively. Survey results should be augmented by observational information from local fishermen who will know when and where octopuses are to be found in association with, or as predators on, more traditional target species (*e.g.*, crabs, shrimps, lobsters).

Any experimental fishery must be well organized and monitored, and the subsidy and incentives given to fishermen who participate in the project must be sufficient to sustain their interest for the duration of the project. It is important to stress that fishermen's experience, observation, and knowledge of seasonality, bottom types and conditions are extensive and should be utilized and incorporated into the project. It is also important to engage fishermen who have expressed interest in and who understand the benefits of a potential secondary fishery to supplement their incomes.

The topics of this paper are a review of specific experimental octopus fisheries projects undertaken in the southeastern United States, and a consideration of the development of a new fishery from the perspective of an international fishery agency, *e.g.*, Food and Agriculture Organization of the United Nations (FAO).

Experimental Octopus Fishery Projects

The following is a review of two examples of experimental fishery projects for octopus. Both were conducted on the East Coast of the U.S. in the mid-I980's with *Octopus vulgaris* as the target species. The first was conducted by the late G.L. Voss (Professor of Biological Oceanography, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami) on the Atlantic and Gulf coasts of Florida and the second by J.D. Whitaker (South Carolina Wildlife and Marine Resources Department) off the South Carolina coast. It is interesting to compare and contrast the two projects because they represent two quite different approaches to determine if *O. vulgaris* populations in the respective study areas are sufficiently extensive to sustain a commercial fishery.

The two projects were conducted in loose coordination with each other under the primary sponsorship of the Gulf and South Atlantic Fisheries Development Foundation. The Florida project initially was designed to conduct a broadly-based study of the potential for a large-scale commercial-level octopus fishery, but the proposals to state and federal funding agencies were not funded. Limited to funds provided by the Gulf and South Atlantic Fisheries Development Foundation, the objective had to be revised to develop a more modest octopus fishery in which local stone crab fishermen could supplement their income from octopus while decreasing predation, thus increasing catch, on the lucrative stone crabs. While the Florida project was conducted without supplementary funding, state monies were used in funding the project in South Carolina. I do not know the dollar amounts spent on these two projects at this time, but I understand that the South Carolina project was significantly better funded. Sources of information for this presentation are the unpublished interim and final project reports to the funding agencies (Voss, 1984a, 1984b, 1985a, 1985b; DeLancey, *et al.*, 1985; Whitaker and DeLancey, I985, Whitaker, *et al.*, 1986). No published reports exist for the Florida project, but the South Carolina project has been described by Whitaker, *et al.* (1991).

Florida - Experimental Octopus Fishing Program

Principal Investigator, Gilbert L. Voss, Florida west and east coasts, January 1984 - June 1985; Gulf and South Atlantic Fisheries Development Foundation, sponsor. This project will be discussed in detail, as no published reports are available.

Background

The impetus for examining the potential for an octopus fishery in Florida waters resulted from several factors:

1. *Octopus vulgaris* at times has been abundant in commercial stone crab (*Menippe mercenaria*) traps, sometimes several animals per trap. Stone crabs have an extremely high ex-vessel value for fishermen (usually greater than $5.00/lb) and were being eaten in the traps by octopus, who thus devoured profits.
2. Voss, a native Floridian and former commercial fisherman, had a long standing interest in the development of cephalopods as an underutilized fishery resource.
3. The Gulf and South Atlantic Fisheries Development Foundation had funds to support experimental fishing on underutilized species. Turning a pest species into a profitable target species seemed to be a doubly good investment.
4. Market demand for food octopus was increasing as a greater segment of the public became aware of and interested in octopus as an unusual, nutritious sea food. In South Florida and Miami there was an especially high demand for octopus in the Hispanic and Asian populations.

The experimental design called for volunteer commercial stone crab fishermen to set strings of octopus pots in both shallow and deep water during the inshore stone crab and offshore snapper/grouper seasons, as well as other seasons, so that an entire year could be covered. Paired strings of pots were set in parallel every two miles inshore/offshore, beginning in 10ft of water. When inshore shallow pots failed to catch octopuses, they were leapfrogged over the next seaward pair, gradually working out to depths of 90-100ft.

