UNIVERSITY OF MIAMI

Rosenstiel School of Marine and Atmospheric Science

Gulf and Caribbean Fisheries Institute

PROCEEDINGS

OF THE

23rd ANNUAL SESSION

WILLEMSTAD, CURACAO . NOVEMBER, 1970

CORAL GABLES, FLORIDA

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Gulf and Caribbean Fisheries Institute

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Fisheries and the IDOE

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The International Decade of Ocean Exploration was proposed by the President of the United States on March 8, 1968, in a message to Congress on the environment. He referred to the Decade as "an historic and unprecedented adventure". The Decade concept was described in a "white paper" published by the National Council on Marine Resources and Engineering Development (1968) popularly known as the Marine Sciences Council. In his message the President invited the nations of the world to join together in a concerted, long-term, cooperative program of ocean exploration, of which the Decade would be the initial emphasis. In effect, he was saying that the world can no longer afford the luxury of individual, uncoordinated, oceanic research efforts, no matter how excellent they may be as scientific programs, at a time when man's growing uses of the ocean are raising serious problems that must be resolved quickly. He did not mean that there is no justification for independent individual oceanic research, but rather that the problems of rational use of the sea and its resources demand that a substantial part of the world's expertise in oceanography must be devoted to a coordinated attack on these problems.

The IDOE concept grew out of discussions of the law of the sea in the United Nations, and particularly through the concern expressed by many nations about ownership of the seabed and its resources, and the resources of the superjacent waters. This concern was given concrete expression in the fall of 1967 in a resolution adopted by the General Assembly of the United Nations which proposed an "examination of the question of the reservation exclusively for peaceful purposes of the seabed and the ocean floor, and the subsoil thereof, underlying the high seas beyond the limits of present national jurisdiction, and the use of their resources in the interests of mankind " (United Nations, 1968). It was the view of the United States that development of a set of principles on which boundaries to national jurisdiction could be based, and decisions on an appropriate international regime for the deep sea, are dependent upon adequate scientific knowledge, and that the necessary scientific knowledge is not now available in sufficient detail. The Ocean Decade was proposed as a means of getting the required scientific background quickly and efficiently.

What is unique about the Decade that sets it apart from other oceanographic or ocean engineering programs? If the proposal were simply a continuation or expansion of past efforts it could hardly merit a distinctive title. But the Decade is much more than that. The proposal anticipates: (1) a sustained exploration of the sea, planned and coordinated for the entire globe, *not* sporadic and independent efforts; (2) emphasis on knowledge for its value in resource management, rather than on scientific investigation for its own sake; (3) merging of the efforts of international organizations like the Intergovernmental Oceanographic Commission, Food and Agriculture Organization of the United Nations, and the World Meteorological Organization, among others, as well as the skills and facilities of individual nations; (4) more systematic collection and more rapid dissemination of data, backed by international standards designed to enhance utilization; (5) emphasis on making information available to the lesser developed countries and helping them to improve their capabilities for ocean research and development.

United States planning for the nation's part in IDOE, now a responsibility of the National Science Foundation (NSF), has been aided by two other documents: (1) "International Decade of Ocean Exploration -- Program Recommendations" prepared by a Federal interagency planning group established by the National Council on Marine Resources and Engineering Development, and including a "Definition of Decade Planning Requirements", endorsed by the Marine Science Council's Committee on Policy Review (National Council on Marine Resources and Engineering Development, 1969); (2) "An Oceanic Quest", an appraisal of the Decade, by the National Academy of Sciences and the National Academy of Engineering, prepared by an eminent group of United States oceanographers and engineers (National Academy of Sciences, 1969).

Responsibility for Decade planning and funding was delegated to NSF in November 1969, and the NSF Office for the International Decade of Ocean Exploration was established in March 1970.[1] Planning and establishment of policy has proceeded vigorously with the aid of a small team of consultants and appropriate advisory mechanisms. The President's budget for the fiscal year beginning July 1, 1970, contained $15 million for IDOE, to support academic programs and programs of other federal agencies in approximately equal amounts. At the time this paper was delivered (November 9, 1970) this NSF budget had not been approved. The National Science Foundation has issued three notices describing the Decade (National Science Foundation 1970a, 1970b, 1970c).

International planning for the Decade has been proceeding as an important part of the activities of the Intergovernmental Oceanographic Commission (IOC) of UNESCO. A valuable background document has been the report "Global Ocean Research" (United Nations, 1969), more commonly known as the "Ponza Report", prepared by a joint international working party of the Advisory Committee on Marine Resources Research to the Director General of the Food and Agriculture Organization of the United Nations, the Scientific Committee on Oceanic Research of the International Council of Scientific Unions, and the Advisory Group on Ocean Research of the World Meteorological Organization. A "Comprehensive Outline of the Scope of the Long-Term and Expanded Program of Oceanic Exploration and Research", which includes the "Ponza Report" as an

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[1]The author was Head of the Office for the International Decade of Ocean Exploration from March to the end of August 1970.

appendix, was approved by the General Assembly of the United Nations in December 1969. IOC has been directed to develop detailed plans as promptly as possible, and to this end it established an international "group of experts" in January 1970.

In these times of budgetary stringency it will be difficult for the United States to preserve the unique characteristics of the Decade in developing its national IDOE program. The budget to be provided in the current fiscal year (if it is provided at all) may be virtually the only new funds allocated to oceanography in the United States, and pressures will be strong to use these funds to support programs already in progress for which funding has been withdrawn or curtailed. The Administration and the National Science Foundation have made it very clear that IDOE funds must not be used for "more of the same", but rather for programs that are imaginative and new in every sense. In issuing this warning the Administration also has made it clear that United States objectives in the Decade are oriented toward rational use and management of the ocean and its resources, not resource development and exploitation. It also has been stressed emphatically on several occasions (although it will be difficult to find this caveat in writing) that fishery research and development will not be a part of the United States Decade Program, at least in the early period. To drive home this point it also has been emphasized that plans and documents prepared and issued prior to the Vice President's announcement of October 19, 1969, in which he described the five initiatives in oceanography to be supported by the Administration, cannot be regarded as official commitments. IDOE was one of the five initiatives, and this means that policy with respect to the U. S. national IDOE program does not antedate the Vice President's announcement. The fourth annual report of the President to the Congress on Marine Resources and Engineering Development (National Academy of Sciences, 1969), however, does make reference to fisheries in the chapter entitled "International Decade of Ocean Exploration" as follows:

> "The enhanced ocean uses and resource potential can provide benefits to developing nations. Unused fishery resources . . . exist off the coasts of a number of developing countries."
>
> "The Expanded Program will give special emphasis to broadening the opportunities for developing nations to participate in the use of the oceans and its resources through encouraging them, for example, to . . . survey coastal fishery resources . . ."
>
> "The oceans contain large unused fishery resources and fisheries offer an opportunity to assist in closing the protein gap with many latent fisheries lying within easy access of nations plagued by serious protein deficiencies. The pooling of knowledge about these resources by interested nations during the Decade could contribute significantly to development and management of world fisheries resources."

From this it appears that the United States sees fishery development in the Decade primarily as a problem of the developing nations. United States policy and programs for its own fisheries are contained in two other chapters in the report cited: "Accelerating Use of Food From the Sea" and "Expanding International Cooperation and Understanding".

Despite these decisions and constraints it is difficult to understand how fishery science and management can be ignored in the United States national program for the Ocean Decade. Marine plants and animals, including those of commercial and recreational value, are important elements of the ocean. They affect the physical and chemical properties of the sea. They are important concentrators and transporters of heavy metals, pesticides, and other natural and introduced constituents of the water. They are useful indicators of environmental quality. Commercial and sport fisheries remove substantial fractions of the standing crops of some species, with demonstrable effects on the ecological balance. Equally important, fishing still is the most valuable extractive marine industry, and to most of the member nations of the Intergovernmental Oceanographic Commission it will be one of the principal beneficiaries of the Long-Term and Expanded Program of Oceanic Exploration and Research and of the International Decade of Ocean Exploration. The United States and some other developed nations have unique experience in fishery research and management, and are among the major present users of living marine resources. This experience and technical skill, together with impressive power to modify the marine environment by catching large quantities of marine plants and animals, carries with it the responsibility to play an important part in the fishery aspects of the Decade.

Importance of Fisheries in IDOE Planning

Despite the denial of historic precedent implicit in the endorsement of the Ocean Decade by the present Administration it is illuminating to review the important part that fisheries played in early planning. The "white paper" of May 1968 (National Council on Marine Resources & Engineering Development, 1968), in describing the Decade concept, started off with the statement: "the ocean is an important source of food". All through this paper, which elaborates the President's message of March 8, 1968, to the Congress, fishery research and management were important themes, as illustrated by the following quotations:

> "the Decade can encourage and assist in the development of resources, and particularly new sources of food, critically needed in the developing areas of the world. Thus, emphasis should be placed on the identification and assessment of food and mineral resources as well as investigation of ocean processes."
>
> "Improved understanding of fishery resources and their reactions to natural and manmade disturbances is necessary to increase and maintain the yield and to resolve international fishery conflicts."

The distinguished group of scientists who prepared "An Oceanic Quest" (National Academy of Sciences, 1969) obviously believed that fisheries would be an important element of the Decade, for they devoted a major part of one chapter to the subject. Similarly, the international group of scientists who prepared "Global Ocean Research" saw fishery research and management as important problems that should receive particular attention. The Long-Term and Expanded Program of IOC also devoted a full chapter to the living resources and the research and exploration needed for their full utilization and management.

In all these documents emphasis was laid upon understanding the responses of living resources to natural and man-made changes in the environment, not on resource development *per se*. Within the three major topics selected for primary emphasis in the early stages of the NSF program (National Science Foundation, 1970b), two, namely Environmental Quality and Environmental Forecasting, have important implications for fisheries, and fisheries scarcely can be ignored in this context. Even the third, Seabed Assessment, will have importance for fisheries also.

The State of Marine Fishery Management

There has been much talk about marine fishery management, and the fishery programs of the United States federal government and the States have management as their major goals. Management is also the central theme of the nine international fishery commissions of which the United States is a member. Yet it is difficult to find good examples of successful marine fishery management, domestic or international. The two examples most commonly cited, the North Pacific fur seal and halibut management programs, are facing problems now which raise doubts as to their economic success, although no one could seriously challenge that they attained their biological objectives. World fish catches have been increasing steadily for a quarter of a century and there is every reason to believe that this growth will continue for a time. Concomitant with this development has come an increase in the number of fairly clear-cut examples of overfishing. Threats to the fisheries from pollution and other human modifications of the environment are assuming alarming proporations. The conviction is growing that the problems are multiplying more rapidly than knowledge is accumulating to solve them. To argue that fisheries bring no net return to the national economy and that therefore they do not merit investigation at the taxpayer's expense is to ignore major segments of the marine fisheries, such as the processor, the importer, and the investor in foreign fisheries. This argument also ignores the recreational and economic contribution of marine sport fisheries, the international obligations of the United States to contribute to management of living marine resources, and our moral obligation to preserve these resources for generations to come.

CONCLUSIONS

The National Marine Fisheries Service, formerly the Bureau of Commercial Fisheries, will need to give continued attention to fishery research, development, and services of various kinds. But it is difficult to conclude that the fisheries can be ignored in the United States national program for the International Decade of Ocean Exploration. The Decade provides a new and unique dimension for fishery research and management, just as it does for oceanography as a whole. This new dimension is the vigorous international planning and coordination that will be a major feature of the Ocean Decade. The scarcity of clear examples of effective marine fishery management is an expression of our lack of understanding of the mechanisms that govern the dynamics of fishery populations, and of our inability to develop acceptable social-political management arrangements. These are precisely the kinds of problems that the Decade proposes to elucidate and eventually to solve.

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Soviet Fisheries and Fisheries Research off the East Coast of the United States[1]

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Abstract

American fishermen have long considered the fishing grounds off the East Coast of the United States to be their own. In 1961, however, large numbers of Soviet trawlers appeared off Massachusetts and American monopoly of the grounds ended.

Trawlers from Poland, East Germany, West Germany, Japan, and several other nations also fish with or near the Soviet fleet. As a result, the overall abundance of groundfishes in some areas has dropped 40% in 4 years. Soviet scouting trawlers were observed on Campeche Bank and the Soviets have taken tuna in the tropical Atlantic. Vessels of Soviet bloc nations fishing as far south as the Patagonian Shelf use Havana, Cuba as a base.

Federal and state fisheries agencies are alarmed at the decline in the abundance of several species fished by the Soviets. In 1967, negotiations were held with the Soviets to draw up a management agreement. At the same time, cooperative fishery-oceanographic cruises, with US and Soviet biologists participating, were launched to survey the New England fishing grounds and the Middle Atlantic Bight. Similar cruises were made each year through 1970. The author served aboard a Soviet fishery research vessel on the first two cruises.

Soviet fishing methods and fishery research techniques are described and illustrated. The scope of the bilateral agreements are outlined and the effects of the regulations are discussed.

INTRODUCTION

For more than 200 years, American fishermen considered the grounds off the US East Coast to be their own. Although the grounds lay in international waters, they were fished almost exclusively by US and Canadian vessels. In contrast, the Grand Banks off Newfoundland have been regularly exploited for over 500 years by vessels from up to 15 European nations. In 1961, large numbers of Soviet trawlers and fleet support vessels appeared on Georges Bank, and American monopoly of the East Coast fishing grounds was ended.

The Soviets came in fleet strength and by the summer of 1963 at least 200 of their vessels were operating on and around Georges Bank. At various times during that year, Soviet stern trawlers were seen fishing as close as 30 miles south of Block Island, Rhode Island. Fleets of mostly medium trawlers with some stern trawlers were operating not far off the United States coast from Massachusetts to Florida.

On Georges Bank, the Soviets fished mostly for Atlantic herring *(Clupea harengus)*. This species is under-utilized by American fishermen and the Soviets

[1]Contribution No. 70-8, Division of Marine and Coastal Resources.

set long strings of gill nets for the herring from modified side tralwers. The nets prevented many American vessels from fishing the grounds with their otter trawls and, in addition, lost gill nets often fouled the gear and propellers of the trawlers. The Soviets later began using midwater trawls for the herring and US Bureau of Commercial Fisheries (BCF) management agents, observing the vessels from low-flying aircraft, estimated some catches to be on the order of 18 to 22 metric tons per tow.

It was not long before the Soviets also turned their attention to bottom fish, especially silver hake *(Merluccius bilinearis)* and red hake *(Urophycis chuss)*. The gill nets were replaced with bottom and mid-water trawls. Later, the Soviets expanded their fisheries in the Northwest Atlantic to include a number of other species, both groundfish and pelagic fishes (Table 1).

TABLE 1

Finfish Landings (000's metric tons) from Georges Bank and the Gulf of Maine

SPECIES	1961	1962	1963	1964	1965	1966	1967	1968
Herring:								
US	27	72	70	28	34	30	32	42
USSR	67	151	97	131	36	117	124	127
Haddock:								
US	52	54	49	52	57	57	40	29
USSR	-	1	2	5	82	48	2	1
Silver Hake:								
US	46	50	47	53	42	41	31	36
USSR	-	42	107	167	281	121	70	44
Red Hake:								
US	13	12	21	24	13	4	7	7
USSR	-	-	3	4	58	83	38	11

The effort of the Soviet fleet, to which has been added the effort of trawlers from Poland, East Germany, West Germany, Bulgaria, Cuba, Greece, Spain, Japan, and several other nations, has had considerable impact on the stocks of fish in the Atlantic Ocean off the American east coast. The overall abundance of groundfish in the waters off New England and New York has dropped 40%. Haddock *(Melanogrammus aeglefinus)* abundance has dropped over 60% (a result in part, also, of natural declines). The Soviets had entered the Georges Bank haddock fishery in 1965 and in that year, while US trawlers landed 57 thousand tons, USSR trawlers landed 82 thousand tons. The annual maximum sustained yield for Georges Bank haddock is estimated to be 50 thousand tons. To compound the situation, this population of haddock has experienced year-class failures each year following the very successful 1963 year class. Thus, the haddock fishery is in dire straits. Red hake abundance has dropped to 25% of its former level. Further, while the average annual US catch of silver hake was about 50 thousand tons, Soviet effort on the species raised the 1965 total catch to over 300 thousand tons, after which the catch declined sharply. In 1969, the Soviets again shifted part of their effort to include yellowtail flounder *(Limanda ferruginea)*. In that year, US landings were 23 thousand tons (near the maximum sustained yield) and USSR landings were 27 thousand tons. Some of these fisheries are discussed in detail by Graham (1968, 1970).

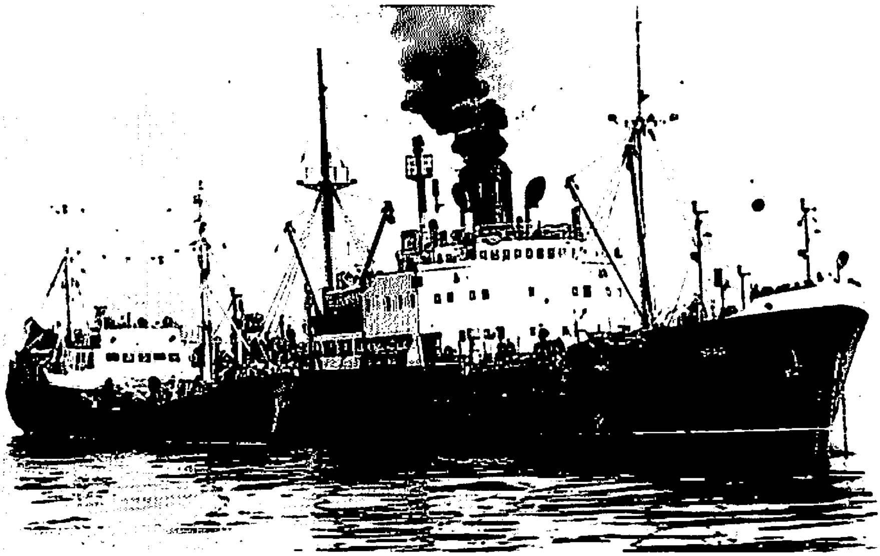

Fig. 1. Soviet base ship, *Ural*, with a trawler (SRT) tied alongside to offload its catch. The plume of black smoke suggests the fish meal and oil plant aboard the *Ural* is operating. (BCF photograph)

CHARACTERISTICS OF THE SOVIET FLEET

The Soviet fishing fleet operating in the Western Atlantic is impressive both in size and number of vessels (Hitz, 1968). The vessels are generally new, modern and efficient, and include fishing, processing, transport, and support ships (Fig. 1). The fishing vessels are of two main types: side trawlers and stern trawlers. Smallest of the side trawlers is the SRT *(Sredniy Rybolovnyy Trauler*, medium fishing trawler), about 37.5 meters long and 265 gross tons. The next largest is the SRTR *(SRT Refrizheratornyy*, refrigerated medium fishing trawler), about 50.8 meters long and 505 gross tons. Largest of the side trawlers is the SRTM *(SRT Morozilnyy*, freezer medium trawler), about 54.2 meters long and 700 gross tons. It was the side trawlers that had taken part in the gill-net fisheries for herring.