Types of Gear

The following three types of gear were used:

1. Quad octopus pots (600 total) were built of 6in diameter and 30in long sections of PVC pipe, either white (cheaper; quickly darkens with fouling organisms), or dark gray (catches slightly better at first) (Figure 1). Two sections were fastened together in parallel and each section was fitted with a 2in concrete plug in the middle, giving a total of four octopus chambers. Each quad pot weighed 30lb. A gangion or double bridle was snapped to a longline of standard black polypropylene pot warp which was preferred by fishermen over white "ragline" (Figure 2). The gangion/bridle was made of hard-laid swordfish longline. Hydraulic haulers, standard for stone crabbers, hauled pots so that they would remain horizontal and would not dump captured octopuses out of the two lower, bottom-facing chambers of a vertically hauled pot. Pots were attached alternately at 25 and 50ft intervals, totaling 60 pots per 2000ft longline.
2. Double octopus pots consisted of 2 sections, 15 - 18in long, of 6in diameter PVC pipe wired together and closed with concrete plugs in one end (Figure 3). A single gangion was fed through adjacent walls at the open end; 0.5in drain holes were drilled in the lower end, and the pot was hauled vertically. The advantage of double pots is that they are cheaper, smaller, lighter-weight, possibly provide less escapement by crawl-out, and have a catch rate "about equally as effective" as the quad pots, according to Voss.
3. Old car tires were cut into thirds, the rims laced together with monofilament or tarred line, and a wooden plug nailed into one end (Figure 4). A single gangion was attached from the laced rim at the open end and the pot was hauled vertically. Tire pots were cheaper to make and Voss found them to be "nearly as effective" in catch rate as the PVC pots.

About 10d of curing time for all types of gear in seawater was required to leach lime from the concrete plugs and the odor (taste) from rubber tires. The grey PVC pipe caught slightly better at first but the white PVC pipe quickly darkened with fouling organisms, so soon fished as well as the grey pipe.

The first experimental fishing took place in February off Crystal River on the Gulf of Mexico, west coast of Florida. Fishing started in 10ft of water, and the strings of pots were leapfrogged out to 25ft depth without any octopus being caught. (Water deepens at about 1ft/mi). This was the expected result that verified fishermen's observations that octopuses had been extremely abundant in October and November but had disappeared by early December. Fishermen thought that the octopuses had migrated offshore, but Voss believed that the disappearance was the result of natural mortality following spawning. Voss' view is supported by the observations that the stone crab traps began to catch juvenile octopus feeding on the bait in December, January and February.

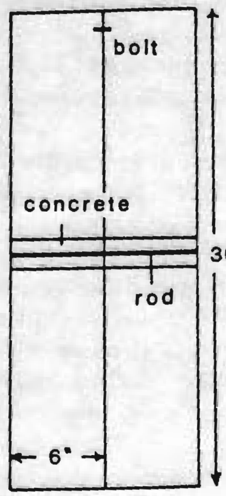

Figure 1. Quad octopus pot, sectional view showing construction details (redrawn from Voss, 1985c).

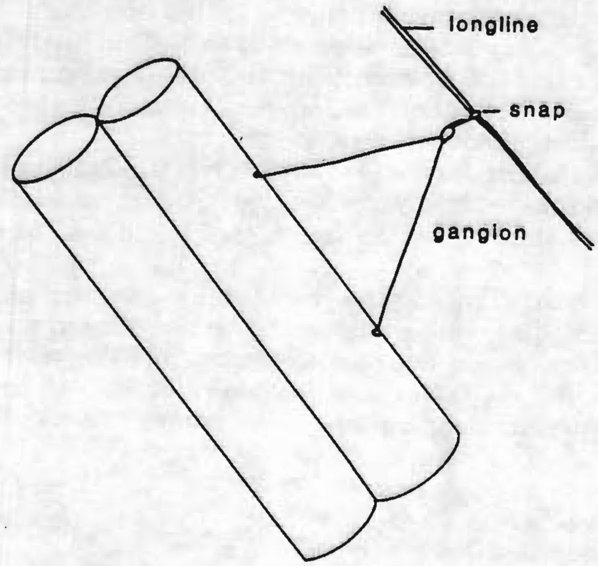

Figure 2. Quad octopus pot, side view showing rip to longline (redrawn from Voss, 1985c).