The largest fishing vessels are the factory stern trawlers. These BMRT's *(Bolshoy Morozilnyy Rybolovnyy Trauler*, large freezer fishing trawler) are most often called, simply, factory trawlers and are about 84.7 meters long and 3,170 gross tons (Fig. 2). The otter trawl is set and hauled back through the stern chute and the catch is completely processed aboard. Below decks the factory trawlers have automated production facilities that behead and fillet the round fish (cod, haddock, etc.). Flat fish are filleted by hand. Other machines skin the fillets which are moved in packages to blast freezers and then to frozen-cargo storage space. The frozen fish may be returned to the homeland aboard the trawler, or, most commonly, are offloaded at sea to special transports. The skin, bones, and viscera are reduced aboard ship in a meal and oil plant.

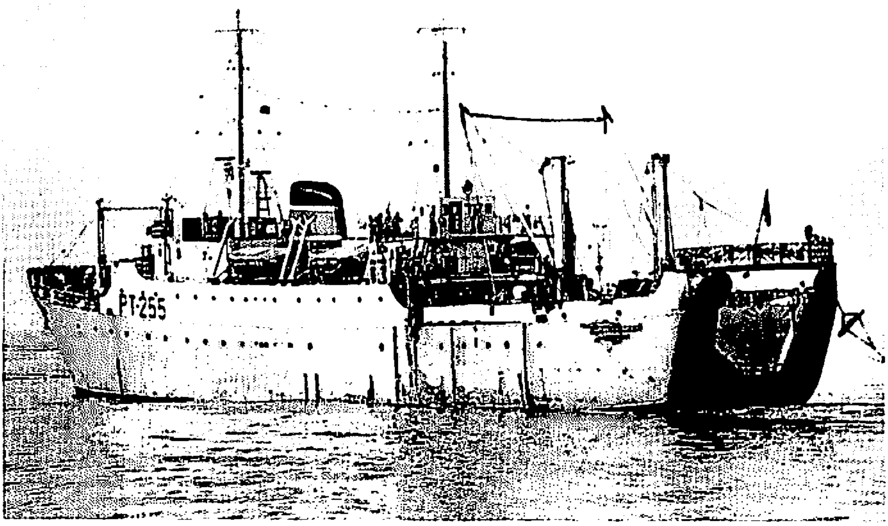

Fig. 2. A Soviet factory stern trawler (BMRT) on Georges Bank hauling back the otter trawl. (BCF photograph)

The service vessels include a variety of transports from 83 to 166 meters long, base ships up to about 166 meters long, tankers, tugs, and repair and salvage ships. The base ships provide medical and dental facilities and, with the transports, bring crews to and from the homeland. They also transport the frozen fish, meal and oil.

The Soviets have developed a catamaran fishing vessel. The ship, named *Experiment*, was fabricated from two SRT hulls with two stern ramps and trawl decks. It can be used for bottom and midwater trawling and for purse seining and is said to have better maneuverability and stability than single-hull trawlers. It was first tested in the Baltic Sea, and in May 1969 it was seen by BCF management agents on sea trials off the New England Coast (US Bureau of Commercial Fisheries, 1969b). To date there have been no reports of the fishing success of this vessel.

Soviet Fishing Strategy

Much of the success of the Soviet fishing vessels lies in their method of fleet operation. Vessels in a particular area usually are under the command of an individual aboard one of the vessels who is designated the "Fleet Commander." The trawlers in the fleet, research vessels, and specially assigned scouting vessels transmit information to the commander enabling him to make prompt decisions about the best strategy and deployment for the fleet. Mathisen and Bevan (1968) state, "Once a day during the 'captain's hour,' weather observations, water temperature, other physical and biological information and catch data are circulated among the fleet." The captain of each trawler has some leeway in his actions, but his decisions are based on the information available to the entire fleet and on the recommendations of the fleet commander.

The fleet technique has enabled the Soviets to be extremely mobile in their search for concentrations of fish. For example, BCF management agents, on a routine reconnaissance flight on April 9, 1969, observed a fleet of 107 Soviet vessels in a 25-mile area, 25 to 30 miles east of Currituck Sound, North Carolina. Moderate catches of fish on board were identified from the air as herring (species). In addition, a number of trawlers were alongside the large factory base ships off-loading fish. The agents had observed this fleet over a period of 10 days and had seen it shift operations north and south several times. At the end of March, the fleet had been located east of the entrance to Chesapeake Bay. Within 2 days, the fleet moved northward to the offing of Delaware Bay, and then returned southward off Chesapeake Bay to the area in the offing of North Carolina (US Bureau of Commercial Fisheries, 1969a).

Observations of Soviet Vessels

A number of US agencies are interested in the activities of the Soviet vessels fishing off the North American coast for a variety of reasons; one is national security. Other agencies are interested because of the obviously large removals of fishery resources being made by the fleets. Some information can be gleaned from surface vessels, and American trawlers, fishing among the Soviet fleets, made many reports to government officials. However, the reports often were colored by the emotions of the Americans who felt they were being forced out of traditional fishing grounds. Both the US Navy and the US Coast Guard sent vessels among the foreign ships to observe and photograph their activities. BCF research vessels occasionally occupied stations near Soviet trawlers so that American biologists could carefully study the fleet and vessel operations. Finally, the Coast Guard began to make aerial observations of the fleets during routine search and rescue flights. To get the most information out of the observations, BCF fishery management agents and biologists accompanied the Coast Guard crews on the flights.

As part of New York State's contribution to the surveillance program, I accompanied the Coast Guard on two flights over the Middle Atlantic Bight. The aircraft flew at altitudes as low as 35 meters and it was possible to clearly see the foreign fishermen and their catches. The species of fish were quite easy to identify at such a low height – at least to differentiate between herring and silver hake, and between red hake and scup *(Stenotomus chrysops)*. High-resolution color photographs of the catches were studied ashore for detailed species identification. Coverage on the two flights generally was confined to the waters off Long Island (New York) and New Jersey. A total of 97 foreign fishing and support vessels were sighted on one flight and identified as 76 Soviet and 21 Polish ships. The Soviet fleet consisted of 2 BMRT's, 67 side trawlers (56 SRT's, 10 SRTR's, and 1 SRTM), 3 refrigerated fish transports, 2 cargo vessels, and 2 factory base ships. The Polish fleet included 3 BMRT's, 15 SRT's, 2 supply vessels and 1 factory base ship.

Of particular interest was the presence of at least five Soviet SRTR's completely equipped for purse seining. The vessels were rigged with power blocks and the seine nets were arranged on the stern section of each ship. One ship was making a set. This was the first known instance of the Soviets purse seining in the Middle Atlantic Bight although they have done so in other parts of their world ocean fishery.

Cooperative US-USSR Fishery-Oceanographic Surveys

Although observations of the Soviet fishing fleets from aircraft and surface vessels provided a greal deal of information about their activities, it was soon obvious there were details not readily apparent. Thus, after negotiations between the US and the USSR, cooperative fishery-oceanographic surveys were begun off the New England-Middle Atlantic coast. The first cruise took place in 1967 and they have continued each autumn through 1970. The sampling scheme and the rationale for the stations occupied are described by Grosslein (1969). Details of the first two surveys are described by Jensen and Poole (1968, 1969) who were participants aboard the Soviet research vessels in the surveys (Fig. 3).

Fig. 3. US and Soviet biologists sort fish aboard the USSR research trawler during the cooperative fishery survey.

Two vessels make the surveys, the BCF R/V *Albatross IV* and a Soviet scout trawler. *Albatross IV* is a 54-meter-long stern trawler especially designed for fishery-oceanographic research. The scout trawler (SRTR) was converted for research by the addition of a small chemical laboratory under the whaleback and hydrographic winch and boom on the port side of the boat deck. The winch and boom are used for making bathythermograph and Nansen bottle casts (Fig. 4).

New York State's interest in the surveys was sparked by the Soviet fishery for species sought by New York's commercial and sport fishermen. In 1963, the Soviet fleets shifted their fishing from the waters off New England to the Middle Atlantic Bight (Cape Cod, Massachusetts to Cape Hatteras, North Carolina). Here they took large quantities of red hake and silver hake, and incidental quantities of summer flounder *(Paralichthys dentatus)*, and scup. The trawlers concentrated on the red hake and silver hake when they were grouped in pre-spawning aggregations in the deep water of the Continental Shelf near the Hudson Canyon. United States landings from the Middle Atlantic Bight in 1963 included 2.8 thousand tons of silver hake and 0.7 thousand tons of red hake (Table 2). By 1966, the domestic landings remained steady at 3.0 thousand tons of silver hake and 0.6 thousand tons of red hake. The 1966 Soviet catch of red hake, however, was 25.7 tons. The landings of summer flounder and scup already were greatly reduced because the two species were in low abundance (a result, some biologists believe, of the cooling of the waters off the Northeast coast).

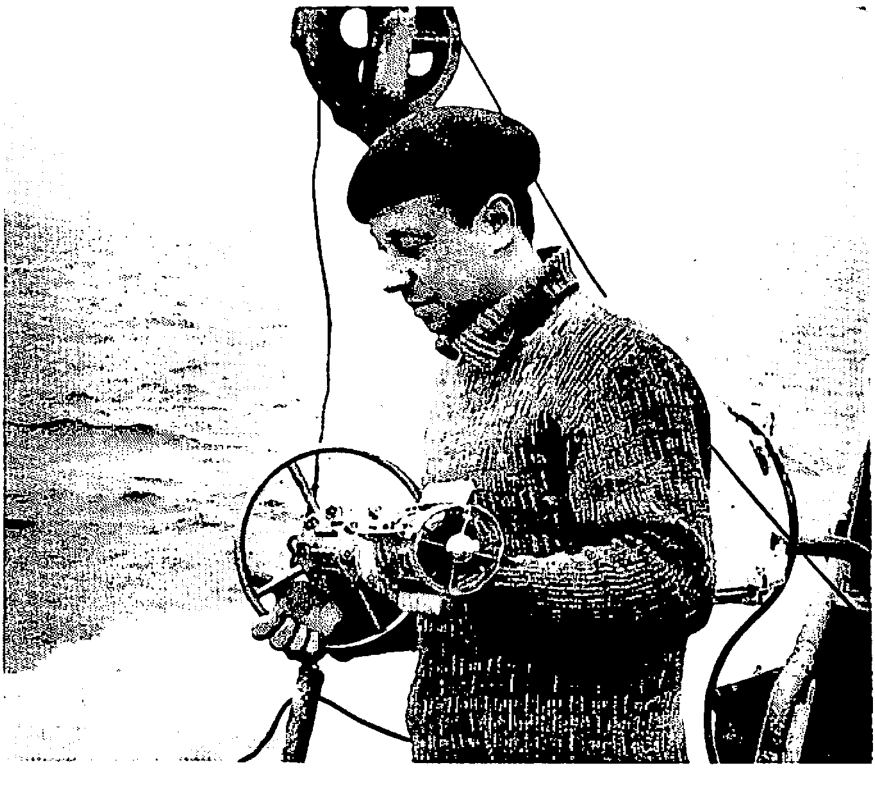

Fig. 4. Scout trawlers used as fishery research vessels by the Soviets are equipped with a small hydrographic winch and platform. Here the Soviet hydrographer prepares to cast the bathythermograph.

FISHERIES AGREEMENTS IN THE NORTHWEST ATLANTIC

In the 1940's, the European nations fishing the Grand Banks organized to formulate an international agreement controlling fishing in that part of the Northwest Atlantic (Graham, 1970). The result was the International Commission for the Northwest Atlantic Fisheries (ICNAF) that held its first meeting in

TABLE 2

Finfish Landings (000's metric tons) from the Middle Atlantic Bight

SPECIES	1963	1964	1965	1966	1967	1968
Herring:	0.7	0.4	2.2	3.0	3.8	29.2
US	0.1	0.2	0.3	0.2	0.6	0.2
Foreign	0.6	0.2	1.9	2.8	3.2	29.0
Silver Hake:	7.0	19.9	21.0	95.9	28.1	18.4
US	2.8	3.0	3.3	3.0	4.4	3.4
Foreign	4.2	16.9	17.7	92.9	23.7	15.0
Red Hake:	1.4	9.0	12.4	26.3	15.6	2.2
US	0.7	0.6	0.6	0.6	0.6	0.4
Foreign	0.7	8.4	11.8	25.7	15.0	1.8
Scup:	15.8	13.5	11.8	7.7	6.1	4.5
US	14.5	13.0	11.1	7.2	5.6	4.0
Foreign	1.3	0.5	0.7	0.5	0.5	0.5
Mackerel:	0.4	0.5	0.6	2.0	6.8	8.9
US	0.1	0.4	0.5	0.8	0.7	0.9
Foreign	0.3	0.1	0.1	1.2	6.1	8.0

1951. One of the earliest management decisions of the commission was to regulate the mesh opening in otter trawls used in the haddock fishery. Eventually the mesh regulation was signed by all 15 member nations of the commission including the Soviet Union (when she became a member in 1958).

At first the mesh regulation applied only to haddock. Eventually it was broadened to include a number of other species including cod *(Gadus morhua)*, a most important species in the Greenland-Grand Bank grounds. Graham (1970) says of the mesh sizes, "Today all subareas [of the ICNAF convention area] have specified minimums: 5-1/8 inches (130 mm) in Subarea 1 and 4-1/2 inches (114 mm) in Subareas 2 to 5. The minimums apply to cod and haddock in Subarea 5 and to several species -- as many as 10 -- in the other subareas."

The results of the mesh regulation in the haddock fishery have demonstrated the need for further control, especially of fishing effort and catch. Thus, when agreements were drawn up to regulate the fisheries in the Middle Atlantic Bight, these other controls were written in as major elements of the documents.

US-USSR Fisheries Agreements

In November 1967, the US and the USSR signed a 1-year agreement in Moscow to regulate their fisheries in the Middle Atlantic Bight. Under the agreement, the two nations closed a rectangular area of about 5,000 square miles south of Long Island, New York, and Block Island, Rhode Island, to fishing by vessels of both nations more than 33 meters long during January through March 1968. This area is in international waters and includes a major part of the wintering grounds of red hake, scup, silver hake and summer flounder. The

Soviets agreed not to increase their total catch here in 1968 beyond their 1967 catch. They also agreed to hold their incidental catch of scup and summer flounder at or below the 1967 level and not to start specialized fisheries for these species.

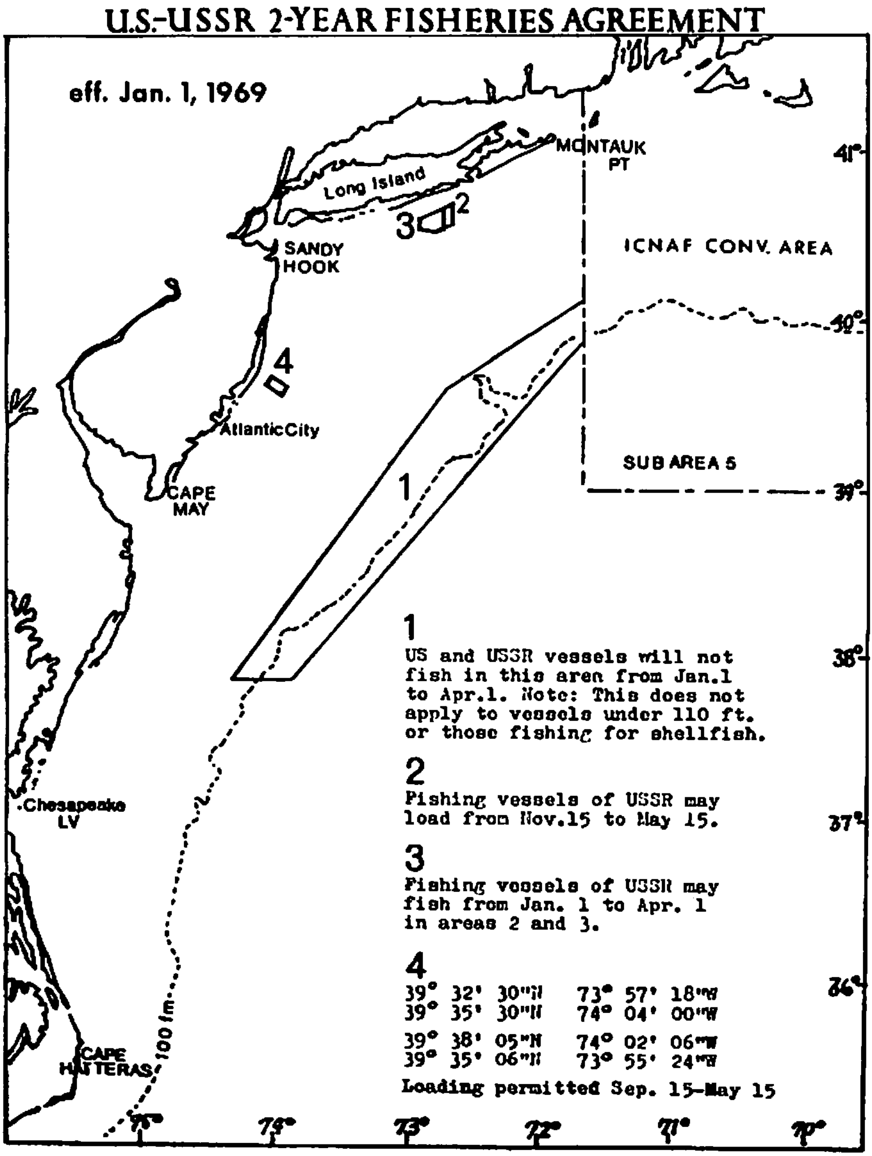

Fig. 5. Areas of special interest established as part of the US-USSR fishing agreements in the Middle Atlantic Bight. The areas are essentially the same in the US-Polish fishing agreement. (From Lundy, 1969; with permission)

In return for the Soviet concessions, the US agreed to permit the loading and transfer of cargos between Soviet vessels in a 20-square-mile area 6 to 12 miles off Long Island from November 15 to May 15, and in a similar area off New Jersey from September 15 to May 15. A third concession the Soviets won aroused a great deal of criticism among many Americans. Trawlers from the USSR were allowed to fish within the contiguous fishery zone -- in a 60-square-mile area, 6 to 12 miles off Fire Island, New York -- from January 1 to April 1. To date, the Soviets have not exercised this last right and probably will not do so. The area is almost totally barren of fishes during the period specified. The concession, however, has tremendous geo-political implications and would be a powerful lever for the Soviets in their negotiations with other nations; for example, to fish for hake off South America.

In December 1968, the US and the USSR signed a new agreement for the fisheries off the mid-Atlantic coast. It extended and modified the 1967 agreement, although the basic provisions of the two agreements are similar (Lundy, 1969). There are two principal differences. The agreement was made for 2 years, to cover the fishing seasons of 1969-70. Also, the area closed to fishing (Fig. 5) was an elongated belt roughly along the 50 to 100 fathom line from Rhode Island to Virginia.

US-Polish Fisheries Agreements

The Iron Curtain countries fishing off the US more or less followed the lead of the Soviets in their strategy. However, Polish trawlers often fished in the closed zone, and since they made up the second greatest number of foreign vessels, it soon became urgent that an agreement be worked out between the US and Poland. This was done in Warsaw in June 1969 with the same basic provisions as in the agreement between the US and the USSR. The agreement was in force for 1 year and was renegotiated in Washington in June 1970. The new agreement added protection to Atlantic menhaden *(Brevoortia tyrannus)*, alewife *(Alosa pseudoharengus)*, and black sea bass *(Centropristis striata)*. The time period for the closed fishing zone was extended to April 15. A third loading zone was provided the Polish fleets off the coast of Virginia, north of Chesapeake Bay, but they were not permitted to fish within the US contiguous fishing zone.

Haddock Fishing Restrictions

The Soviet Union had insisted that her fishing agreements in the Middle Atlantic Bight be negotiated bilaterally rather than multilaterally within the 15-member ICNAF. They argued that the area in question was outside the ICNAF Convention Area and thus did not come under the jurisdiction of that commission. However, a multilateral agreement to regulate the haddock fishery was drawn up with ICNAF in 1970 inasmuch as the grounds involved -- Subarea 5; Georges Bank and the Gulf of Maine -- were entirely within the Convention Area.

This agreement closed three areas on the banks (including one south of Nova Scotia, Subarea 4) to haddock fishing during the haddock spawning season, March and April 1970-1972. The areas are known centers of haddock spawning and it was hoped that the closure would permit the stocks to reproduce without being disturbed by groundfishing operations. Fishermen were specifically restricted from using otter trawls or similar devices, hook and line gear, or gill nets. In addition, a total annual catch quota of 12 thousand tons was set for the haddock fishery in Subarea 5. This contrasts sharply with historical US annual landings of about 49 thousand tons. Under the protocol established for this regulation, the 15 member nations of the commission agreed that when 80% (or about 9.0 thousand tons) of the quota was reached, fishing for haddock in the area would cease. Eighty per cent of the quota was reached and the haddock fishery in Subarea 5 was closed on October 23, 1970.

SOVIET RESEARCH AND DEVELOPMENT IN THE NORTHWEST ATLANTIC

Over the past half century, as Soviet fishing fleets and areas of operation expanded, she has given more and more attention to research in oceanography, fisheries biology, and exploratory fishing. Mathisen and Bevan (1968) characterize the USSR as "...one of the greatest contributors of marine biological data today." The major thrust, in terms of capital investment, has been in oceanographic research. The most famous of the Soviet research vessels, the 102.6 meter long *Mikhail Lomonosov*, and the newer, 115-meter-long *Akademik Kurchator*, have been engaged over most of the world ocean on a variety of lengthy expeditions. Fishery biologists, however, have had to accompany large trawlers to make their observations and collections. Or, as often as not, scout trawlers, such as those that take part in the cooperative US-USSR fishery surveys, are used for research.

Exploratory Fishing

Much of the success of Soviet fishing operations is that her fishermen know where to find large available stocks of fishes. This information is gained from the exploratory fishing carried on by the scout trawlers. These SRT's search for new fishing grounds and also explore traditional grounds for unutilized stocks (such as the herring off the East Coast of the US). Some of the exploratory surveys have been conducted in cooperation with her allies, Cuba, for example (Sal'nikov, 1965). And in January 1968, Soviet exploratory vessels were seen off Campeche, possibly as a prelude to future exploitation of the fishery resources of the area (US Bureau of Commercial Fisheries, 1968). The results of some of the exploratory expeditions are shown in Fig. 6.

Gear Research

The Soviets have put considerable effort into developing the most efficient otter trawl to use in their fisheries for groundfish. The trawl used most commonly on the SRT's is a type called a "herring trawl." It is 42 meters long from wings to codend knot. The footrope is 27.4 meters long and is fished without the rollers used by US trawlers, for example, on rough bottom. The headrope is rigged with closely-spaced floats (Fig. 7) and fishes 4 to 6 meters off the bottom. This gives the mouth of the net a wide opening and enables it to filter a large volume of water. The twine throughout is *Kapron*, a Soviet synthetic fiber similar to nylon. The net is fished with 600 kilogram oval otter boards and because there are no rollers on the footrope, it tends bottom closely. During comparative tows on the cooperative surveys, the Soviet net outfished a standard Yankee 36 trawl about 2 to 1, and sometimes more for certain species. For example, the catch of flounders was about the same for both nets but for red hake, silver hake, Atlantic mackerel *(Scomber scombrus)*, and butterfish

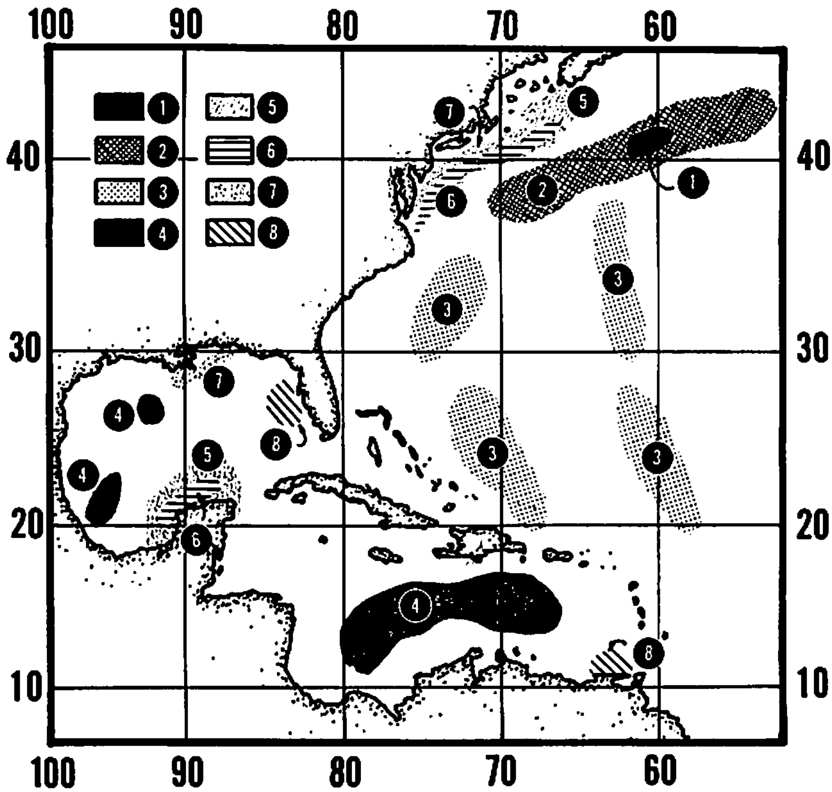

Fig. 6. As a result of their fishing efforts and exploratory cruises, the Soviets and their allies have evaluated the resources on the Atlantic and Gulf fishing grounds. The symbols are: (After Sal'nikov, 1965; with permission)

1. Very high tuna catches	5. Medium trawl catches
2. High tuna catches	6. High trawl catches
3. Good tuna catches	7. Good trawl catches
4. Medium tuna catches	8. Research on trawling should be continued

(Peprilus triacanthus), the catches made by the Yankee 36 trawl were only 10% to 25% of those made with the Soviet net.

The Soviets are furthering their gear research with experiments on deep-water trawls (Office of Foreign Fisheries, 1970). Early in 1969, the Soviet Northern Fisheries Administration ordered all BMRT's of the Murmansk fleet to be equipped by year's end with deep-water trawls (with special otter boards) to fish at 1,300 meters. In May 1970, the Soviet Western Fisheries Administration reported that one of its BMRT's had succeeded in fishing as deep as 2,000 meters off Canada's Labrador Peninsula. The Soviet Deputy Minister for Shipbuilding explained the rationale behind this interest in deep trawling as follows: "... many coastal states will extend their territorial zones considerably

Fig. 7. Crewmen aboard a Soviet trawler prepare to rig a "herring trawl" for fishing. The design of this net has made it a very efficient piece of gear.

[thus there is a need] to develop means to bring marine animals from greater depths than before . . . ."

The catamaran trawler mentioned previously represents another avenue of Soviet gear research. The *Experiment* was designed to meet a growing requirement of the Soviet fleet for versatile vessels capable of fishing different kinds of gear in different areas under the most severe weather conditions (Fishing News International, 1970).

Reports of Soviet Research

The results of Soviet fisheries research have been published for many years, of course, in Russian in their own journals. Recently, however, more and more of them are appearing in English in journals published outside the Iron Curtain. For example, the Research Bulletin of ICNAF frequently contains reports by Soviet scientists of their work in the Northwest Atlantic. Translations of Soviet reports also are available. One important and informative publication is the compilation of papers included in the volume *Soviet-Cuban Fishery Research*, edited by A. S. Bogdanov (1965). It was translated from the Russian by the Israel Program for Scientific Translations under an agreement with the US Department of the Interior and the National Science Foundation through the US Department of Commerce Clearing House for Federal Scientific and Technical Information.

The Soviet serial publications, *Problems of Ichthyology* and *Hydrobiological Journal*, are available bimonthly in English from the American Fisheries Society.

The Soviets report their fisheries landings to ICNAF and the Food and Agriculture Organization (FAO) for publication. Thus, fisheries workers in other parts of the world are able to keep fairly well informed about Soviet researches and about their exploration and exploitation of diverse stocks of fishes.

DISCUSSION

At this point the question may well be raised: What is behind the Soviet push in world-wide fishing? The answer seems rather simple; there is a near-desperate need for animal protein in the homeland and in the satellite nations with whom the Soviets have trade pacts. A series of agricultural failures in the USSR have forced Soviet officials to look elsewhere for animal protein food. Nor does there seem to be any likelihood that the agricultural picture will improve in the near future. An analysis of Soviet agricultural economy (Schwartz, 1969) blamed poor production on extremely severe winter weather. There were serious farm losses during a harsh winter and deliveries of livestock to state-run slaughterhouses fell well below the planned levels. In the winter wheat areas of the Ukraine and the North Caucasus, storms with hurricane-force winds ruined many of the previous autumn plantings of wheat. Thus, faced with shortages of animal protein and grain, the Soviets seek elsewhere for food.

Saltwater fish has never traditionally been an important part of the Russian diet. Toward the end of the Czarist era, in 1913, fish production in Russia amounted to 1.05 million tons with 86.9% of the catch derived from inland waters (Mathisen and Bevan, 1968). For the period 1957-59, Gulland and Carroz (1968) report that fish contributed (per capita) only 2.0% of the total protein and 5.9% of the animal protein supply in Eastern Europe and the USSR. The Soviets, of course, lacked easy access to the sea but territorial expansion following World War II soon gave the access needed. Further, in the mid-1950's the Soviets embarked on a program to recruit fishermen for distant water fisheries and acquired a modern fleet of fishing vessels capable of using a variety of gear in any part of the world ocean. As we have seen, this program has proven to be quite fruitful.

With fisheries intelligence supplied to them by the explorations of the scout trawlers, the Soviet fleets have demonstrated an effectiveness that is challenging many traditional fisheries efforts. As Graham (1970) points out, their long-range, mobile fleets are in a position to take advantage of unusual fish abundance at great distances from the home port. They may harvest the crop to the disadvantage of the adjacent coastal state.

Although the Soviets are efficiently and systematically cropping a number of abundant stocks of fishes, they appear anxious to avoid being pictured as mere exploiters of the marine resources. Thus they have been quick to espouse conservation-oriented programs in their distant-water fisheries. In a number of areas around the world, Soviet entry into existing conservation treaties closely followed the expansion of fishing operations by her fleet into treaty waters. However, Mathisen and Bevan (1968) emphasize that, "Membership in a fishery convention is sought by the U.S.S.R. . . .when it is necessitated by economic interests." In the Middle Atlantic fishing agreements, the USSR has been largely cooperative, both in the drafting of the agreements and in carrying out their provisions. Admittedly, some of her motives may be geo-political in nature but her actions appear to at least carry out the concept of conservation of fishery resources. With relatively few exceptions, Soviet vessels have avoided the Middle

Atlantic closed fishing zone. The trawlers that did fish in the zone during the closed season (either through genuine navigation error or willful disobedience) were warned off by US Coast Guard aircraft and surface vessels. In addition, the large identification numbers on the tralwers' hulls were reported to the Soviet fishery administration through their Washington embassy. Embassy officials advised the US State Department that the erring fishermen were returned to the USSR to be reprimanded. Before the US-Polish agreement in the Middle Atlantic was signed, the Soviets similarly took care of infractions by Polish trawlers that trespassed in the closed zone.

CONCLUSIONS

The efficient, massive fishing effort of the USSR in the waters off the East Coast of North America has had a profound effect on some of the stocks being exploited. The haddock, already suffering consecutive years of spawning failure, was placed in serious jeopardy by the Soviet fishing effort. Similarly, the yellowtail flounder, being fished at or near the maximum sustained yield by American fishermen, has recently been the object of intensive Soviet fishing. The resulting decline in abundance of both these species has meant serious economic hardship in the fishing communities of Boston and New Bedford, Massachusetts.

Although commercial fishing forms only a very small part of the gross national product of the US, it is of considerable importance to her coastal states. There have been many convincing arguments for the US to establish a 200-mile coastal limit to protect the marine fisheries from foreign exploitation. For the moment, however, there is little likelihood of such a limit being included in US foreign policy. It is obvious, of course, that the interests of the coastal states should be preserved. But this presently is best accomplished within the framework of a regulation or agreement negotiated with a nation engaged in high seas fisheries off the coastal states. The exclusive rights of coastal nations to fish off their own shores and the freedom for all nations to fish on the high seas are still the basic principles on which international fishery law rests.

ACKNOWLEDGEMENTS

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Informal Comments on Foreign Competition and the U. S. Fisheries

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The seas are ancient, yet they are new. Their regimes are immutable, yet they are fragile. They are catalysts for progress, yet platforms for discord. The right to fish like the right to navigate finds its genesis in ancient history.

In the days of Caesar the Mediterranean was considered a Roman lake. No one fished or navigated there without Roman consent or license. In the realm of Edward the Third, such a British lake extended from Norway to Spain. The most extravagant and optimistic claim of title was published as a Papal Bull in 1494 when Pope Alexander neatly divided the Atlantic between Spain and Portugal. Spain received title to all west of the line and Portugal everything to the east. Thus, the Pacific, the Caribbean and the Gulf of Mexico was acknowledged as Spain's, while Portugal had to be content with the addition of the South Atlantic and the Indian Ocean.

Four-hundred years ago when the suppression of piracy became a matter of international mutual convenience and Great Britain concluded that a regime of freedom of the high seas encouraged ocean commerce and therefore wealth, the concept of freedom of the high seas flowered and flourished. Grotius, the Dutch publicist, reduced the concepts to writing and the civilized world, spearheaded by Great Britain, fought to make the concept of freedom at sea a reality.

Out of this grew the concept of a narrow territorial sea -- 3 miles. And out of this grew a freedom to fish without constraint any place on the high seas outside of territorial waters.

A little over 250 years ago when modest increases in the ability to catch fish at sea evolved, there grew up, particularly in Europe, bilateral arrangements which essentially provided for qualified rights to fish between the participating countries. In fact, one of the very first treaties the United States made, as an infant nation, was with Great Britain pertaining to the conduct of fisheries in what is now the Canadian Maritime Provinces. That treaty still exists.

Some 70 years ago with a proliferation of fishing activity another element came into the equation and that was conservation. This principle of conservation grew in strength because of the growing awareness that the living resources of the high seas were not inexhaustible and that heavy continuous fishing could destroy valuable food resources -- thereby denying the resource to future generations.

For some stocks of fish it was too late – the world no longer has an Atlantic halibut fishery. For some stocks it came just in time – we can witness the rebuilding of the North Pacific fur seal herds.

A whole family of international arrangements grew out of the application of the principle of conservation – the United States is a party to nine of them.

The principle was incorporated in the Geneva Convention of 1958 as a guide to the conduct of fishing on the high seas.

That Convention simply stated that all states have the right for their nationals to engage in fishing on the high seas subject to their treaty obligations and to the need for conservation of the living resources of the high seas. In treaty language it is stated as follows:

"All States have the duty to adopt, or cooperate with other States in adopting, such measures for their respective nationals as may be necessary for the conservation of the living resources of the high seas." In brief, it was being indicated that no one had the privilege of an unqualified right to fish -- fishing must be conducted so as not to destroy the fisheries for future generations.

The principles of conservation as enunciated in the 1958 Geneva Convention have served to protect numerous stocks of fish and indeed serves as a basis for innumerable multilateral and bilateral agreements now in force throughout the world.

It is apparent, however, that the world community, including the United States, no longer finds the principles of conservation *alone* to be sufficient to protect the fisheries off their coasts. Only 27 countries have ratified the Geneva Convention. As you are aware this dissatisfaction became evident to a marked degree with the appearance of large foreign fleets off the Atlantic and Pacific coasts of the United States. Even had the foreign fleets conducted their fisheries fully and precisely in accord with the principles of conservation it was clear that the affected U.S. fisheries found the situation very difficult. Thus, starting in 1967 bilateral agreements were reached with the Soviet Union, Japan and Poland regarding their conduct of fisheries off our coasts. In these cases the U.S. objective has been (1) to insure conservation of resources off our coast, (2) to insure *access* by U.S. coastal fishermen to traditional fishing grounds, and (3) to prevent gear conflicts which have occurred in some areas. On the reverse side of the coin in our negotiated bilateral agreements with Canada and Mexico involving U.S. fishing off *their* coasts, the United States has tried to strike a balance in order to maintain our fisheries off the foreign coasts. It should be noted that at the present time we are renegotiating our present agreement with Japan in Tokyo and plan to do the same with the Soviet Union in December and January.

I mentioned before the Geneva Convention on Fisheries. At that same conference, and again in 1960 at Geneva, the world community was unable to reach agreement on the breadth of the territorial sea. This failure to reach agreement has cast a shadow over many uses of the sea. Indeed, the situation regarding territorial and other special purpose jurisdictions has deteriorated to a point approaching anarchy -- this has an adverse impact in several respects: strategic, involving U.S. Navy mobility and strategy, commercial shipping, air transport, and scientific research as well as fisheries. We *recognize* the inequities involved in competition between large, mobile fishing fleets and coastal small-boat fisheries which are limited in range -- we believe some acceptable solution to this problem has to be found if agreement on the overall problem of jurisdiction is to be obtained. Beyond this, the general question of oceans policy has been a matter of increasing international debate, particularly as to jurisdiction and use of the seabed and the rising problem of pollution of the high seas.

From what I have said thus far two things are clear. One is that while certain principles regarding the living resources of the high seas are generally adhered to, major elements of the law of the sea are in a state of flux and, *secondly*, that with technological improvement and the expanded utilization of the high seas, problems are increasing in both number and scope. These U.S. problems are reflected in various ways throughout the world and affect the fisheries of *all* countries whether coastal or distant water.

All of us know that since our country was first founded the United States has adhered to a 3-mile limit. It was only in 1966 that we extended our fisheries jurisdiction to 12 miles. This policy of a narrow limit was pursued because of our strong belief in the need for freedom of the seas. Events of the past 15 years have dictated that our classic posture be changed.

On May 23, 1970, President Nixon said of this nation's ocean policy, "The nations of the world are now facing decisions of momentous importance to man's use of the oceans for decades ahead. At issue is whether the oceans will be used rationally and equitably and for the benefit of mankind or whether they will become an arena of unrestrained exploitation and conflicting jurisdictional claims in which even the most advantaged states will be losers.

"The issue arises now – and with urgency – because nations have grown increasingly conscious of the wealth to be exploited from the seabeds and throughout the waters above, and because they are also becoming apprehensive about ecological hazards of unregulated use of the oceans and seabeds. The stark fact is that the law of the sea is inadequate to meet the needs of modern technology and the concerns of the international community. If it is not modernized multilaterally, unilateral action and international conflict are inevitable . . . It is . . . important to assure unfettered and harmonious use of the oceans as an avenue of commerce and transportation, and as a source of food. For this reason the United States is currently engaged with other states in an effort to obtain a new law of the sea treaty. This treaty would establish a 12-mile limit for territorial seas and provide for free transit through international straits. It would also accommodate the problems of developing countries and other nations regarding the conservation and use of the living resources of the high seas."