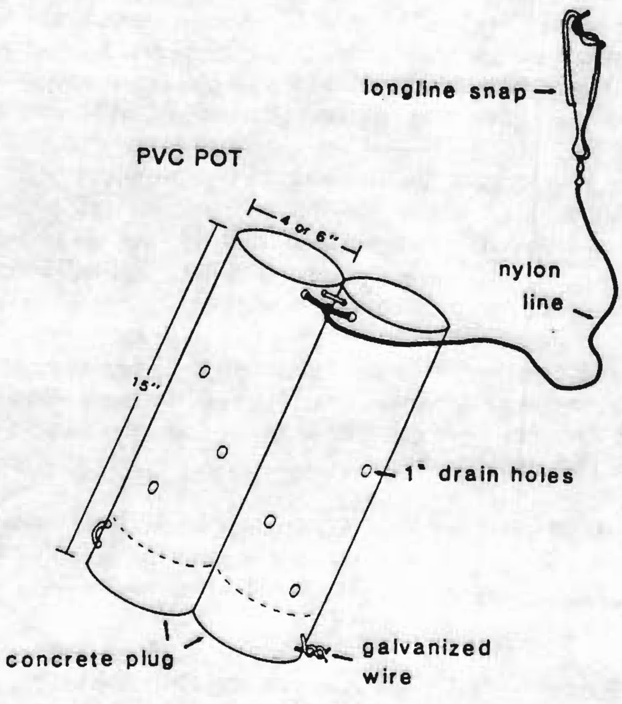

Figure 3. Double octopus pot showing construction details (from Whitaker, *et. al.*, 1991).

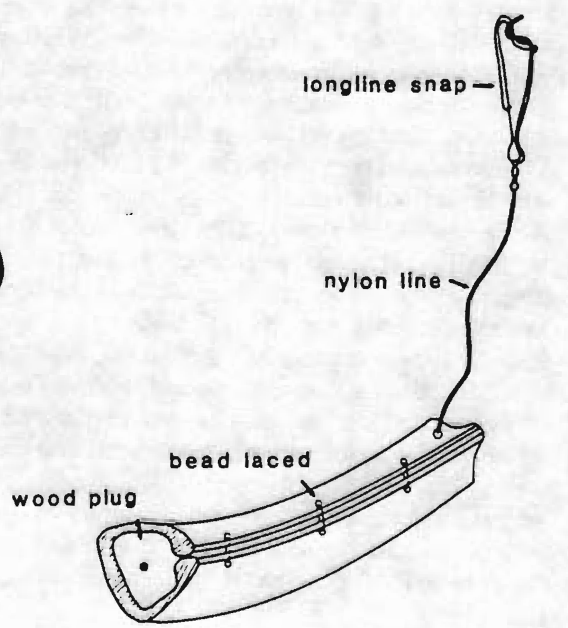

Figure 4. Tire pot showing construction details (from Whitaker, *et. al.*, 1991).

One fisherman reported that the juveniles were 1-2in total length in December, 2-3in in January, 4-6in in February and 8in long by the end of March. At this growth rate, octopus should have been of market size by June or July. This could not be verified, however, because the fisherman who was running the gear stopped fishing in April to build a new boat. No replacement volunteer was found at that time and octopus fishing did not begin again until August in about 35-40ft of water. During the summer, there were numerous reports of large octopuses captured in the offshore grouper fisheries at depths of 60-90ft. A few octopus pots were set offshore by a volunteer and caught octopuses on a two-day soak, but the string could not be found on the next trip. It was suggested that the buoys may have been cut off.

Back inshore off Crystal River, the first octopuses were caught in early September and averaged 1lb each; by October, males were becoming sexually mature. Here 18 octopuses were caught in 40 pots (a 45% catch rate), and catches stopped in late October in that area, but the pots were not relocated.

Sixty pots were set in September at various localities off Palm Beach and south of Fort Pierce on the east coast of Florida. The soak times were quite irregular, but catch rates varied from 45-90%. Pots were set at depths of about 60ft on sand bottom between the second and third reefs, on lines running parallel to shore. Originally octopuses were small, but during the later period of fishing octopuses averaged about 2lb each.

The final six months of the Florida project were a disaster. Fishermen who volunteered to fish octopus pots either lost interest after one or two sets, or never set the gear at all. One boat wrecked and sank with all pots aboard. So the project ended without the objectives having been fully met.

Whereas the experimental fishery was not conclusive, Voss made an extensive effort to publicize the potential of an octopus fishery and the value of octopus as food through seminars, demonstrations, newspaper and magazine articles, TV and trade show interviews and a widely distributed octopus fishery information leaflet (Voss, 1985c).