As noted by the President an important part of the U.S. proposal is a formula for a new international regime for fisheries. Perhaps the present situation in regard to international fisheries is clearly expressed by Roy Jackson, the Assistant Director General of FAO, when he stated, "The traditional assumption, that fishing is free to all, is unrealistic and has lead to inefficient resource management. Each fish stock is limited." Technological advance in the past decade has made it possible for large sophisticated fleets to harvest the allowable catch of any given stock of fish. Indeed, there are examples of a fishery being depleted because of the use of modern fishing equipment. It is also now manifest that conservation conventions, while generally successful in protecting, for posterity, a stock of fish, are not adequate to protect economic interests. In short, there is a need to consider the allocation of catches. Along with and part of the need to allocate catches is the need to recognize the special interests of the coastal state in fisheries located off their coast. It is this that lies at the heart of the U.S. proposal concerning a new international regime for fisheries.

Over the past 2 years we have been engaged in discussing our proposals with a great number of countries. Our formula for international fisheries, while recognizing the special interest of the coastal state, attempts to create a balance between the distant water state and the coastal state. It has received generally favorable comment. Of course, some conservative states are of the opinion that too much preference for the coastal state is provided; other states, particularly in the developing world, are of the view that greater preference should be given to the coastal state; and a number of countries are of the opinion that the balance created hits the right note.

It is difficult to estimate when a world law of the sea conference will be called. My personal speculation is that the spring of 1972 is a good target date. Unquestionably, there is much work yet to be done. Whenever the date, it is clear that there will be changes in the regime for international fisheries growing out of such a conference. It is our hope that the resulting changes will reflect the basic elements of the U.S. proposal.

Report from Malta[1]

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In mid-June 1970 an international meeting was held on the Mediterranean island of Malta to consider how to achieve peace in the sea. The title of the meeting, *Pacem In Maribus,* was derived from the encyclical of Pope John XXIII called *Pacem In Terris.*

The meeting started its discussions on the basis of the following declarations: (a) that the ocean floor and seas beyond national jurisdiction should be used for peaceful purposes; (b) that the mineral and fishery resources of these regions are the "common heritage of mankind"; (c) that these resources should be explored and exploited for the benefit of mankind as a whole, and particularly for that of the poorer countries.

The meeting was organized because of deep concern felt by many over the rapidly rising tempo of exploitation of high seas resources, and threat of conflict over the sharing of these resources in the face of unrestrained competition. The possible use of the seabed of the ocean for the implantation of weapons of war was an additional sharp spur. Present international machinery was believed to be inadequate and ineffective in controlling harmful competition, over-exploitation and depletion of the fishery resources. Nor was existing machinery seen to be capable of checking the threat of serious damage to the ocean environment and to the living resources through massive pollution. It was therefore urged by some of those present that in order to achieve equitable sharing of the common ocean resources and to protect the ocean from pollution, the present arrangements should be restructured; an extreme view was that exploitation, management and distribution of fish should be placed in the hands of an international agency.

The location of the meeting in Malta resulted from a resolution in the General Assembly of the United Nations proposed by the U.N. Ambassador from Malta, Dr. Arvid Pardo. On November 1, 1967 Dr. Pardo introduced what later became famous as the "Malta Resolution", proposing that the mineral resources of the ocean floor beyond territorial limits should be declared the common property of mankind, and that their exploitation and distribution should be put under the control of an international body. Profits would be used to finance the proposed international organization and to benefit poor nations.

These profits were declared to be potentially large, so that very soon a great deal of money could be expected to enrich the international community.

Following favorable reception to the general concept of the Malta Resolution, the United Nations created the Commission for the Peaceful Uses of the Sea Bed and Ocean Floor Beyond the Limits of National Jurisdiction. This Commission has concentrated on the design of machinery to prevent the sea bed being used as a site for war-like devices. An international treaty has been drafted by the Commission and presented to the General Assembly in October, 1970. Both the United States and the Soviet Union have urged its ratification.

The idea that the mineral resources of the ocean floor should be reserved for

[1] Contribution No. 1332 from the Rosenstiel School of Marine and Atmospheric Science, University of Miami.

mankind as a whole has aroused vigorous debate. Inevitably discussions have had to be extended to include the most valuable resource of the oceans, the fisheries.

The proposal of joint ownership and control of marine resources raises complicated and bewildering problems. The *Pacem In Maribus* meeting did not supply solutions to any of these. But the meeting did provide part of the necessary preliminaries–sharper definitions of the problems, the ventilation of various points of view, and at least some progress toward the correction of common and damaging misconceptions about ocean resources and their exploitation.

This paper considers some of the problems of fisheries arising from the Malta meeting, and the discussions which took place there. One serious misconception that has clouded the discussions of ocean resources is the assumption in some quarters that there are large quantities of fish beyond the limits of territorial waters, and therefore that great wealth is waiting as soon as the world declares it to be international property. Of course there *are* large stocks of fish offshore, and these are certainly worth pursuing with vigor and protecting with wisdom. But the abundance of fish decreases as we go seaward, and as we go progressively deeper. And there are few if any enormous unexploited offshore stocks whose wealth can be used to fill the thin coffers of the United Nations, nor to support any new international agency established to manage sea resources.

Then, the quantities of fish which would be available as the common property of mankind are being rapidly reduced by political action. Some of the same countries which would supposedly benefit from a scheme to reserve high seas fish resources as common property are extending their territorial limits. Nine nations now claim jurisdiction over 200 miles of the sea off their coasts, and ownership of the fishery resources in these waters. If all countries of the world, especially those like the United States which have great coastlines, were to follow this lead, there would be thin pickings in the common pool.

Furthermore, according to one part of the 1958 Convention on the Continental Shelf, coastal nations have sole rights to the creatures which live on the bottom on the continental shelves off their shores. Many nations including the Soviet Union and the United States are taking advantage of this. It is under the provisions of this agreement that the United States assumes ownership of the king crabs of the Bering Sea, and controls the catches of Japanese and Soviet fishermen there.

A second misconception, and one which caused very apparent disagreement among participants at Malta, was whether those exploiting the high seas resources are conscious of the necessity for conservation, or willing to accept regulation. All those making a living in the sea were labelled by some observers as thoughtless exploiters. Some of this idea was expressed by Justice William O. Douglas, Chairman of the *Pacem In Maribus* meeting, in his address of welcome. Mr. Douglas asked, "Is the aim of man 'development' of the oceans? Should the aim not be at least in part 'conservation'?" This low opinion of ocean users was widely held at the meeting. It implies that concern for the protection of high seas fishery resources is a new idea, and that nations engaged in this activity have to be persuaded to accept a conservation viewpoint.

In point of fact, the realization that fish resources of the sea are finite, and that limitation must sooner or later be placed on the amount of fishing pressure each stock can withstand is at least as old as this century. In the 1890's this concern was so strong among nations exploiting the North Sea that they sank their differences sufficiently to organize the International Council for the Exploration of the Sea, which came into being in 1902. Today there is no significant voice among scientists denying the direct and substantial effect of fishing on the welfare of stocks of fish, and most fishery industry people likewise recognize that their activities must be controlled when fishing pressure reaches a certain level.

A third misconception which was prevalent at Malta was that fishery resources and mineral resources can be managed in substantially the same way, by the same global agency. One of the solid accomplishments of the meeting was that at least some of the participants were persuaded to discard this concept.

The major difference between mineral and fishery resources is that the latter are renewable. Once a ton of mineral has been removed it is gone forever; but a ton of fish caught will be replaced by another ton if wisdom is used the way the removal is done.

The living resources of the sea are different from the mineral resources in other significant ways. One of the most obvious of these, and one that has great influence over decisions, is that fisheries are very old institutions, with long-established patterns of operation - local, regional and international. By contrast, ocean mineral extraction has yet to be even started for the most part, with only the oil industry as an operating unit, and this having only about a quarter of a century of experience in the sea.

A third difference between the fisheries and the industry for extracting minerals from the sea is that while fishing can be conducted by small enterprises, with small capital investment and with simple equipment, mineral extraction (including oil) requires enormous investment, complicated technologies, and large enterprises. These two branches of ocean resource extraction cannot be covered by the same kinds of regulations, nor even the same theoretical or philosophical approaches to management and control.

A fourth misconception held by many of the participants of the *Pacem In Maribus* meeting was that no machinery exists to solve problems of exploitation of the sea–the technical problems of how fish stocks decline under fishing pressure, and how to devise regulations to check this. But the truth is that since the formation of the International Council for the Exploration of the Sea at the turn of the century, over forty international fishery agreements have been created; these operate in every part of the world, involving most if not all nations fishing the sea. Some of these arrangements are complex and have many participants, some involve only two countries. Some of the arrangements have been highly successful, some moderately so, some nearly unsuccessful. But they exist, and in their sum they have had a great deal of experience in solving some of the same problems posed at Malta. Thus the concern about conservation of oceanic stocks and attempts at solutions of international fishery problems did not start with *Pacem In Maribus.*

A fifth misconception at Malta was the supposed future role of aquaculture, whose new promise was mentioned many times in urging the necessity for a new policy of high seas fishery control. But very little aquaculture will be conducted in international waters. It will have an important part to play in the future course of extracting food from the sea, but the rewards will be to individual nations and not to any community of nations whose control is only offshore. By far the most–perhaps all–aquaculture operations will be well within the limits of national jurisdiction.

Yet, despite the misunderstandings and misconceptions at Malta, the troubled concerns expressed there about the possible fate of sea resources are justified. It is obvious to most observers that the ocean fisheries are pursuing dangerous courses, and that the threats of damage by overfishing, unbridled competition and pollution are extremely dangerous.

The history of fisheries development follows a common pattern leading to overuse, overcapitalization and small profits for individuals. If the fishery is valuable enough to justify management, biological research may be conducted and regulations imposed to control the amount and kind of fishing, and the stocks may be brought back to biologically satisfactory levels. But because the resources belong to everyone, in successful fisheries more and more boats enter the industry until the profits become thin despite successful biological management. These trends take place in national and international fisheries alike.

Fishery scientists, social scientists and other observers agree that unless a better record is achieved in the future, mankind is in danger of losing an important part of its heritage and a substantial source of food. The sharp differences of opinion arise in the suggestions of solutions to be applied.

The real issue is whether the present kinds of international agreements are moving in the right direction, or whether their patterns should be changed in favor of some new machinery--perhaps a global agency with responsibility for research and management of the fisheries, and distribution of the catches.

The principal problem so far unsolved by existing fishery agreements is that of dealing with new entrants. When nations operating over a period of time in a certain fishery have established a set of rules for conserving the stocks (and in a few cases distributing the catch), and have achieved a satisfactory delicate balance in these matters, the entry of new nations may tear down the whole structure. This is the kind of situation facing Japan, the United States and Canada, the present participants in the eastern North Pacific Ocean, in the face of strong efforts by Korea, the USSR and other nations to enter the salmon, halibut and other fisheries of the region. In 1970, for example, Korean vessels caught between a half and three-quarters of a million salmon from North American stocks being managed by the International North Pacific Fisheries Commission, the management including intensive, costly research, and restriction of the catch by fishermen of the member countries over many years. And the pressures by several nations to engage in trawl fisheries in the area where the International Halibut Fisheries Commission has successfully managed halibut stocks since the 1930's threaten the whole fabric of that agreement between the United States and Canada. Recent entry by Japan and Canada into the fishery for tunas in the eastern central Pacific has put such strain on an agreement among the United States, Mexico, Costa Rica and other countries that the very existence of the commission has been periled. Yet provision must somehow be made to allow fishing by new countries while acknowledging that traditional participants have special rights.

But this does not solve the most puzzling of all problems--how to distribute the harvest. In many existing cases there are not enough fish in the biologically allowable maximum sustainable yield to satisfy the requirements of all nations or all boats within nations, and this situation will be extended rapidly to more and more stocks if the present pattern of expanding fishing effort persists. In a few cases countries have come to agreement about the division of the catch: Canada and the United States share equally the harvest of the salmon of the Fraser River; the United States, Canada, the Soviet Union and Japan share the catch of fur seals according to a negotiated formula; the USSR and Japan agree on the harvest of some Asian salmon following hard bargaining that takes place each year. But there is no division by the Inter American Tropical Tuna Commission of the tuna catches, nor by International Commission for the Exploration of the Sea of the many species caught in the North Sea; nor by most international bodies of the fish under their control.

It is clear after an examination of the amount of success or failure achieved by the various fishery commissions and other international agreements that the difficulties are less with the scientific input than with the application of information on the administrative and political levels. In many important cases there are enough biological and mathematical data to devise effective regulations, and in some cases regulations have been successfully applied, especially those specifying total catches, or gear restrictions like those fixing the size of the meshes of nets. These are mechanical regulations which are relatively easily applied and enforced. But so far it has usually not been possible to achieve agreement concerning limitations of the number of participants or of fishing effort, and to a far lesser degree to achieve a mutually acceptable division of the harvest. The latter will continue to be the overwhelmingly difficult stumbling block impeding management of international fisheries.

No meeting at Malta, or elsewhere, can solve this or any of the other major problems. But the gathering at Malta allowed the expression of many opposing views and it modified the opinions and outlooks of most participants. But judging from the Proceedings, all the arguments and rhetoric left a great many people with substantially unaltered basic opinions. The report expresses continued skepticism about the value of existing regional fishery commissions, saying that while "regional fishery arrangements have proven successful in a number of cases. . . .these solutions seem somewhat antiquated." The unhappiness with the regional commissions boils down to the issue that they cannot successfully be rationalized on the biological or even the managements level, but on what is described as "political or ethical terms." The report of the meeting says that "regional arrangements fail to apply to or even advance the application of the concept of the common heritage of mankind. Nothing goes to mankind as a whole." What this latter statement meant to some participants was that those who catch the fish do not give part of their harvest to the poor nations. The heart of the dilemma, it seems to me, is the gap between the noble concepts, and the hard reality of their transmutation into food or dollars. According to opinions frequently expressed at Malta, certain individuals are to perform the services and then to give at least part of the rewards to other groups which have made no contribution to their realization. Such a conception of what the "common property of mankind" implies is not only unrealistic but prolongs the hated and destructive processes of charity that has so damaged the whole fabric of international aid.

A major suggestion of the group which organized the meeting is a revealing example to me of the gap between theory and reality. This is the proposal to institute an "Ocean Development Tax" of 1% on ocean produce. This tax would cover "non-living and living resources as well as services (shipping, etc.) no matter where production takes place or services are rendered in the ocean environment, outside national jurisdiction or within."

It did not seem to me that the Malta meeting pushed the world forward in any measurable way toward a solution to what is to be the central and overwhelming problem of conservation of high seas fishery resources, the problem of how to accommodate the needs of long-time participants as well as those of ever-crowding new participants from resources of fixed size. I was not convinced, nor were a great many other participants, that the substitution of one enormous global regime to control the fisheries would lessen, let alone solve, the problems that smaller, local, specially designed arrangements have only partially solved. The failures of most of the regional commissions and other arrangements are not usually the fault of the design or the structure of these arrangements, but due to the inability of human beings to agree on the necessary levels of cooperation and compromise. It is unrealistic to expect that added agreement or greater willingness to compromise would follow the involvement of all the states of the earth, with their jealousies and their opposing interests.

But if the major problems were not solved at Malta, most participants came away with a strengthened conviction that better machinery must be provided for the protection and fair use of the offshore fishery resources of the world ocean. The meeting sharpened the general understanding of problems of high seas fisheries, and convinced some newcomers to the game that the complexities had not been created by the present fishing nations merely to justify the status quo nor to protect their own interests. The meeting also spurred those whose task it will be to offer improvements to the system to redouble their efforts.

DISCUSSION

International Session

Discussion Leader: Lee J. Weddig
Discussion Panel: Harvey Bullis, Edward A. Schaefer

Fisheries and the IDOE

J. L. McHugh

Q. Bullis: What is being done about staffing and funding IDOE?

A. McHugh: Our budget request for fiscal year 1971 was $15 million, but the budget bill has not yet been passed by the Congress. The appropriation will be divided approximately 50-50 between federal and private agencies. In subsequent fiscal years the 50-50 formula will not be a precedent; federal agencies will compete with all other candidates for funding and awards will be made on the basis of merit and on adherence to the criteria established for the decade.

Q. Bullis: What is the significance of the three priority categories?

A. McHugh: The three broad subjects selected for emphasis were Environmental Quality, Environmental Forecasting, and Seabed Assessment. The National Science Foundation has already issued an important Notice and a brochure, and other descriptive material is in preparation. You should write to the Office for the International Decade of Ocean Exploration in NSF for information.

Q. Schaefers: Tell us of the countries involved in IDOE, and of their progress.

A. McHugh: Some 60 countries are members of the International Oceanographic Commission of UNESCO. Many of them are interested in IDOE, but as far as I am aware none has announced a national program. I suspect that they may be waiting to see what the United States does, since we proposed the Decade. Our program is not yet funded.

Q. Weddig: Just what will IDOE mean for fisheries?

A. McHugh: As I said in my talk, direct support of fishery research has been specifically prohibited in the U.S. Decade program. But I expect that most of the biological research in IDOE will have important applications to fisheries. Even though the program has not yet started, proposals already are coming in. Most of the biological proposals received so far do not seem appropriate for IDOE support. By helping candidates to develop good program proposals by working with them from the start, we expect that biology will receive substantial support.

Q. Ripley: Give us some idea of coordination between IDOE and on-going programs.

A. McHugh: The Ocean Decade has as its primary purpose support of bold, imaginative, new programs, not support of old programs already under way, or in trouble financially because support by other agencies has been curtailed. Some on-going programs like CICAR, for example, are very much in the spirit of the Decade, and it is quite probable that IDOE funds could be used to accelerate certain promising phases of existing international oceanographic research, or to explore promising leads suggested in their early phases.

Soviet Fisheries and Fisheries Research off the East Coast of the United States

A. C. Jensen

Q. Weddig: What is the caliber of the Soviet biologists on the cruises in which you participated?

A. Jensen: I think they are good, capable fishery scientists. Most of their research is at about the same level as ours was about 30 or 40 years ago; that is, mostly descriptive, life-history studies. However, the USSR is progressing in this field and probably will move forward more rapidly in the future. Incidentally, the Americans and Soviets got along very well on the cruises, despite the language barrier. We found the scientists and crew to be cooperative and helpful and we tried to be the same. All of them were very energetic and worked hard.

Q. Griffiths: Tell us about the progress of the results of the fishing survey with the Soviets.

A. Jensen: The data are still being worked up and so all of the results are not known yet. Reports of the research will be published in English-language journals and, I presume, in Soviet journals, over a period of a number of years.

Q. Weddig: The Soviets are using stern trawlers. With the U.S. using smaller vessels, our catch will be still less. Wouldn't U.S. fishing companies get the same results as the Soviets if we fished with stern trawlers?

A. Jensen: I don't think our fleets would be as effective – in an economic sense – because they are not subsidized, whereas the Soviet fleets are. In fact, most European fishing fleets are heavily subsidized. With our high labor and material costs, the management investment in stern trawlers would be too high to be profitable.

Informal Comments on Foreign Competition and the U. S. Fisheries

B. H. Brittin

Q. Schaefers: The U. S. is a member of several international conventions. What new bilateral treaties do we anticipate?

A. Brittin: We have about six bilateral treaties – two productive, one operational at our cost, two operational and at the cost to foreign countries.

Q. Schaefers: What is done to coordinate activities with other nations so that bilateral treaties are kept in agreement?

A. Brittin: We negotiate with such countries.

Q. Schaefers: Suppose a party to the treaty exceeds their fishing quota or violates some other treaty provisions? What do we do then?

A. Brittin: We have the power to ask them to leave. Also, bargaining is in progress with non-treaty member nations to bring them into agreement.

Q. Bullis: Management should realize that stock has to be based on functionality. Shouldn't management gather all information possible to avoid error?

A. Brittin: In some treaty areas because we don't have all the answers we are managing on approximately the best conservation practices. We are not sure that this is always understood even though a great deal of time has been spent in explaining this to all parties concerned.

Q. Fitzgerald: Do bilateral fleets seek military information under the guise of legitimate fishing?

A. Brittin: We do not question many vessels, but there is really little of that kind of trouble. These treaties do much to solve this problem.

Q. Whiteleather: Do you see, in the near future, more work in the Gulf of Mexico?

A. Brittin: We do know that there is good fishing in the Gulf and I would imagine that we need more protein. To locate more and different protein sources would require more work in the Gulf.

Report from Malta

C. P. Idyll

Q. Bullis: Is not the real problem a question of how to satisfy the needs of individual countries when the requirements may be in conflict?

A. Idyll: Yes, basically this is right. There are not enough fish which can profitably be harvested from the sea to satisfy the demands of all countries, yet fish are regarded as a common resource, open to exploitation by everyone. No satisfactory general scheme has been devised to determine how to divide the catch. There are those who argue that distribution should be on the basis of need alone, but this proposal ignores the economic considerations.

Q. Schaefers: If a central agency was created to control world fishing, what kinds of enforcement of regulations would be instituted? And, where would we go for information needed for management?

A. Idyll: These questions were not discussed at Malta except in passing. But it was urged by many of us in the fisheries sector that many of the problems related to fishing were different in fundamental ways from those of mineral extraction. This view is being more and more accepted.

Q. Schanes: In many cases instead of eating fish we feed it to poultry and other farm animals. Shouldn't we be making better use of scarce protein?

A. Idyll: It would be desirable to feed fish to humans directly, and thus avoid the losses of energy and substance which result from cycling the protein through farm animals. We should devise better preservation methods and distribution schemes as quickly as possible. Meanwhile, we are able to make use of enormous quantities of fish by feeding it to poultry and swine, fish which would otherwise be completely unavailable to man.

Q. Schanes: Should we be working to develop fisheries or to find other sources of protein?

A. Idyll: The food needs of mankind are so large that we must work hard to develop all possible sources of protein, including fish.

TUESDAY A.M. — NOVEMBER 10, 1970

Chairman - H. O. STURGIS, *Yarmouth, Maine*

Comments on Economic and Financial Aspects of the Gulf Fisheries

ARTHUR H. KANTNER
Vice President in Charge
New Orleans Branch
Federal Reserve Bank of Atlanta
New Orleans, Louisiana 70160

This is a time of fantastically large demand for use of available funds in our nation's economy, now approaching one trillion dollars in size. You in the shrimp and menhaden business are among those who use funds, who allocate them to specific purposes, who seek more funds for new needs, who wonder how best to get funds for the needs. It is timely to review the economic aspects of your industries which can have a pronounced influence on your financial progress.

We know that the health of your firms is affected by the economic climate for them. If the climate is hostile, with demand inadequate, production declining, costs mounting, funds short, credit hard to get, the very survival of individual firms or even industries, comes into question. Economics is called the dismal science; its analyses and finds can be pretty unsettling at times. Yet in historical perspective, the economic history of our remarkable capitalistic society reveals that firms and industries have responded to economic realities with quite fruitful results for our nation's people as measured in overall economic growth and well-being. You have the challenge of adjusting your business operations to sustain your firms and industry to benefit consumers.

As managers, you realize that the economic climate cannot be your only point of interest. You seek increased knowledge about the biological factors affecting your production. You look also for research findings on a wide variety of problems relating to your work; you have problems encompassing engineering concepts, nautical matters, legal affairs, insurance coverage, rules, regulations, legislation and management practices.

While obtaining information in these fields may be vital and even crucial for the life of your shrimp and menhaden businesses – and often the technical possibilities and impossibilities determine financial success or failure – it is clear that given sound technology, the economic relationships for your firms greatly influence your profits.

My focus in this brief period with you will be on the general economic situation I observe for the shrimp and menhaden industries. I will also consider the pressures you probably feel for adjusting your businesses to cope with economic trends and developments, especially adjustments which may involve mergers of operations and firms. Sometimes the modifications you plan require more funds, or at least a change in the application of funds you can control. In this connection, I shall make a few comments on the general availability of funds in the economy.

ECONOMIC CLIMATE FOR SHRIMP AND MENHADEN INDUSTRIES

The Gulf fisheries industry faces the happy situation of a strong demand for its products and a growing market for them. Shrimp, of course, is used directly in many food dishes enjoyed by Americans. Menhaden, in the form of fish meal used in poultry and animal feeds, ends up as "fried chicken" and other poultry and meat products so well liked by consumers. These products are highly favored by consumers in the United States and are foods more and more in demand. This salutary market situation clearly is a boon to the Gulf fishermen.

Shrimp consumption per capita has been in a persistent up-trend for 20 years at least. Moreover, reflecting the high favor Americans have for shrimp, consumer spending on it has advanced at a much sharper pace than the total spending on food. This powerful market situation for Gulf shrimp fishermen is reflected in the increasing share of the world shrimp catch being marketed in the United States, by far the largest market for shrimp. At present, about one third of the world catch is sold in our country, compared with about a fourth in the mid-1950's. United States shrimp production is valued at about $115 million, and most of it occurs in the Gulf area.

In large measure, the shrimp market has developed nationwide as better refrigeration services became available. Technological advances in preparation of shrimp have also boosted sales. These are two potent aids in marketing shrimp far from major production areas in the Gulf of Mexico. Having now the capability of freezing and storing shrimp and holding them for more favorable prices when the relatively short shrimp fishing season is ended, processing plants in the Gulf area gain added economic punch.

Food consumption trends also favor items produced by utilizing products of the menhaden. American consumers have used increasing quantities of poultry in the past three decades. Chicken usage rose from 14 pounds per person in 1940, to about 36 pounds at present. Turkey consumption went from 2 pounds per person to 8 pounds. Consumers have held their consumption of pork at a relatively high level of 65 to 75 pounds per person. Feeds used to produce these meat products include fish meal as a significant ingredient and the tonnage of feed mixes continues to increase each year.

Reflecting the growing mixed feed market in the United States and abroad, world trade in fish meal expands apace. Fish meal importing nations purchased 2.8 million tons in 1968, more than double the purchases in 1961. Menhaden producers in the United States, however, have not been able to share fully in the expanding market. Output of the United States industry grew steadily until the early 1960's when a sharp down-trend developed. Fish meal production which had risen to 248 thousand tons in 1961, declined to 143 thousand tons in 1968. Production of fish solubles also declined dramatically in the 1961-68 period.

These aggregate movements in output mask the shift in fish meal production areas in the United States. Fish meal output declined sharply along the Pacific and Atlantic coasts, while it increased along the Gulf coast. Taken generally, however, American fish meal producers have been unable to capitalize on the growing national market in recent years. Yet, the market potential remains a strong, positive element in the economic climate for the fish meal industry.

Price trends for both shrimp and menhaden products have also been a boon for the Gulf fisheries. Retail prices for shrimp have been trending rather steadily upward in recent years. Prices now are almost double those prevailing in 1964. Wholesale prices have moved higher over the years, although there are marked seasonal fluctuations each year. Prices for fish meal have been more erratic, moving down through the 1950's then up sharply in 1966. In the next few years they declined somewhat and then moved to a peak of $200 a ton in late 1969. Prices have moved lower again, but they still stand well above their 1960 level. With demand for the meal at a high level and generally inelastic, fluctuations in available supplies bring wide swings in prices. Fish oil prices, on the other hand, have been in a fairly steady down-trend since the mid-1950's.

We see from what I have said that the economic climate for the Gulf fisheries provides a strong underlying demand for the products and a generally favorable price situation. Yet, fishermen who land shrimp and menhaden are not sharing in the growing market to the degree an observer like me might think possible. Both groups of fishermen are providing a smaller and smaller share of the nation's supplies. Imports from other nations are providing most of the added volume needed to satisfy our national market.

PRESSURES FOR MODIFYING FISHING BUSINESSES

What is the reason for the lagging market share for the Gulf fisheries? The question seems straightforward and simple, but the answer you will agree is complex, and the remedies no doubt must be quite varied. Price and cost relationships in the fishing operations acutely affect the situation and often some positive action by managers is required to gain some economic ground. Relative costs of catching the fish and producing the products induce variations in competitiveness; availability of the fish varies by areas, and fishing techniques and intensity may be inadequate to consistently obtain large catches.

Investment capital and operating funds, of course, may fall short of needs for some firms. Government rules and regulations concerning fishing and fish preservation may be inadequate for some phases and too exacting for others. Perhaps research on technology and other industry needs and on biological aspects of fish production does not meet requirements. Possibly some company managements need revitalization to provide leadership for expanding catches and reducing costs. A highly significant adverse factor is the extremely short supply of skilled labor to man the boats.

Undoubtedly these factors influence your business operations in some degree. Whether sole reliance on increased capital investments and use of more operating funds in particular firms and for particular company operations can reverse the fundamental trends in the industry and capture a larger share of a growing market appears questionable to me. Some rather penetrating efforts along a broad front could be the more likely need.

Gains in economic performance of the shrimp and menhaden fishing industries will be sought through several points of leverage, it seems to me. Most important is preservation of the strong consumer demand. Second, assembling production resources and combining them effectively for output will benefit operators. The emphasis here is on providing suitable modernized vessels, well equipped and well manned; the vessels will do best when they serve plants that are modern, efficient, capable of processing and marketing the catch, and well located for low cost operations.

A persistent short labor supply for the shrimp industry is a fundamental and formidable obstacle. More crew members are needed to expand the fishing effort and utilize new vessels effectively. Capital investments in modernized far-ranging boats probably are required in some firms, but without crews for the boats, it will be hard to increase the fishing effort and enlarge the shrimp catch.

Similarly in the menhaden industry, modernized far-ranging boats adequately crewed can enhance the catch. Even so, improved techniques for finding the fish and increasing production can be an equally important factor.

No doubt the operators of vessels and plants who will do best are those who use them at fullest capacity. Fishing must be intensive, processing must be rapid and technologically sound, storage and distribution of products must be geared to market needs and conditions. Not least in this pattern is the firm control of quality by operators to insure highly saleable products. These products should reach consumers in a timely manner and in desired form; customers at distant places also want assurance that the products they demand flow regularly to them. Often the consumers need assistance or guidance in using the products. You can appreciate that effective channels of distribution are quite important to the fisheries industry. Finally, a healthy operation requires that owners obtain enough returns for their services to consumers to pay the workers, earn salaries, and obtain adequate earnings on capital invested.

These organizational efforts are no less important to you in the shrimp and menhaden industries than in any other industry. Yet they are difficult to achieve, especially in a fragmented industry such as the shrimp industry, and in an industry battling severe foreign competition and declining production such as the menhaden industry.

MERGER FOR ECONOMIC BENEFIT

Will mergers of units and firms help segments of the industry gain more leverage in the economic spheres I have noted? Some observers feel that mergers would be appropriate and helpful. And in some cases, given favorable conditions, they might. We should all agree at this point, however, that mergers of business units must grow from sound economic bases to gain income and profits. As a generalization, we can say positively that pooling weaknesses or losses will not create stronger and more profitable units.

Having acknowledged this fact of life for mergers, we can speculate that mergers may be attractive to some firms under present conditions in the shrimp and menhaden industries. Mergers may bring consolidations helpful in fighting competition. At bottom, a merger can enable some firms to better perform the economic functions for consumers who collectively are the ultimate authority in our economic system. Capital may become more productive, raw materials more ample, marketing arrangements more fruitful.

We recognize at the same time that difficult analytical effort is usually required to judge whether a merger will benefit particular firms or producers. The question "Why merge?" is typically evaluated by measuring the pertinent reasons given for merging against the economic bases found in a specific industry. If the bases are sturdy and broad, then one or more of the reasons for merger can assume sufficient weight to bring the action.

Why merge? Several points are offered as crucial elements by a person who thinks through the proposition. He ponders whether he can gain a broader product base through diversification of products made and sold. These may minimize impacts from seasonal fluctuations and changed market conditions. Possibly the merger of successful firms will, in fact, bring fast growth in size and sales and increase profits rapidly, much more rapidly perhaps than waiting on the long pull with an independent firm.

The person considering a merger also inquires whether he can gain efficiencies in operations and spread his risks. He considers a broader use of capital, perhaps through the merger obtaining working capital for product development, or realizing tax advantages, or using fully some idle capital he might have in hand. The merger also may be an economical means for acquiring skilled management or providing management continuity for a family business or a single proprietorship.

A merger can bring to the buying firm new market outlets without incurring start-up costs, and rapid acquisition of technology without burdensome costs for uncertain research and development. It may even be effective in assuring plentiful and low cost supplies of raw materials under some circumstances. Possibly that reason for merger would have much weight in the shrimp and menhaden industries where the search for an assured and large supply of raw material is intensive and never ending.

Whatever your individual response to such analytical probings in regard to a merger, it is clear that buyers and sellers of firms look for one or more of several positive elements in the unit being evaluated -- competent management, a record of growth, a sound financial position, satisfactory earnings, complementary products or lines, and a whole that is greater than the sum of the parts. What we come to in the end, is a more limited scope for the merger route than many interested persons might initially envision.

VIEW OF THE FINANCIAL SCENE

You shrimp and menhaden operators undoubtedly will make capital investments soon for a variety of needs. You require investment funds for increasing your efficiency, combating rising costs for labor, and applying technological improvements. You may need modernized vessels, larger vessels, better equipment, desirable modifications to plants and investments for increased quality control. Your cash requirements for general operations and working capital purposes and the carrying of inventories of fish products and supplies also are on the rise. Day to day, you use funds for stocking your vessels, paying your expenses and living through slack periods. All told, I can confidently say that few, if any, shrimp and menhaden firms will be able to reduce their financial requirements very much.

Traditionally you have obtained funds for the varied purposes from your own resources -- from the cash flow generated by your sales, from your retained earnings -- and from creditors such as your suppliers and your processors and financial institutions. No significant change in these patterns is in prospect in my opinion. You will continue using short term credit for operational needs, such as outfitting boats and processing, warehousing and marketing the catch. You will finance equipment and technical innovations from funds already in hand or borrowed on medium terms of perhaps 3 to 5 years. Probably you will finance investments in plant facilities and major production systems with long-term funds.

Operators have the difficult problem of deciding how best to apply their limited funds, obtainable at relatively high interest rates, to uses that will pay off. Is modern equipment the paramount need? Should expensive long-term funds be sunk in a new plant at a new location, or can that investment be postponed until capital markets are more favorable? Under present conditions, should all available funds be applied to maintain operations at present levels while awaiting more favorable investment opportunities? No one of these decisions is lightly or easily made, and emphasis given the choices will vary among firms.

The problem is general. Other groups pressed by needs for advancement and improvement seek funds in the money markets. Many industries in our nation must adjust to changed production needs and market conditions. Additional major competitors for the available money are the numerous local and state governments that are pressed to provide essential services for communities. The federal government remains a principal bidder for money.

We have no assurance that all needs can be met under current conditions. Firms with top credit ratings may fare reasonably well, though at relatively high rates. Those in less solid financial condition may obtain funds, but at a somewhat higher rate. Firms and operators without financial leverage probably will have difficulty locating creditors unless special relationships exist or unusual arrangements are established.

I base this rather cloudy financial outlook on the continuing imbalance in our inflation - gorged economy, and the persistent huge appetite for capital in the United States. The American economy in its current state, fueled by the innovative nature of its people, their exploration, inquisitiveness, practicality, engineering capability, management skill and their insatiable wants for goods and services, is generating an immense demand for capital. Not all needs can be met simultaneously. Choices must be made. The necessary rationing of funds to particular firms and particular uses, of course, directly affects firms in the shrimp and menhaden fishing industries.

In the competitive market for funds in the United States, industry struggles against industry. In the end, comparative advantage in the use of resources to provide what consumers want forces the play. The industry in the best economic position relative to the demands for its products, to its location and raw material base, to its labor productivity and supply, will be able to bid more for the money available. It can bid more because it can afford to pay a higher rate of interest.

It is against this backdrop of economic struggle that we find the shrimp and menhaden industries in a squeeze. They are squeezed by competition for capital and labor, by inadequate production and uncertain supplies of fish, and by competition from foreign suppliers. Not every adverse element in the economic situation can be effectively met in every firm with an injection of funds. But prudent investments undoubtedly can help particular firms compete more adequately. In the capital rationing process, firms that can use the funds profitably, probably will obtain them.

Why Merge?

JACOB SALIBA
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As a life-long resident of New England, I am somewhat familiar with some of the trials and tribulations which have plagued our fishermen. Although this industry has many unique problems, I must admit that in our northeast region it has had setbacks which have a parallel in some of the other basic industries of this area. Although there is no apparent relationship between the fishing and textile industries, we find that many of the basic causes and conditions which have led to the decline of one industry also have had the same adverse effect on the other. Excessive fragmentation, limited product lines, inefficient equipment, foreign and sectional competition, increased production costs, reduced productivity and dwindling sources of raw materials are limiting factors which have been most damaging to the New England fishing industry, but every one of these conditions has also adversely affected the New England textile industry as well as the New England shoe industry.

Where there is a broad area of compatibility and economic justification, the merging of individuals, companies or associations can have and has resulted in great benefits and improvements. Those who are skeptical will say that few potential merger combinations can meet my two demanding requisites of compatibility and economic justification.

In spite of the significantly high percentage of divorced persons and also the large number of unhappily married couples, the major source of merging still remains the state of matrimony. It works because over the ages it has brought physical, social and economic benefits to the two contracting parties, and in the aggregate the benefits to both parties have offset the liabilities.

For the same reason, business mergers have taken place since the dawn of history. In fact, whenever two persons or groups agree to do anything in unison, they are essentially merging. A merger may be of very short duration, or it could be a permanent union. So much for the broad concept of merging.

As businessmen and entrepreneurs, you are probably more interested in its application to your type of business. First of all, let me give you an example of a small fragmented industry and how it has been affected by the recent merger movement.

Some 20 years ago I had a number of clients in the garment industry in New England. Many of these were small operators whose plants employed less than 75 persons. At that time there were more than 300 such small plants in New England, and this was a dog-eat-dog business with the number of new companies coming on stream each year about matching those that failed. There was little or no industry order, and both the employers and employees suffered by the erratic and cyclical nature of this business. Probably the two greatest problems they faced were the absence of sound management operating methods and the very narrow range of their product line. As a consequence of this, the bankruptcy and failure rate in garment manufacturing at that time exceeded that of any other industry in New England.