Results

Voss (1985b) summarized the results of the brief Florida study in his final report to the sponsoring agency:

1. There are sufficient octopus stocks on both coasts of Florida to support a directed fishery.
2. Stone crab and grouper/snapper fishermen are not going to turn to octopus fishing until it has been demonstrated to be profitable by at least one fisherman.
3. Octopus can be fished inshore during the stone crab season using baited traps and pots, but unbaited pots and traps will not attract octopus when baited stone crab traps are easily available, especially if they contain stone crabs as well.
4. Octopus can be caught offshore with unbaited pots during late winter and summer in depths of around 90-100ft on the grouper grounds.
5. Fishermen and fish companies need to be educated on methods of fishing, holding, cleaning, packaging and marketing of octopuses.
6. Fish companies need to be provided with marketing information on octopuses in order to obtain maximum price and give maximum pay to the fishermen.
7. The National Marine Fisheries Service, (NMFS), Sea Grant and the Florida Department of Natural Resources should join together to give a series of one day seminars and demonstrations around the state to provide full information on the various aspects of fishing and marketing of octopuses.
8. The NMFS or other agency should initiate a market survey to provide local fish companies with market sources and current prices for octopuses.
9. Continued publicity at both state and national levels should be developed to increase the national market, increase the demand and thus increase the value of the octopus fishery.

In analyzing the Florida project several factors appear to have contributed to the objectives not being achieved:

1. The most serious impediment to the full success of the project was that it was underfunded, which resulted in the remaining factors.
2. The use of volunteer stone crab fishermen. Stone crabs bring an extremely high price to the fishermen for relatively low labor expended. The prices for octopus are much lower and very unstable and the effort to catch them is viewed by the stone crabbers as relatively labor intensive.
3. Because the project was designed so that it depended only on volunteer help from fishermen, no experimental fishing was undertaken by a university or state fisheries unit; thus, there was no rigid scientific or statistical base to the project.
4. There was no provision in the project nor with state fisheries agencies to follow through with the fishermen or the fish companies with additional information on marketing, pricing, etc.
5. Knowledge about the population structure, fluctuations and biology of *O. vulgaris* in Florida waters currently is insufficient; a 2-year cycle of experimental fishing would have provided a much firmer basis for determining the actual potential for an octopus fishery.

These factors among others, need to be considered whenever an experimental octopus fishery project is contemplated in the future.

South Carolina - An Investigation Into the Feasibility of Harvesting Underutilized Cephalopod Resources in the South Atlantic Bight.

Principal Investigator, J.D. Whitaker, South Carolina, August 1984 - June 1986; Gulf and South Atlantic Fisheries Development Foundation, sponsor. Details of this project are given in Whitaker and DeLancey, 1985; Whitaker, DeLancey and Linsey, 1986; and Whitaker, *et al.*, 1991.

The following information is summarized from these three sources. The feasibility program in South Carolina was designed to study both squids and octopuses. Only the octopus potting project will be addressed in this paper.

Types of Gear

This project used a different approach from that taken in Florida. Four chartered commercial fishing vessels were used in addition to two of the South Carolina Wildlife and Marine Resources Department vessels. The fishing areas were off Charleston, Georgetown and at the North Carolina border, in 40-70ft depths. All vessels used similar gear.

The experimental fishing regimen called for use of 15 pots spaced 30ft apart with 5 pots of three different types on each 600ft ground line. Some pots were white PVC pipe and there was some early concern that they would not fish well, since Voss had used white pots that had not fished well initially. Within a few weeks, however, the white traps were covered with fouling organisms and whiteness was no longer a factor. In the second year, the South Carolina project used 4-6in septic drain pipes (SDP) rigged either as single or double pots (Figure 5). Sections of automobile tires also were used.

The commercial fishermen were asked to record precise LORAN coordinates and total catch by location and gear. Once fishermen arrived in port, the biologists examined the octopus for weight, length and sex, returning the octopus to the fishermen to sell. More extensive data were collected from the octopuses caught by the Marine Resources group during their experimental fishing.

Results

The total catch rate for the 2yr study was 27.8% (1,042 octopuses from 3,754 pots). Catch rates were high in summer, highest in fall, then dropped off in winter and spring. The catch rates ranged from a low of 7% in winter to a high of 63% in fall. *Octopus vulgaris* sizes were just over 1lb in the summer time and by fall they were up to almost 3lb. The average size of octopus showed a direct relationship with gear size: 4in pots caught smaller octopuses and 6in pots caught larger ones. Double 4in pipe in the fall fished at a catch rate of up to 67%, and the tire pots fished almost as well as the pipes. A boat of approximately 30ft length is the most profitable and practical to operate, because of its low fuel consumption, great speed and maneuverability. With 6-10d soak time, fishing can be worked around poor sea conditions and other fishing activities.

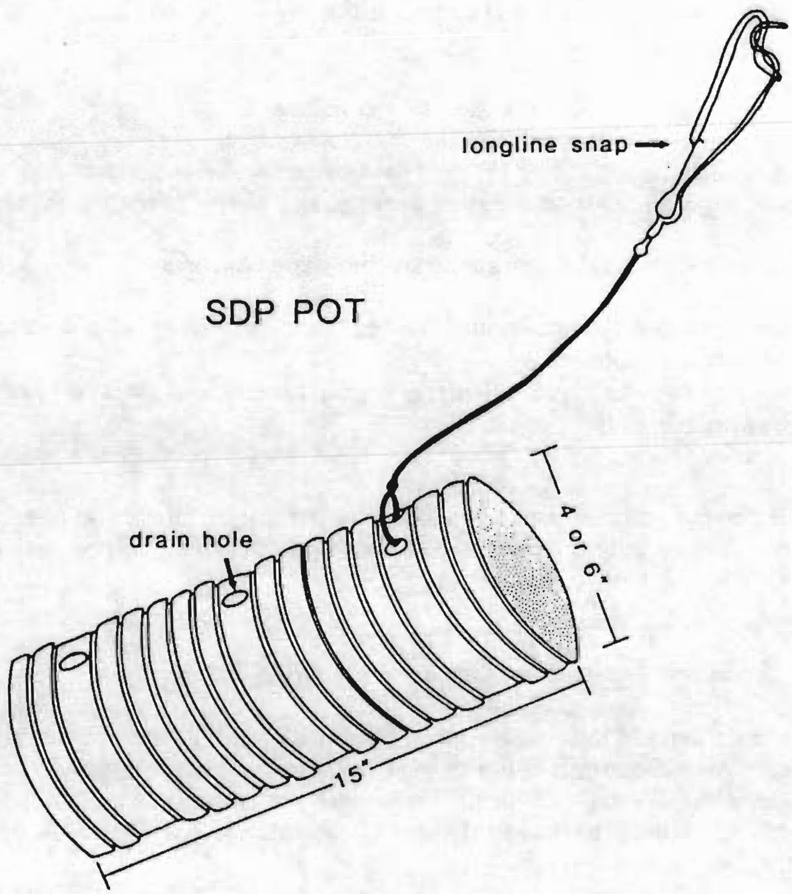

Figure 5. Septic drain pipe (SDP) pot showing construction details (from Whitaker, *et. al.*, 1991).

Final recommendations of the South Carolina project were as follows:

1. The fishery should be pursued primarily during late summer through the fall to early winter when catch rates and sizes are maximum.
2. Gear should be set on sand/shell-hash bottoms; mud bottom should be avoided.
3. Single sewer drain pipe (SDP) pots are recommended for years of very good catch rates. In leaner years double PVC or SDP pots probably are best.
4. Larger diameter pots catch larger octopuses, although early season catch rates may be higher in smaller pots because the octopuses are smaller.
5. If tire pots are chosen, weights must be attached to them to prevent movement of the pot on the bottom.
6. Pots should be soaked for 6-10d, although this too may vary with population density.
7. A few drops of vinegar or lemon juice squirted into the pots will stimulate octopuses to leave the pots quickly once they are on deck.
8. Relatively small orange buoys are recommended, as white buoys are difficult to see in white caps and choppy seas.
9. A good LORAN is imperative and a plotter can be helpful when grappling for a lost line.
10. Anchors should be used on each end of the longline to prevent fouling of the gear.
11. Octopuses should be stored in an ice-seawater bath to reduce their movement (and escaping) and to retain quality.

This project demonstrated that *Octopus vulgaris* can be potted successfully off South Carolina and Georgia and that catch rates can be very high. With this knowledge, fishermen in this area will have the option to fish octopus in the future and be assured of some supplemental income, provided they use appropriately sized boats and methods as determined by this project. Any prediction of a major fishery is premature until a reliable standing stock and market estimates can be determined.

General Recommendations

This review of two experimental fishery projects for *Octopus vulgaris* permits the addition of some general recommendations for consideration in future projects, *e.g.*, in any potential experimental octopus fishery in California.