In the past 10 years, this industry has undergone a startling change. The more successful small manufacturers began consolidating. At first these mergers were primarily of the type where a manufacturer joined forces with his competitor. These companies usually were in the same garment line and essentially of the same size and financial standing. Most of these combinations were of such a small size that the surviving company still remained a private, closely-held concern. In most cases, this resulted in immediate economies and made possible the expansion of their product lines and the initiation of fairly simple data processing and management services such as inventory controls, marketing and sales analysis. In addition, it brought an improvement in manufacturing procedures, reduced sales overheads, and of significant importance, it taught people of varying backgrounds and experience how to work more closely together. It also prepared them for the second round of mergers when they were to combine with the larger and more stable publicly held companies. Although many of these companies may not have gone the full cycle, most of the successful operators who have survived in the last 25 years have had to use this method to strengthen their competitive position. There were a few well-capitalized companies who did not need outside help, but they were the exception. In this respect, I can speak from first-hand knowledge, and I would like to share an experience with you.

For over 150 years, the Boston area was the base of two of the leading protective clothing manufacturers of America. These companies were the H. M. Sawyer Company and the A. J. Tower Company. They had several common distinctions. For example: (1) They made an excellent but unprofitable rainwear product; (2) They met each other's price competition come hell or high water; (3) They had in-bred managements that had kept them both in a stagnant state; and (4) They operated profitably only during periods of crisis (i.e., war or national emergency), so that theirs was always a feast or famine type of business. In essence, they suffered from all of the maladies that then faced the textile industry and to which I alluded at the start of my talk.

From beginning to end, the fate of these two companies seemed to be closely intertwined. The Sawyer Company, which was in deep financial trouble, lost its president in 1955 and his executors were forced to sell this company. Along with three associates, I bought this concern for less than its net worth because the Boston banks, which were the trustees, did not want a liquidation. Actually, a liquidation would have substantially reduced the return to the shareholders even below our purchase price. We fortunately had experienced management to take over the newly acquired company.

Fate also played a part in our merging of the Sawyer and Tower Companies. The aging owners of the A. J. Tower Company were frightened and benefited by the sad experience of the Sawyer stockholders (their principal competitors) and became apprehensive of their own vulnerable position. They initiated merger negotiations with our group, and we acquired them, merging the two companies but retaining their name, product lines and product brands. The combined companies became known as Sawyer-Tower, and thus began a complete renaissance and revitalization of these two ancient concerns.

By consolidating four separate and antiquated plants into one modern and efficient factory, we were able to substantially reduce our product cost while competitors were accelerating theirs. The funds for this modernization program were obtained through the sale of surplus real estate. In the marketing area we were able to get far greater coverage with only 3/5 of the former combined sales organizations, and promotion expenses were even more favorably affected.

Laboratory and other vital services which neither company could formerly afford were now initiated. There were dramatic improvements in new product development, quality control, production scheduling and deliveries. The most important change occurred in the realm of profits. In the 3 year period prior to the merger, the average combined annual profits of the two companies amounted to $125,000 on average sales of $3,200,000. Following the merger many unprofitable lines were completely eliminated, and in the following 3 years, the average annual profits were more than three times (over $400,000) the former figure with slightly less sales due to the discontinuance of unprofitable lines. As a result of this merger, Sawyer-Tower is now, after some 15 years, a viable company whose rescue can be wholly attributed to the beneficial effects of the merger of two weak rivals.

This is not an isolated case, nor is it only typical of the textile industry. There are many parallels in all segments of American industry. Since our interest is fishing and seafoods, I would like to give you a few examples where such mergers have not only been helpful but actually have been lifesavers for the parties involved.

I need not tell any of you of the cyclical nature of your industry and the financial risks involved. Weather, limited product lines, over-exploitation of resources, foreign competition and imports, new production techniques and mounting costs of equipment and capital requirements are making this a very tenuous operation.

Gentlemen, you are in an industry that calls for technical as well as financial skills, and the stakes and requirements are far different from what they were 15 or 20 years ago. There is no longer a simple industry, and fishing is no exception. Any thought of turning back to the nostalgic days of fishing from an open dory would have to be placed in the category of pipe dreams. There are some who will say that this complexity has been caused by the entrance of the "Big Boys" in this game. I will agree if you will include the many foreign participants who through their major concerns, national subsidies and huge investments have forced us to change the ante of our poker game. You cannot set your own rules for competing in this game. Whether you are fishing for, processing, or marketing shrimp, tuna, king crab, cod fish, haddock or any other seafood, you will need a capital investment and a management capability commensurate with the foreign and domestic competition.

The American people spend more money on seafood than any other nation of the free world, and for that reason it is truly a "Big Business" with all of the attendant problems and opportunities.

Although fishing is one of the oldest industries in the nation, its most dramatic technological advances have occurred only quite recently. New methods of refrigeration, processing and distribution have opened new and exciting horizons. These new developments call for vastly increased capital investments, and the most successful participants have been those companies that have met these new requirements. *Whether we like it or not, this is the price of progress!*

In line with this, it is my observation that the most successful seafoods operation is the one that is completely integrated. Companies like Consolidated Foods, Castle & Cook, General Mills and Ralston Purina may flounder and make serious initial mistakes, but in the long run with efficient production and processing facilities and their own distribution resources, they can and will weather the sometimes erratic production cycles of this commodity.

I do not want to leave the impression that you must be a giant to succeed in this industry. Katy Industries recently acquired a group of independent shrimp operations which were profitable and competitive, but I must be frank in stating that their managers were successful because they knew their business and they had the necessary physical and financial resources to meet the basic requirements and risks that I have already enumerated.

I have made a good case as to why it has been beneficial for New England garment plants to merge, but your concern is the fishing industry, and you are probably wondering if the same patterns I have outlined for the textile industry apply to your industry. Here again a few examples may prove helpful.

Everyone is familiar with the problems that have plagued the Alaskan king crab industry in the last three years. The three largest producers and processors of Alaskan king crab were Wakefield Seafoods, Pan Alaskan Fisheries, and American Freezerships. In 1968, all three of these companies were privately owned and operated. In 1967 and 1968 as head of W. R. Grace's Frozen Foods Division, I negotiated at one time or another with each of these companies. We finally acquired American Freezerships, while Hunt Foods acquired Wakefield. Pan Alaska's discussions with a number of major listed companies were not fruitful. Now some 2 years later, it is safe for me to say that neither Grace nor Hunt Foods have benefited very much by these acquisitions because of the drastic reduction in king crab production.

On the other hand, the former stockholders of Wakefield and American Freezerships in my judgment, are relatively far better off than those of Pan Alaska who remained unattached. In the long run, Grace and Hunt Foods will weather this setback, and in the final analysis, it is the consumer who will benefit through more efficient boats, processing plants, and reduced distribution costs.

It is not failing companies that produce a competitive atmosphere or improvements in any industry. The entrance of Grace, Hunt Foods, Gortons' (General Mills), Ralston Purina and Castle & Cook into the Alaskan field has helped stabilize this industry at one of its most critical periods, and I only hope that the government analysts who look with suspicion on every industry action will see the beneficial results of some of these acquisitions.

Because of the very high consumption of seafoods in this country, it is doubtful that we will ever see the day when import duties are applied to this commodity. As a consequence, we should focus our concern on the foreign competition that exists and the best methods to cope with this serious threat to our industry. In my opinion, there is no better means than through the combining of organizational, financial and physical resources to meet this foreign competition that has its own rules and is free of the many controls which now seem to dominate our "free enterprise" system.

In closing, I hope that my few comments on this subject will not give the impression that merging is the panacea to all management problems. In this respect, I must again emphasize that mergers should only be consummated where there is an apparent high degree of operating compatibility and true economic justification. Then a merger action may make the combined operation a much more viable entity. As in any form of business enterprise, there are good and bad mergers, and the results quite often reflect the scope of home work done by the merging parties.

Optimal Investment and Financial Strategies in Shrimp Fishing[1]

ROBERT R. WILSON, RUSSELL G. THOMPSON, AND RICHARD W. CALLEN[2]

INTRODUCTION

In April 1970, Thompson, Callen and Wolken (1970a, 1970b) published the first of two Texas A&M University Sea Grant Reports. The first bulletin contained a deterministic optimal control model of a shrimp fishing firm in addition to much background information on the industry and justification for the model specification. The second publication contained an extension of the model as first presented that took into account unknown, but random, future catch and shrimp price and a constraint that required solvency to be maintained with a high probability based on the probability distributions of the random price and catch.

In this study, the original deterministic model is extended to require the purchase of integer (positive) numbers of vessels. Fractions could be purchased in the original application (Thompson et al, 1970a), but industry representatives suggested that a more realistic specification would require the purchase of integer numbers of vessels. This extension is significant in cases in which holding companies cannot be formed readily to overcome capital indivisibilities. Integer requirements clearly restrict the growth of the firm's physical capital and, in turn, net worth over a finite planning horizon. If holding companies could be utilized without additional cost, vessel owners could clearly experience a faster rate of net worth accumulation. However, because capital indivisibilities have not generally been overcome in the shrimp fishing industry the integer restriction is necessary for the model to be reflective of industry conditions.

The paper also serves to illustrate the importance of following an optimal strategy. Alternative strategies are compared with the optimal one in terms of net worth, net profits per year and accumulated net profits. The strategy that produces optimum net worth also performs best otherwise.

Using the same initial net worth and the same parameter values three alternative investment strategies were employed with respect to shrimp vessel purchases. Strategy I, a conservative one, was to purchase no additional fishing capacity and retain all cash flows net of debt repayment as savings. In Strategies II and III, three additional boats were purchased. In Strategy II, a fairly comfortable savings cushion ($43,300) was accumulated before the second boat was purchased. Additional purchases were made as soon as available cash was sufficient for a down payment. Strategy III was the mixed-integer-linear programming solution to the investment problem. It reflects the optimal boat purchases for the given model and parameter values. In Strategy III the decision rule generated was to buy additional boats as soon as savings were sufficient to make a down payment. In each of the three strategies, borrowings were optimized using linear programming.

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[1] Partially supported by the National Science Foundation Sea Grant Program Institutional Grant GH-101 to Texas A&M University.

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Description of the model

In the model, the objective of the fisherman is to maximize the amount of savings held in the last year of the decision-making period, z_T, less the amount of indebtedness outstanding at that time, y_T, plus the value of the boats owned in the last year with an allowance being made for technological depreciation, ψ_t, and inflation in purchase prices, $\sum_{t=0}^{T} \psi_t \tau_t v_t$. There are three sets of difference equations and also three sets of inequality restrictions limiting the size of this objective. There is one other set of constraints restricting the boat purchases in each period v_t to have integer values. Indebtedness, y_t, savings, z_t, and boats owned, x_t, are the state (stock) variables in the model; boat purchases, v_t, and borrowings, w_t, are the control (flow) variables. Initial values of the state variables--number of boats, indebtedness, and savings--are taken as given; final values of the state variables are determined as a part of the solution to the problem.

In each year t, the shrimp fishermen in the model must repay a specified percentage of the indebtedness outstanding at the end of the previous year. In case the fisherman chooses to borrow in year t, he cannot borrow more than a fraction of the value of the boat investment in that year. That is, the fishing firm can only borrow money for the purchase of new boats; and in every case, the fisherman must have enough savings in the bank to cover the difference between the maximum loan value and the investment in boats. Letting κ denote the fraction (maximum) of the boat investment that can be borrowed, the upper-limit for borrowings in year t is $\kappa\tau_t v_t$, where τ_t is the purchase price (per boat) and v_t is the number of boats bought. We may now state the inequality restrictions on w_t as follows:

(2.1) $$0 \leq w_t \leq \kappa\tau_t v_t, \quad t = 1, 2, ..., T\text{-}1.$$

These restrictions mean that in any year t borrowings, which must clearly be non-negative, may occur only if new boats are purchased, and then they cannot exceed the fraction κ of the investment $\tau_t v_t$.

In the model, we do not allow the fisherman to sell boats. He can only purchase boats during the decision-making period:

(2.2) $$v_t \geq 0, \quad t = 1, 2, ..., T\text{-}1.$$

Furthermore the fisherman may only buy integer numbers of boats:

(2.3) $$v_t \text{ a member of I}, \quad t = 1, ..., T,$$

where I is the set of integers.

Since some time is generally necessary between the time when the decision is made to buy a boat and the boat is operational, the number of boats operated in year t was specified to be the number owned at the end of year t-1; and accordingly boat purchases in the last year of the planning period were specified to be zero. Thus, the change in the number of boats owned is described as follows:

(2.4) $$x_t - x_{t-1} = v_t,\ x_o \text{ given, } t = 1, 2, \ldots, T\text{-}1,$$

$$X_T - X_{T-1} = 0, \text{ so that } v_T \equiv 0.$$

In accordance with the final purchase assumption above, borrowings in the last year are also specified to be zero. Moreover, since the fisherman must always repay in year t a fraction β of the indebtedness owed at the end of the previous year, the change in indebtedness is as follows:

(2.5) $$y_t - y_{t-1} = w_t - \beta y_{t-1},\ y_o \text{ given; } t = 1, 2, \ldots, T\text{-}1,$$

$$y_T - y_{T-1} = -\beta y_{t-1}.$$

To describe the fishing firm's cash flow, it is helpful to have the following symbols: γ is the exvessel price received by the owner in year t after the lay is paid; λ is the expected catch per boat in pounds of shrimp; η is the sundry expense associated with the fishing operation; ζ is the interest rate paid on debt; ξ is the interest rate earned in savings; σ is the income tax rate; θ_t is the cost of operating a fishing boat in year t; and $g_t(v_i)$ is the depreciation allowed in year t on the boats purchased in year i. Then the difference equations describing the firm's cash flow are:

(2.6) $$z_t - z_{t-1} = w_t - \beta y_{t-1} - \eta - \tau_t v_t + (\gamma\lambda - \theta_t)x_{t-1} - \zeta y_{t-1}$$

$$+ \xi z_{t-1} - \sigma[(\gamma\lambda - \theta_t)x_{t-1} - \eta - \zeta y_{t-1} + \xi z_{t-1}$$

$$- \sum_{i=0}^{t-1} g_t(v_i)],$$

$$z_o \text{ given, } t = 1, 2, \ldots, T\text{-}1,$$

$$z_T - z_{T-1} = -\beta y_{T-1} + (\gamma\lambda - \theta_T)x_{T-1} - \eta - \zeta y_{T-1} + \xi z_{T-1}$$

$$- \sigma[(\gamma\lambda - \theta_T)x_{T-1} - \eta - \zeta y_{T-1} + \xi z_{T-1} - \sum_{i=0}^{T-1} g_t(v_i)].$$

In every year except the last one, the cash flow or change in savings is equal to the change in indebtedness less the boat investment plus the earnings retained after taxes. Before tax earnings equal net revenues to the boat owner and interest earnings on savings less interest payments on debt. In calculations in this paper discounted net profits after taxes will be regarded as the retained earnings after taxes. Such a definition implies that no personal allowances are used from the earnings in case the ownership is non-corporate and that no dividends are declared if ownership is corporate. If a boat is owner-operated, of course, the captain's share of the lay also goes to the owner and is an additional element of profit that our definition overlooks.

Initially, the fishing firm is regarded as having a given amount of fishing capacity, $x_o > 0$, with possibly some indebtedness, $y_o \geq 0$. It may or may not have any savings at the beginning of the period, $z_o \geq 0$.

The parameters in the model, which are denoted by Greek letters, are all positive with $\sigma, \zeta, \xi, \beta$, and κ being less than unity. It is also assumed that $\zeta > \xi$.

Mathematical statement of the decision-making model

In this section, the model described above is formally stated as a discrete-time control problem.

Maximize $I = z_T - y_T + \sum_{i=0}^{T} \psi_i \tau_i v_i$

satisfying the difference equations

(I.1) $x_t - x_{t-1} = v_t$, x_o given and positive,

$$x_T - x_{T-1} = 0,$$

(I.2) $y_t - y_{t-1} = w_t - \beta y_{t-1}$, y_o given and non-negative,

$$y_T - y_{T-1} = -\beta y_{T-1},$$

(I.3) $z_t - z_{t-1} = w_t - \beta y_{t-1} - \tau_t v_t + (\gamma\lambda - \theta_t)x_{t-1} - \eta - \zeta y_{t-1} + \xi z_{t-1} - \sigma[(\gamma\lambda - \theta_t)x_{t-1} - \eta - \zeta y_{t-1} + \xi z_{t-1} - \sum_{i=0}^{t-1} g_t(v_i)]$,

z_o given and non-negative,

$$z_T - z_{T-1} = -\beta y_{T-1} + (\gamma\lambda - \theta_T)x_{T-1} - \zeta y_{T-1} + \xi y_{T-1} - \eta - \sigma[(\gamma\lambda - \theta_T)x_{T-1} - \eta - \sum_{i=0}^{T-1} g_{T-1}(v_i) - \zeta y_{T-1} + \xi z_{T-1}],$$

and satisfying the inequalities

(I.4) $w_t \geq 0$, $t = 1, 2, ..., T-1$,

(I.5) $w_t \leq \kappa\tau v_t$, $t = 1, 2, ..., T-1$,

(I.6) $z_t \geq 0$, $t = 1, 2, ..., T$,

(I.7) $v_t \geq 0$, $t = 1, 2, ..., T-1$,

(I.8) v_t is a member of I, the set of integers, $t = 1, 2, ..., T-1$.