1. Contract for fishing by commercial fishermen, pay the expenses, and let them keep the catch to sell; do not use volunteers.
2. Keep in close contact with the fishermen and fish dealers; follow up with information, progress reports, data from related projects, etc.
3. Begin biological studies immediately, particularly on life history and population dynamics.
4. Develop a parallel approach to the project:
   a. the fishery - define where, when, how, who, how much; conduct a fishery/biology pilot project.
   b. the product - determine edibility and adaptability to current products and new products; insure highest quality. Begin public information campaign, provide recipes and demonstrations, insure steady supply and steady price.

Food and Agricultural Organization (FAO) Perspectives

In accordance with the theme of the workshop on Catalina Island, it was appropriate to discuss the FAO perspective on experimental octopus fisheries in relation to the possible development of fisheries for various octopus species in California. Basically there does not seem to be an official FAO stance on how one would approach developing an octopus fishery. It depends on the approach of the individual and on which division of FAO is represented.

The FAO generally does not finance primary experimental fisheries development in developing countries but serves as a technical facilitating agency for funding bodies such as the UNDP (United Nations Development Program) or by offering advice to national aid programs of individual countries, *e.g.*, Germany, Denmark, Norway. National and state agencies in the U.S., as well as domestic regional fisheries development foundations, have their own programs to assist in developing fisheries especially for underutilized species, *e.g.*, the Gulf and South Atlantic Fisheries Development Foundation. The international organizations generally do not support development programs in already developed countries.

The following discussion is based on personal communication with John Caddy of the Fishery Resources and Environment, FAO (4 August 1989) and represents his views and observations, some of which he has published (*e.g.*, Caddy, 1983, 1984, 1989). Caddy is responsible for many aspects of cephalopod fisheries for FAO.

As far as FAO goes there is no standard institutional response, since almost never has the fisheries management system been planned in advance of the start of a fishery. In practice, "management" usually is a question of attempting to deal with the consequences of economic decisions and social allocations of the resources that were made earlier without reference to a management plan. In a developing fishery, management usually parallels development, and, if allowed, this whole process calls for a common-sense approach. The first thing Caddy suggested was to start out with a solid survey of distribution and biomass of the stock at the very beginning of exploitation, then attempt to obtain size distribution data and catch rate as early as possible in the fisheries. In fact, he suggested that this be done before commercial fishing begins. This would provide the first information about catch rates corresponding to the virgin biomass. These studies can be analyzed to provide information on natural mortality rate, (Jones, 1984; Sparre, 1987). Next he suggested attempting to make a rough estimate of the sustainable yield using a reasonable range of values for natural mortality based on octopus populations elsewhere. These figures would then have to be adjusted as the fishery progresses. Even if a rough idea of the maximum sustainable yield is obtained, this amount should not be the objective catch. Fishery biologists suggest that only about 2/3 of the effort calculated to provide the maximum sustainable yield be expended (Doubleday 1976). From FAO's experience, this is somewhere close to the effort that yields the economic optimum. In the first few years, however, it may be prudent to aim for a lower effort level than that which yields 2/3 MSY, because one of the functions of a new fishery in the first years is to provide the information to allow a more refined estimate of potential yield (Caddy and Cirke, 1983; Caddy and Bazigos, 1985). Although fishermen will not readily agree to this approach, because a new fishery frequently is a very lucrative fishery, the risks of overfishing, and consequent government intervention, are reduced. Early controls, therefore will help avoid social and economic disruptions that result from collapse of a fishery because early estimates were erroneous. Determining growth and natural mortality rates for preliminary yield modeling and yield per recruit, modeling and fitting production models are all elements to consider in research on exploited resources.

For short-lived species like cephalopods, the importance of having a management framework with real time consultation between government and industry is emphasized by Caddy (1983). Very early in the developmental stage, a decision has to be made whether there is a serious intention to manage the fishery, then whether catch is to be by quotas, (by total allowable catch available to all comers or by a more controlled individual boat quota), or whether it is to be controlled by effort limitations in addition to license limitations. Another alternative would be to allocate specific fishing grounds to each boat, which may not work well, although it has been applied for generations with the oyster fisheries in some parts of Chesapeake Bay, and it occurs *de facto* in the Maine lobster fishery.

Because quotas require too much of an investment in surveillance and control, Caddy recommends some form of license limitation (see also Bowen and Hancock, 1989). He emphasizes that not to make a decision on management also is a decision of a sort that may result in stock depletion, and can lead to distortions such as those typical of some of the northeastern Pacific inshore salmon fisheries which are open for just a few weeks or days. In the first few years of a developing fishery, it may be wise to aim for a pilot fishery for 3-4yr with a small number of boats, each obliged as a condition of the licensing, to keep good logbook records (Caddy and Bazigos, 1985). In Caddy's opinion, there seems to be no alternative to some sort of license limitation through which the exploitation rate for a given fleet size can stay about the same, whatever the level of reproduction in any given year. This is a main advantage for a fluctuating fishery, as is typical for many cephalopods, in which the catch varies from year to year. Using quotas, the situation is the inverse, where catch remains the same, but exploitation rate varies, being higher in years of poor reproduction, thus driving the stock still further to depletion. This can have severe adverse effects on a population.

As a final note, other biological considerations are that octopuses (*e.g.*, in the Mediterranean, Western Sahara Bank and Japan) are subject to very intensive fisheries and a legitimate question is whether these resources are in danger of overfishing. The answer seems to be "yes" since the world's largest fishery for octopus off the Western Sahara appears to be showing signs of depletion after an initial phase in which *Octopus vulgaris* greatly increased in abundance following the overfishing of its main fin fish predators (Caddy, 1989). At the same time, octopuses are implicated as major predators on crustaceans and bivalves in the western Sahara Bank. A fishery on cephalopods may then pay off in terms of improved returns on these higher priced crustacean and molluscan target species by reducing the abundance of a major predator. It is wise to consider each fishery on its own merits, however, realizing that one of the objectives of fisheries management is economic, namely to ensure that fishermen have a sustained-yield product to enable them to make a livelihood in their profession. They will not be able to do that if the resources are depleted.

Another primary interest of the Fisheries Resources Division of FAO has been to produce Species Identification Sheets and Catalogs of species of interest to fisheries. No fisheries identification sheets have been done for the West Coast of the United States, because it is a fishing area for which FAO has had no request for advice on this topic from the government of the U.S. or Canada. FAO identification sheets and catalogs include scientific names, local names, synonymies, diagnoses of species, distinguishing characters, biology and distribution, and the interest to fisheries (active fishery, potential, types of gear, annual landings, seasons, etc.). Examples for cephalopods include Roper (1978), Roper and Sweeney (1981), and Roper *et al.* (1984). FAO now is developing a world wide database on species of interest to fisheries. Apparently, the model for the comprehensive database is the cephalopod fishery since it is of a manageable size.

Quite clearly a number of factors must be considered before it is feasible to move forward with the development of a fishery for any of the California species of octopus.

Acknowledgements

I most sincerely thank the following people for their assistance in preparing this paper: N.A. Voss, RSMAS, University of Miami, and J.D. Whitaker, S.C. Department of Wildlife and Marine Resources, for discussions and providing the reports on the Florida and South Carolina projects, respectively; W. Rathjen, Rathjen Associates, Satellite Beach, Florida, for much information and material on octopus fishing; J.F. Caddy, FAO Rome, for extensive material and discussion concerning fisheries development from an FAO and fishery ecology perspective. All also have kindly read the manuscript, as have M. Vecchione and M.J. Sweeney, National Museum of Natural History, Smithsonian Institution, Washington, DC. I also appreciate the good efforts of the Workshop Organizers and the sponsoring agencies: California Sea Grant, University of Southern California Sea Grant, Tatman Foundation, and MBC Applied Environmental Sciences.

Literature Cited

Bowen, B.K., and D.A. Hancock. 1989. Effort limitation in the Australian rock lobster fisheries. Pp. 375-396. *In:* J.F. Caddy (ed.): Marine Invertebrate Fisheries: Their Assessment and Management. John Wiley and Sons.

Bravo de Laguna, J. 1989. Managing an international multi-species fishery: the Saharan trawl fishery for cephalopods. Pp. 591-612. *In:* J.F. Caddy (ed.): Marine Invertebrate Fisheries: Their Assessment and Management. John Wiley and Sons.

Caddy, J.F. (ed.). 1983. Advances in assessment of world cephalopod resources, FAO Fish. Techn. Pap. 231: 452 p.

Caddy, J.F. 1984. An alternative to equilibrium theory for management of fisheries. Pp. 173-214. *In:* Papers presented at the expert consultation on the regulation of fishing effort (fishing mortality). FAO Fish. Techn. Rep. 259 (suppl. 2).