Solving the difference equations in 1.1, 1.2, and 1.3 for their respective "closed-form" solutions, the state variables can be stated in terms of their initial values and the unknown control variables:

(2.7) $$x_t = x_o + \sum_{i=1}^{t} v_i \,.$$

(2.8) $$y_t = y_o (1-\beta)^t + \sum_{i=1}^{t} w_i (1-\beta)^{t-i} \,.$$

(2.9) $$z_t = z_1 Q_{t1} + \sum_{i=2}^{t} [w_i - \tau_i v_i + \Delta_i x_{i-1} + \pi y_{i-1} + .091\sigma \sum_{j=0}^{i-1} \tau_j v_j$$

$$+ (\sigma-1)\eta] Q_{ti} \,.$$

where $v_T = 0 = w_T.\ g_t(v_i) = .091\ \tau_i v_i \,.$

$$\Delta_i = (\gamma\lambda)(1-\sigma) - (1-\sigma)\theta_i \,.$$

$$\pi = \zeta(\sigma-1) - \beta \,,$$

$$Q_{ti} = (1+\Gamma)^{t-i} \,,$$

$$\Gamma = \xi(1-\sigma),\ i = 1, 2, \ldots, t \text{ and } t = 1, 2, \ldots, T.$$

Substituting the closed-form solution for x_t and also y_t from (2.7) and (2.8) into (2.9), we obtain the following solution for z_t in terms of the initial values for the states, the unknown controls, and the parameters:

(3.0) $$z_t = C_t + \sum_{i=1}^{t} w_i P_{ti} + \sum_{i=1}^{t} v_i D_{ti} \,,$$

where

$$C_t = \sum_{i=1}^{t} Q_{ti}[(\Delta_i + .091\sigma\tau_o)x_o + (\sigma-1)\eta] + \pi y_o \sum_{i=1}^{t} Q_{ti}\chi^{i-1}$$

$$+ (1+\Gamma) z_o Q_{t1} \,,\ t = 1, 2, \ldots, T-1 \,,$$

$$\chi = 1 - \beta \,.$$

$$P_{tt} = Q_{tt},\ t = 1, 2, \ldots, T-1,$$

$$P_{ti} = Q_{ti} + \pi \sum_{j=i+1}^{t} Q_{tj} R_{j-1,i} \,,$$

$$i = 1, 2, \ldots, t-1 \text{ and } t = 2, \ldots, T-1 \,,$$

$$D_{tt} = -\tau_t Q_{tt}\,,\ t = 1, 2, \ldots, T-1\,,$$

$$D_{ti} = \sum_{j=i+1}^{t} \Delta_j Q_{tj} + .091\sigma\tau_i \sum_{j=i+1}^{t} Q_{tj} - \tau_i Q_{ti}\,,$$

$$i = 1, 2, \ldots, t-1 \text{ and } t = 2, 3, \ldots, T-1;$$

$$z_T = \sum_{i=1}^{T-1} w_i P_{Ti} + \sum_{i=1}^{T-1} v_i D_{Ti} + C_T\,, \tag{3.1}$$

where

$$C_T = (1+\Gamma)C_{T-1} + .091\,\tau_0 x_0 \sigma + (\sigma-1)\eta + \Delta_T x_0 + \pi y_0 \chi^{T-1}\,,$$

$$P_{Ti} = \pi R_{T-1,i} + (1+\Gamma)P_{T-1,i},\ i = 1, 2, \ldots, T-1\,,$$

$$D_{Ti} = \Delta_T + (1+\Gamma)D_{T-1,i} + .091\sigma^{\tau}{}_i\,,\ i = 1, 2, \ldots, T-1\,,$$

$$R_{ti} = (1-\beta)^{t-i},\ i = 1, 2, \ldots, t \text{ and } t = 1, 2, \ldots, T.$$

The Sequential Integer Programming Model

Substituting the solutions above for the state variables--x_t, y_t, z_t --into the objective function and the inequality restrictions of the control model, the state variables (and the difference equations describing them) are removed from the problem. The resulting problem is the following integer programming model:

$$\text{Maximize } I = a + \sum_{t=1}^{T-1} B_t v_t + \sum_{t=1}^{T-1} A_t w_t$$

subject to the inequality restrictions

(II.1) $w_t \geq 0\,,\qquad t = 1, 2, \ldots, T-1\,,$

(II.2) $\kappa\tau_t v_t - w_t \geq 0\,,\qquad t = 1, 2, \ldots, T-1\,,$

(II.3) $\sum_{i=1}^{t} P_{ti} w_i + \sum_{i=1}^{t} D_{ti} v_i \geq -C_t\,,\qquad t = 1, 2, \ldots, T\,,$

(II.4) $v_t \geq 0\,,\qquad t = 1, 2, \ldots, T-1\,,$

(II.5) v_t is a member of I, $\qquad t = 1, 2, \ldots, T-1$

where

$$A_t = P_{Tt} - R_{T-1,t}(1-\beta),\ t = 1, 2, \ldots, T\,,$$

$$B_t = P_{Tt} + \psi_t \tau_t,\ t = 1, 2, \ldots, T\,,$$

$$a = C_T + \psi_o \tau_o x_o - y_o x^T, \text{ and}$$

I is the set of all integers.

Letting

$$h_t \equiv h_t (w_1^o, ..., w_{t-1}^o, v_1^o, ..., v_{t-1}^o) \equiv C_t + \sum_{i=1}^{t-1} P_{ti} w_i + \sum_{i=1}^{t-1} D_{ti} v_i, \; t = 1, 2, ..., T-1 \; ,$$

inequality II.3 may be expressed as follows in terms of the non-negative function h_t:

$$\text{(II.3)} \quad w_t - \tau_t v_t + h_t \geq 0, \; t = 1, 2, ..., T-1 \; .$$

AN INVESTMENT STRATEGY FROM THE MODEL

As done in the first report (Thompson et al, 1970a), the model developed above is applied to a relatively small shrimp fishing firm operating 73-foot steel hull trawlers. Our aim is to illustrate how a shrimp fisherman having a given amount of physical and money capital might use the model to obtain guidelines for investment and financial decision-making.

Initial state values and values of the parameters considered

In this application, the value of x_o, is specified to be one boat. That is, the model firm is initially operating one 73-foot steel hull trawler. It is further visualized that this boat was purchased at the end of 1969 for a price of $100,000 and was completely outfitted for shrimp fishing. The model fisherman had $30,000 in cash with a minimum down-payment of $25,000 being made on the boat: $\kappa = .75$, y_o = $75,000, and z_o = $5,000. The loan contract requires the indebtedness to be repaid at a rate of 10% yearly starting at the end of the first year with interest (including mortgage insurance) at 9½% annually: $\beta = .10$ and $\zeta = .095$. This borrowing rate, which reflects 1969 conditions may be somewhat high at the end of 1970 and may continue to decline. The interest rate on savings is specified to be 5½% annually, the present maximum rate on savings deposits: $\xi = .055$.

Since it is quite common for owners of vessels like this one to obtain 65% of the gross revenues with the captain and first mate (who pay for all of the groceries) receiving the other 35%, the net price per pound of shrimp landed is specified to be 65% of the excessel price in year t, ϵ_t . That is, $y_t = .65 \, \epsilon_t$. The exvessel price for shrimp in year t ϵ_t was determined by the equation developed in Thompson et al. (1970b, p.10):

$$\ln \epsilon_t = 4.4725 + 0.0176t.$$

The above equation gives estimates of the exvessel average price of shrimp with landings at the mean value of the period 1958 through 1967 and a projected 1.5% rate of growth in real per capita income. The 1.5% rate of growth in real per capita income reflects the slow rate of growth of the late 1950's. This rate of growth appears reasonable as opposed to a faster rate of growth observed in the middle 1960's.

To convert to money terms, the projected prices from this equation are multiplied by the value of the consumer price index (with base 1957/59 = 100) for 1969, 1.277, and a price inflating factor of 1.5% in each year thereafter. Taking the product of the projected price and the expected annual landing per vessel with an adjustment for the lay fraction, the owner's expected annual revenue per vessel was obtained. The expected annual landing per vessel λ_t used in this study was the average of the landings per vessel obtained by the cooperating firms in the period 1958 through 1969 (57,560 pounds of heads off shrimp). There was, of course, a steady rate of technological improvement in that period so that this average is likely to be an underestimate of a 73-foot vessel's annual catch potential. Thus, the value of the expected annual owner's revenue per vessel for the stipulated 1.5% economic growth rate is a conservative estimate. It might have been further increased for expected technological improvements.

From the cost records of cooperating firms, the annual cost of operating a 73-foot trawler was found to be $30,000 in 1969. This cost figure includes an allowance for overhead and insurance costs. Representatives of firms interviewed indicated these costs have increased by 3% per year in recent years. Thus, the annual production cost per vessel, τ_t , was specified to be 30,000 $(1.03)^t$.

To reflect inflation, the purchase price of new vessels was specified to increase at 3% per year: $(1.03)r_o = r_t$.

Straight line depreciation methods were used for tax purposes with an 11 year depreciation period being used for a fully outfitted vessel. This average was estimated on a value weighted basis from the records of a number of firms. The reciprocal of this figure, 0.91, was the depreciation fraction used for $g(v_i)$.

The initial value of the technical depreciation rate ψ_o is .65 and is based on the argument in Thompson et al. (1970a, p.29), where $\psi_t = 1/(1.044)^{T-t}$.

Income for tax purposes is the sum of the revenue received by the owner after the "lay" less operating costs, interest costs, and depreciation. The income tax rate, which is denoted by σ, was taken to be 25% of this figure. This rate was paid in the late 1960's by a number of the small fishing firms studied.

In shrimp fishing, as in every business, there are sundry expenses for a number of factors related to the firm. Some of these costs, it might be argued, are not absolutely necessary for the operation of the business; but for the sake of convenience (or acceptance), they are commonly incurred. Such costs are difficult to estimate. Thus, in this study, a base allowance of $1200 per year was specified for sundry expenses: η = $1200.

In shrimp fishing, the captain and first mate of the vessel are commonly paid on a "lay" basis wherein they receive an agreed upon percentage of the revenue earned by the vessel. The third crew member, who is called a header, is typically paid on a per box basis. An allowance for his wages was included in the value of the production cost per vessel.

Values of the initial states and parameters are summarized in Table 1.

TABLE 1

Values of parameters and initial state values specified

Parameter	Value
β – Debt repayment rate	.10
τ_t – purchase price per boat	$\$100{,}000\,(1.03)^t$
ψ_t – technological depreciation	$1/(1.044)^{T-t}$
ζ – interest rate on debt	.095
ξ – interest rate on savings	.055
κ – financeable fraction of investment	.75
θ_t – operating costs per boat	$\$30{,}000\,(1.03)^t$
σ – rate of withdrawal from income for taxes	.25
$\sum_{i=0}^{t-1} g\,(v_i)$ – the depreciation function for taxes	$.091 \sum_{i=0}^{t-1} g\,(v_i)$
x_o – initial fishing capacity	1 boat
y_o – initial indebtedness	\$75,000
z_o – initial savings	\$5,000

APPLICATION OF THE MODEL TO THE SELECTION OF OPTIMAL INVESTMENT STRATEGIES

The sequential integer programming form of the model is evaluated for the alternative investment strategies. In Strategy I the fisherman enters year 1 with one boat, purchases no other boats and borrows no additional capital. Capital accumulation is based strictly on the accumulation of net retained earnings as savings and the amortization of the initial debt in Strategy I. Solutions for Strategy I for the period are presented in Table 2.

In Strategy II, three boats are purchased in periods 7, 8, and 9 in addition to the boat that was owned in the initial period. Through the purchase of additional boats net worth at the terminal period was increased by some \$40,845 and accumulated net profits by some \$36,699. Solutions for Strategy II are given in Table 3.

In Strategy III the second boat was purchased as soon as sufficient savings had accumulated to meet a down payment. Similarly the third and fourth trawlers were acquired at the first opportunity. By acquiring additional capacity as rapidly as possible, the terminal net worth was increased over that of Strategy II by \$20,961 and accumulated net profits by \$21,187. Strategy III is the optimal mixed integer programming solution to the problem. The purchase of fewer boats or boats in other periods will either be infeasible or less profitable than Strategy III. Solutions for the optimal strategy are given in Table 4.

TABLE 2

Optimal solution to investment Strategy I

Year	States			Strategy Parameter	Control	Objective	Companion Values	
	Boats Owned x^o_t (number)	Indebtedness y^o_t (dollars)	Savings z^o_t (dollars)	Boats Purchased v_t (number)	Borrowings w^o_t (dollars)	Net Worth (dollars)	Profit (dollars)	Accumulated Profit (dollars)
1	1.00	67499.94	17080.70	0.00	0.00	49580.76	12080.68	12080.68
2	1.00	60749.99	18033.70	0.00	0.00	57283.71	952.95	13033.67
3	1.00	54674.99	21097.20	0.00	0.00	66422.19	3063.51	16097.18
4	1.00	49207.49	26300.50	0.00	0.00	77093.00	5203.31	21300.49
5	1.00	44286.73	33688.80	0.00	0.00	89402.06	7388.33	28688.82
6	1.00	39858.06	43323.20	0.00	0.00	103465.10	9634.42	38323.24
7	1.00	35872.25	55279.90	0.00	0.00	119407.60	11956.67	50279.91
8	1.00	32285.02	69650.63	0.00	0.00	137365.50	14370.72	64650.63
9	1.00	29056.52	86542.63	0.00	0.00	157486.00	16891.93	81542.56
10	1.00	26150.87	106077.00	0.00	0.00	179926.10	19535.07	101077.63

It should be noted that the solutions to Strategies I and II given in Table 4 and 3 respectively are optimal in a sense also. The numbers of boats to be purchased was first chosen in each case. Then the optimal level for borrowings was obtained by linear programming techniques. In Strategy III mixed integer programming was used to obtain both the optimal boat purchases and the optimal borrowings per period.

The progress of the firm after the planning period with respect to net worth, net profits and accumulated net profits is given in Figures 1, 2, and 3 respectively. The growth of the firm from Strategy I arises in the growth of savings rather than additions to the number of boats In Strategy II, the firm grows faster as a result of the increased revenue earning power of the added boats. In Strategy III, the firm adds boats at the optimum time and in the optimum number with correspondingly improved results.

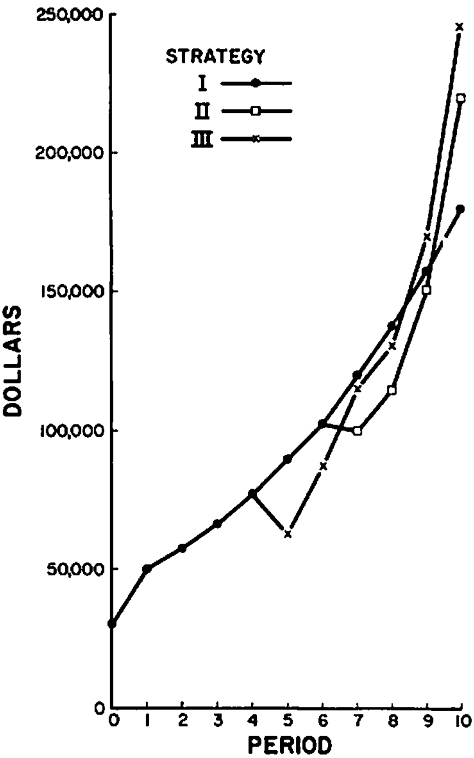

Fig. 1. Growth of a company in terms of net worth.

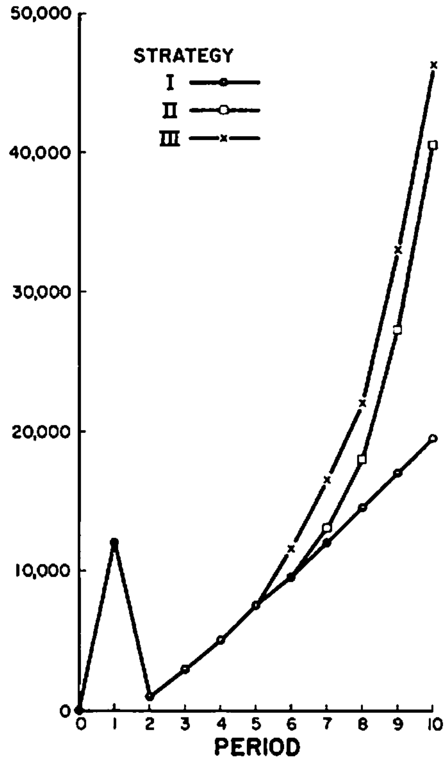

Fig. 2. Growth of a company in terms of net profit after taxes.

From the above discussion, it may appear that a shrimp fisherman should buy additional boats, as many as he can, as rapidly as he can save up a down payment. If such were actually the case, this model would be of limited use for the answer to the problem would be very well known. The reason for this simplicity is that average price and catch were assumed to be known and to be so

TABLE 3

Optimal solution to investment Strategy II

Year	States			Strategy Parameter	Control	Objective	Companion Values	
	Boats Owned x^o_t (number)	Indebtedness y^o_t (dollars)	Savings z^o_t (dollars)	Boats Purchased v_t (number)	Borrowings w^o_t (dollars)	Net Worth (dollars)	Profit (dollars)	Accumulated Profits (dollars)
1	1.00	67499.94	17080.70	0.00	0.00	49580.76	12080.68	12080.88
2	1.00	60749.99	18033.70	0.00	0.00	57283.71	952.99	13033.67
3	1.00	54674.99	21097.20	0.00	0.00	66422.19	3063.51	16097.18
4	1.00	49207.49	26300.50	0.00	0.00	77093.00	5203.31	21300.49
5	1.00	44286.73	33688.80	0.00	0.00	89402.06	7388.33	28688.82
6	1.00	39858.06	43323.20	0.00	0.00	103465.10	9834.42	38323.24
7	2.00	122803.90	19224.90	1.00	86931.69	99941.00	11956.69	50279.93
8	3.00	205530.60	5449.20	1.00	95007.13	114757.80	17893.38	68173.31
9	4.00	282834.80	0.00	1.00	97857.31	151710.60	27169.92	93343.23
10	4.00	254551.20	40777.40	0.00	0.00	220771.50	40777.42	136120.65

TABLE 4

Optimal solution to investment Strategy III

Year	States			Controls		Objective	Companion Values	
	Boats Owned x^{o}_{t} (number)	Indebtedness y^{o}_{t} (dollars)	Savings z^{o}_{t} (dollars)	Boats Purchased v^{o}_{t} (number)	Borrowings w^{o}_{t} (dollars)	Net Worth (dollars)	Profit (dollars)	Accumulated Profits (dollars)
1	1.00	67499.94	17080.70	0.00	0.00	49580.76	12080.68	12080.86
2	1.00	60749.99	18033.70	0.00	0.00	57283.71	952.85	13033.67
3	1.00	54674.99	21097.20	0.00	0.00	66422.19	3063.51	16097.18
4	1.00	49207.49	26300.50	0.00	0.00	77093.00	5203.31	21300.49
5	2.00	126524.80	0.00	1.00	82238.19	62997.81	7388.51	28689.00
6	2.00	113872.30	11427.60	0.00	0.00	87077.94	11427.60	40116.60
7	2.00	102485.10	27877.80	0.00	0.00	112915.30	16450.20	56566.80
8	3.00	169491.00	0.00	1.00	77254.38	131350.90	21544.42	78111.52
9	4.00	250059.90	0.00	1.00	97518.13	170488.10	32958.77	111069.99
10	4.00	225053.80	46238.20	0.00	0.00	241732.30	46238.20	159308.19

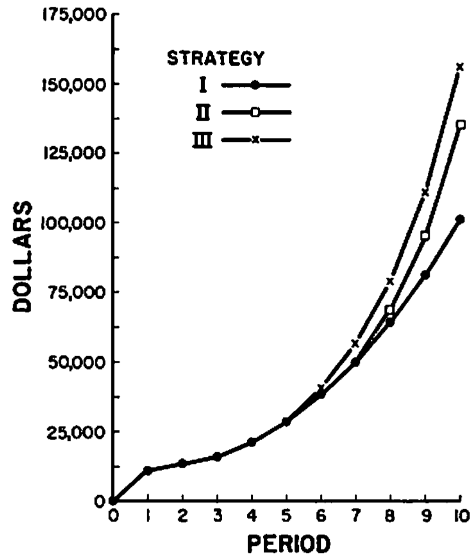

Fig. 3. Growth of a company in terms of accumulated net profits.

high that the rate of return on additional shrimp boats was greater than the rate of return on savings. Thompson et al. (1970a) was able to demonstrate periods in which the rate of return on savings was higher than the rate of return on additional boats by utilizing altered price and catch assumptions with a somewhat different model specification. Thompson's model delineated years in which the best decision was to deplete all savings in order to buy boats, years in which it was best not to buy boats regardless of cash on hand, and years in which it was best to invest in a limited way and also to maintain cash balances for future obligations.

The prices used by Thompson et al. (1970a) varied from \$.52 to \$.65 per lb. net of lay. Prices used in the present study varied from \$.76 to \$1.16 in periods 1 and 10, respectively. In the present study, the catch was assumed at the industry mean 57,560 pounds but in Thompson's first study catch was specified at 60,000, 70,000, and 80,000 pounds. It appears that the investment climate in our model is only slightly more attractive than in Thompson's because of the higher catches he assumed. In both studies, catch and price are specified to be known in advance; a specification they did not need in the second study (Thompson et al 1970b). In the earlier models the boat purchases may be any fraction of a boat and thus, do not appear to be as reflective of the industry as they might.