Caddy, J.F. 1989. Brief review of the distribution of world cephalopods and recent trends in their fisheries as judged from FAO information sources. Conference reprints, World Conference, SQUID '89, Lisbon, Feb. 1989: 22 p.

Caddy, J.F. and G.P. Bazigos. 1985. Guidelines for statistical monitoring. FAO Fish. Techn. Rep. 257: 86 p.

Caddy, J.F. and J. Cirke. 1983. Approximations to sustainable yield for exploited and unexploited stocks. Oceanogr. trop. 18(1): 3-15.

DeLancey, L., D. Whitaker, and J. Jenkins. 1985. Feasibility of establishing an experimental *Octopus* fishery off South Carolina. Unpublished report.

Doubleday, W.G. 1976. Environmental fluctuations and fisheries management. Selected Papers ICNAF: 141-150.

Joll, L. 1976. Mating, egg-laying and hatching of *Octopus tetricus* (Mollusca: Cephalopoda) in the laboratory. Mar. Biol. 36: 327-333.

Joll, L. 1977. Growth and food intake of *Octopus tetricus* (Mollusca: Cephalopoda) in aquaria. Austr. J. Mar. Freshw. Res. 28: 45-56.

Jones, R. 1984. Assessing the effects of changes in exploitation pattern using length composition data (with notes on VPA and Cohort analysis). FAO Fish. Techn. Pap., 256: 116 p.

Paust, B. 1988. Fishing for octopus. A guide for commercial fishermen. University of Alaska Sea Grant Report No. 88-3: 48 p.

Rees, W.J. and J.R. Lumby. 1954. The abundance of *Octopus* in the English Channel. J. Mar. Biol. Assoc. U.K. 33: 515-536.

Roper, C.F.E. 1978. Cephalopods. *In:* W. Fischer (ed.): FAO species identification sheets for fishery purposes: Western Central Atlantic (Fishing Area 31). Rome, FAO, Vol. 6: 78 p.

Roper, C.F.E. and M.J. Sweeney. 1981. Cephalopods. *In:* W. Fischer, G. Bianchi and W.B. Scott (eds.): FAO species identification sheets for fishery purposes: Eastern Central Atlantic (Fishing Area 34). Rome, FAO, Vol. 6: 92 p.

Roper, C.F.E., M.J. Sweeney and C.E. Nauen. 1984. Cephalopods of the World. An annotated and Illustrated Catalogue of Species of Interest to Fisheries. FAO Fisheries Synopsis No. 125 (Vol. 3): 277 p.

Sparre, F. 1987. Computer program for fish stock assessment. Length - based fish stock assessment for Apple II computers. FAO Technical Paper 101 (Suppl. 2): 219 p.

Voss, G.L. 1984a. Experimental octopus fishing. Interim report. Unpublished report to Gulf and South Atlantic Fisheries Development Foundation, January 31, 1984.

Voss, G.L. 1984b. Experimental octopus fishing program. Final report. Unpublished report to Gulf and South Atlantic Fisheries Development Foundation, May 11, 1984.

Voss, G.L. 1985a. Experimental octopus fishing program. Interim report. Unpublished report to Gulf and South Atlantic Fisheries Development Foundation, June, 1985.

Voss, G.L. 1985b. Experimental octopus fishing program. Final report. Unpublished report to Gulf and South Atlantic Fisheries Development Foundation, December 10, 1985.

Voss, G.L. 1985c. Octopus fishery information leaflet. Gulf and Atlantic Fisheries Development Foundation, Tampa, Florida, 11 p.

Voss, G.L. 1988. White sails, cayucos and pulpos: Octopus fishing in Yucatan. Sea Frontiers, 34(6): 348-353.

Whitaker, J.D. and L.B. DeLancey. 1985. An investigation into the feasibility of harvesting underutilized cephalopod resources in the South Atlantic Bight. Unpublished project report to Gulf and South Atlantic Fisheries Development Foundation, July 1985.

Whitaker, J.D, L.B. DeLancey and P. Lindsay. 1986. An investigation into the feasibility of harvesting underutilized cephalopod resources in the South Atlantic Bight. Unpublished project report to Gulf and South Atlantic Fisheries Development Foundation, August 1986.

Whitaker, J.D., L.B. DeLancey and J.E. Jenkins. 1991. Aspects of the biology and fishery potential for *Octopus vulgaris* off the coast of South Carolina. Bull. Mar. Sci. 49(1-2): 482-493.