Our objective in this paper has been to illustrate a method for obtaining optimal investment strategies for shrimp fishermen. The objectives of our three-year Sea Grant Research Project have included (1) the development of models of optimal investment decisions in shrimp fishing; (2) the refining of those models to be reflective of industry conditions and practices and be practicable as a management tool; and (3) to disseminate the information for use by fishermen.

The first objective has been previously accomplished. This paper was concerned with objectives 2 and 3.

To develop a practical management tool several refinements may be relevant. Parameter values should be reevaluated with additional data, to insure their reflectiveness. A study of alternative sizes of boats would be of interest but will require much additional data on parameters.

The possibility of trading old boats in on new ones should also be investigated. The present models do not allow such reversability in investments.

The integer restriction suggests that it would be meaningful to study the opportunities for increasing the net worth of fishermen through holding companies to reduce capital indivisibilities. If additional management costs were minimal, such an arrangement could be significant in increasing net worth.

A previous study (Thompson et al. 1970b) described a dynamic stochastic model that differed from the one presented here in that prices and catches did not have to be assumed known in advance. The dynamic model learns the prices and catches in each harvesting period, just as does the shrimp fisherman. Thus, random or actual sequences of prices and catches may be utilized to obtain optimal decision rules that closely simulate industry conditions. The integer refinement along with the refinements mentioned up to this point should be implemented with the dynamic model to more closely reflect industry conditions and to make definitive recommendations.

Finally the models should be very carefully monitored using parameter and initial state data from a variety of fishing firms and making comparisons of optimal prescriptions with actual decisions. Guidelines may be obtained for the industry in general using hypothetical initial conditions and parameter values. However exact prescriptions for any given firm should be obtained using that firm's particular initial asset position and it's own parameter values. Computer costs for individual application of such models, given that the firm has the expertise to obtain and apply the information, should generally be less than $100 per year.

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Evaluating, Planning and Managing Risk Ventures

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INTRODUCTION

For purposes of this paper risk ventures are defined as any company activities which are outside the area in which the company normally operates or is familiar. Further, the enterprise, if successful, must have sufficient benefits to compensate for the inherent risk of failure. The types of risk ventures we plan to discuss are those which might be undertaken by a single established company; or, at most, a joint venture of two such companies.

The pressure for risk ventures develops because of constant change which is characteristic of business. To survive, a company must constantly venture into new areas of business. In some cases these new areas can be explored and developed in small bits. These result in gradual change and can generally be readily adjusted to. Other potential ventures require a relatively large commitment of either capital or manpower, or both, on the part of a company. These usually imply a dramatic improvement in company performance if they succeed. Conversely, failure sometimes results in severely limiting a company's maneuverability until losses have been made up.

These major ventures with great potential rewards are the ones we are considering. These require careful consideration and decision making in order to increase the chances of success and at the same time minimize the costs of possible failure. Adequate evaluation and planning often make it possible to go after these big ones at a risk which is acceptable to the company. The purpose of this paper is to outline some of the specific steps which will help assure success in risk ventures.

CLASSIFICATION OF RISK VENTURES

Risk ventures can be classified by degree of complexity or the number of new problems you expect to encounter. One level of complexity is expansion of a single proven activity into new geographic areas. Examples of this sort of venture would be expansion of a sales territory or establishing a processing plant in an existing fishing area where the company has not had a plant before. This involves successfully duplicating what is already being done.

A higher level of complexity and risk involves moving several segments of the business into new areas. Examples of this would be opening an entirely new fishing ground in a remote location. This involves proving out the fishing ground, establishing a fishing fleet, fleet support facilities, handling, processing and transporting the catch and many additional details of a similar nature. Another example is introduction of a new product line involving entirely new processing techniques.

In these examples there are a whole series of interdependent elements, each of which is unproven in practice. These complex new ventures require highly competent evaluation, planning and management to insure a maximum possibility of success; and, at the same time, to minimize potential losses in the event of possible failure.

Ideas for risk ventures

Ideas for risk ventures are usually plentiful; and we will assume that to be true in this instance. Therefore, the problem becomes screening available ideas to select an idea, or ideas, which warrant detailed consideration.

SELECTING A VENTURE

Characteristics of the sort of venture we are concerned with are: (1) Success will significantly improve company profits, yield a very high return on investment, or significantly increase the company's market share. (2) Adequate management is available or can be obtained. (3) A critical element or elements which will determine success is unproven. (4) Cost and manpower requirements of proving out the unknown elements are within the capability of the company. (5) Capital required is available, or can be obtained as each step is proven out.

Screening available ideas against the above criteria will produce those which deserve the attention of the company's top management. We should note in passing that putting capital in last place was intentional. Even in these days of tight money a highly regarded company which proves out a sound concept can generally obtain capital to take advantage of it.

Evaluating proposed ventures

The kind of investigation required to evaluate a venture, of course, depends on the specific nature of the proposed project. However, there are general guidelines which simplify this evaluation.

On larger projects a formal written evaluation will increase the likelihood that all significant factors have been considered. Elements which must be considered are:

1. Specify the goal of the proposed venture - (i.e., increase raw material available to the company, reduce the cost of raw material, reduce transportation costs, increase the area which can be served economically by a company, etc.) This step may seem somewhat academic; but merely stating the goal of a venture often stimulates development of alternate approaches to the problem.

2. Detail program proposed to achieve goal.

3. Define information needed to evaluate the venture.

4. Collect data - i.e., what information is available regarding the proposed venture? What non-company assets are available, (i.e., freezing and storage facilities, transportation, etc.?)

5. Define critical factors - (those which are critical to the success of proposed venture and the operating results of which are unknown.)

6. Define appropriate format for presentation of evaluation - (consider comparisons to existing company operations, to similar competitive operations, standard P&L.)

7. Define secrecy requirements.

8. Make sure alternate means of achieving goals have been given adequate consideration.

9. Develop the most economical means of prognosticating accurate estimates of operating results in the critical unknown areas.

10. Define performance standards – (go-no-go criteria, projected operating results anticipated with various assumed results for critical unknown areas.)

11. Find a means for subjecting all assumptions and plans to the most rigorous critical review.

Even in preliminary evaluations a clear distinction should be made between anticipated costs of proving out (or researching) a concept and the cost of implementing a concept which has been proven to your satisfaction. The research costs are not usually expected to be recoverable; and, are normally treated differently from an accounting standpoint. In addition, delineation of these costs helps clarify thinking with reference to the project.

Planning

After the project has passed muster, in the evaluation phase, you move into bedrock planning. This phase is greatly simplified if evaluation has been thorough; however, some new elements are introduced. These include: (1) Establishment of a firm program and schedule. (2) Definite program check points with pre-determined performance criteria to monitor progress. (3) Alternate action plans to be initiated dependent on results obtained up to the check points above. For example, what is to be done if results are greatly better than anticipated? (4) Precautions to insure that the company, rather than its competitors, benefit from positive operating results.

Implementation

This is the phase toward which all prior work was directed. The overall picture has been well defined. The detail which went into this definition allows for rapid evaluation of operating results. Stepwise testing and review of assumptions is followed by scaling up the various segments of the new operation.

Speed is often crucial both from the viewpoint of securing a position against possible competition and from the standpoint of cost. Again, the speed with which one is able to move is dependent on the thoroughness of earlier planning; and on the caliber of management assigned to the new venture.

The proving out of untested assumptions and gearing up new operations requires a great deal more management attention and skill than is required to manage an on-going operation. No matter how carefully planning has been done, unexpected situations do arise. When they arise there is no substitute for experienced management which has a "feel" for the total situation so that they can quickly evaluate the significance of deviations from plan. Many companies assign their most qualified managers to the testing and gearing-up phase of new ventures. Also, it is fairly common to find a greater than normal number of management personnel assigned to new ventures. After the venture is underway the excess management is then reassigned to other segments of the business.

Everyone who has been through the start-up of new ventures knows the challenge and excitement of proving out new areas of business. Also, developing a theory, proving it and building it into a continuing part of a business, yields lasting satisfactions. If our suggestions lead to greater speed in evaluating, and sureness in implementing risk ventures, they will have served their purpose.

Items which should be kept in mind are: (1) The better the preparatory work the fewer number of unanticipated events which will occur. (2) The better the preparation the easier it is to evaluate the effect of unanticipated events. (3) Don't let your enthusiasm suck you in over your head. If after giving the venture the trial you felt was reasonable before you started, results are not up to your predetermined standard, follow your plan and gear down or cut off according to your original plan. (4) Adhere firmly to a predetermined review schedule to maintain direction of your program. (5) Find a means of subjecting every element of your program to the most uncompromisingly thorough review.

Examples

Now, let's look at how two different companies have approached two entirely different ventures.

First, a conservative United States meat canning company who successfully initiated a canning operation in Venezuela.

Over the years a profitable business had been built up based on importing U.S. production into Venezuela. In the late 1950's the Venezuelan government began serious efforts to accelerate industrialization in order to reduce imports and broaden the Venezuelan economy. The government program entailed gradually restricting imports of products which could reasonably be produced locally.

There were several concerns which the company had: (1) Whether increased prices resulting first from smaller scale operations and later from more expensive local raw materials would drastically affect sales volume. (2) Ability to maintain suitable management in a remote Venezuelan area. (3) Ability to produce products at a new location which were commercially identical to those produced over several decades in the United States. (4) Productivity of Venezuelan labor. (5) Whether the Venezuelan government would nationalize foreign manufacturers.

The company had two choices, either: (1) Establish a local company which would can, distribute and market their products, or (2) Gradually relinquish their market position to new competition which would accept the risk.

The company chose a cautious stepwise program aimed at establishing an independent Venezuelan operation. It consisted of the following elements: (1) Simultaneous [a] Site search and operating cost analysis to determine initial production costs (based on imported raw materials); and to establish the most favorable long-term production location. [b] Market research to determine the effects on sales volume and profits of various cost and price levels. (2) Based on satisfactory projections in the above, establish a local canning plant. (3) After the canning plant was established, actively participate in development of local raw materials sources. (4) Develop a local distribution, marketing and sales organization.

The distinguishing features of this program were: (1) An established demand. (2) Stepwise planning and execution where progress from one step to the next was based on satisfactory accomplishment of the preceding step.

Everything was not easy. There was a lot of hard work and some costly shortcomings. However, every initial objective was met by a comfortable margin and the program has been eminently successful. Furthermore, most of the initial concerns have proven groundless.

The second venture we will look at is a tomato growing project in Mexico. Since progress in this case was not as smooth as in the Venezuelan venture we will look at it in more detail.

The Bracero farm labor program in the United States was eliminated a few years ago. This was a program under which Mexican nationals entered the United States on temporary agricultural work permits. When the Bracero program was eliminated it was widely predicted that agricultural labor costs in the United States would sky rocket.

Shortly after the Bracero program was terminated, a produce growing area in Sinaloa State in Mexico came to the attention of a very large and sophisticated United States firm. Tomatoes were grown, almost exclusively for export as fresh vine-ripe tomatoes to the United States. A joint venture with Mexican interests to provide general management, technical guidance, financing, distribution and sales for a large tomato growing enterprise was suggested.

This concept was being vigorously promoted by vegetable brokerage firms with operations in Nogales, Arizona; which is the major United States entry point for fresh tomatoes from Mexico.

The major points brought out in favor of the venture were: (1) Low cost of labor. (2) Low cost of irrigated virgin land. (3) People who had pioneered tomato growing in the area had made fortunes. True, in regard to the last item, it was admitted that for the last few years things had not gone too well; but, termination of the Bracero program in the United States was expected to change all that.

The question was referred to the United States company's economist. Based on low labor and land costs he wrote a favorable opinion. Based on this opinion, and without thorough research, a tomato growing program was launched as a joint venture with the Mexican partners.

Neither acreage, growers nor a packing shed were available in the vicinity of Culiacan where most of the Mexican tomato production is concentrated. However, all three were available about 100 miles north near Los Mochis. Because of climatic conditions, the Los Mochis tomato harvest usually starts in late March and peaks in late April or early May. It is, therefore, directly competitive with major production areas in Florida.

As the project developed it began to assume proportions beyond the economic means of the Mexican partners; so, the U. S. firm assumed the major economic role with the Mexican partners providing primarily grower coordination, farm management, Mexican legal counsel and local government liaison.

A substantial first year loss was shrugged off as the necessary entry fee to a good thing. However, as it became clear the second year would also result in substantial losses, a hard second look was initiated. This second look brought out that a pro-forma profit and loss projection for the venture had been prepared. However, the overall initial evaluation had the following serious weaknesses: (1) The economist's favorable opinion was based on general considerations. He had developed no financial calculations on which to base his judgement. (2) The pro-forma P & L did not take into account the effect of Mexican production volume on the United States price structure during the Los Mochis harvesting season. (3) There was no comparison of production and distribution costs with those of the major competitive production area (southern Florida).

Projected cost estimates which allow for evaluation of these factors follow:

COMPARATIVE TOMATO PRODUCTION AND MARKETING COSTS

	Southern Florida	Los Mochis Mexico
Growing cost per acre[1]	$1,520	$ 550
Yield per acre (20 lb. lugs)[2]	1,800	1,000
Costs per 20 lb. lug		
Growing cost	.84	.55
Harvesting and Packing	1.10	.84
Hauling to U.S. Shipping point (Nogales, Ariza.) plus Duty and Fees	-	.85
Selling and Administrative Overhead	.19	.27
TOTAL FOB U.S. SHIPPING POINT	$ 2.13	$ 2.51

DELIVERY COST TO SELECTED MARKETS FROM NOGALES, ARIZONA AND SOUTHERN FLORIDA

FROM	New York	Chicago	San Francisco
Southern Florida	$0.45	$0.50	$0.80
Nogales, Arizona	0.93	0.61	0.39
DIFFERENCE (unfavorable to Mexico)	(0.48)	(0.09)	0.41

The cost data from both production areas were evaluated for possible errors; and, the magnitude of such potential errors was estimated. The conclusion was that tomato production in the Los Mochis area exceeds the economically justified level in normal production years; and further investment in that production area was not justified.

CONCLUSIONS

Risk ventures are an essential element in successful businesses. Careful evaluation, planning and management of risk ventures minimizes the degree of risk involved; and, at the same time maximizes profits flowing from successful ventures. In evaluating potential ventures it is important to state the specific goal of the venture and evaluate the position of the venture in current and projected competitive situations. Careful and detailed planning is essential to smooth project implementation and to confident decision making in the management phase of a risk venture.

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[1]Based on 1967-68 growing season.

[2]Estimated, based on better than average grower competence in each area.

Fishermen's Protective Fund

RICHARD T. WHITELEATHER
Director, Southeast Region
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Freedom of the seas and the right of fishermen from any nation to fish in international waters throughout the world is a doctrine imbedded deeply in the tradition and history of the United States. Our commercial fishermen, as well as those from any other countries, range far and wide in search of their catch. The United States has opposed efforts to limit freedom of the seas through excessive claims to territorial waters or fishing limits by any country. By statute, we recognize a 12-mile limit for fishing purposes. We do not recognize the legality of jurisdictional claims beyond 12 miles, unless, of course, an international agreement has been entered into to the contrary. Furthermore, we have encouraged our commercial fishing industry, through programs of technical and financial assistance, to range far and wide in studying and using the resources of the sea.

During recent years, however, some of our fishermen have faced problems of detention or seizure as they fished in international waters near countries claiming fishing rights in these waters. As a result, requests began early in the 1950's to reach the Congress of the United States for protection of these fishermen. These requests eventually resulted in passage of the Fishermen's Protective Act on August 27, 1954. This Act directed the Secretary of State to attend to the welfare of any U.S. flag vessel and its crew seized by a foreign country in international waters or on the high seas on the basis of rights and claims not recognized by the United States. It also directed the State Department to secure the release of the vessel and its crew. If a license fee, registration fee, or a fine was charged, it directed the Secretary of the Treasury to reimburse the owners of the vessel in the amount certified by the Secretary of State being the amount actually paid, provided there is no dispute of material facts relative to the vessel's location or activities at the time of seizure.

This situation remained relatively static through the late '50's, but in the early 1960's, United States fishermen began to experience more frequent difficulty as additional nations extended their claim for fishing rights beyond 12 miles. Many of these countries were located in South and Central America and claimed fishing rights up to 200 miles. As seizures of United States tuna and shrimp vessels increased, vessel owners began experiencing significant losses beyond those of fees or fines paid to the foreign countries. These losses included confiscated or spoiled catches as well as lost fishing time. Further congressional action resulted in the passage of the Fishermen's Protective Act of 1967. This Act, approved August 12, 1968, under which authority we are now operating, provides assistance to the commercial fishing industry through February 8, 1973, at which time it will expire.

As you know, on October 3, 1970, Reorganization Plan No. 4 of 1970 became effective. This reorganization, among other things, transferred the Bureau of Commercial Fisheries and the direction and supervision of its financial assistance program, including administration of Section 7 of the Fishermen's

Protective Act, from the Department of the Interior to the Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Consequently, the Secretary of Commerce is authorized to enter into a Guarantee Agreement with the owner of a U.S. flag fishing vessel. Under this agreement, the Secretary guarantees to reimburse the vessel's owner for all actual costs, except those specifically covered by Section 3 of the Act, incurred by the owner during the seizure and detention period of the vessel and as a direct result thereof. These losses may include damage to or destruction of the vessel or its fishing gear or equipment, losses from confiscation of the vessel gear and equipment, and dockage fees. The Act also authorizes the Secretary to reimburse the vessel's owner and crew for the market value of the fish caught before seizure of the vessel as a result of confiscation or spoilage. It also provides for reimbursement to the owner and its crew for not to exceed 50% of the gross income lost as a direct result of the seizure or detention. The exact extent of these losses, of course, must be determined by the Secretary according to prescribed procedures.

A fee is charged for the privilege of entering into a Guarantee Agreement. Fees are based on anticipated losses and are established to recover the cost of administering the program and at least one-third of the sum of estimated claims. The remaining two-thirds are to be provided by the Government. All payments under the Act are made out of fees so long as they are available, and then out of appropriated funds.

Section 5 of the Act directs the Secretary of State to take such action as he may deem appropriate to make and collect claims against a foreign country for amounts expended by the United States under the provisions of this act. If such country fails or refuses to make payment in full within 120 days after receiving notice, the United States shall withhold an amount equal to this unpaid claim from any funds programed for the current fiscal year for assistance to the government of such country under the Foreign Assistance Act of 1961.

The fee during the current fiscal year is set at $60 plus $1.80 per gross ton as listed on the vessel's documents. Fractions of a ton are not included. The fee year ends on June 30. No refunds of a fee or any portion of a fee will be made after agreement is executed by the Secretary. The fee schedule, of course, may be increased or decreased by amendment at any time as warranted by changing conditions.

Eligibility for entering into a Guarantee Agreement is limited to the registered owner or bare-boat charterer of a vessel licensed or enrolled and licensed as a fishing vessel of the United States engaged in catching, or catching and processing, fish and/or shellfish. This means that a vessel must be properly documented as a vessel of the United States at the time of seizure in order for claims to be paid. Consequently, if anything occurs that would cause a vessel to lose its rights as a vessel of the United States, the agreement would be voided. Among other things, employment of an alien as an officer of the vessel might have this effect and void the agreement.

The vessel must also be insured during the period of the agreement with hull and machinery insurance and protection and indemnity insurance. The amount and form of insurance must be satisfactory to the Secretary. If such insurance is not in effect at the time of seizure, the agreement may be void and no claims paid.

Making application for a Guarantee Agreement under the authority of the Fishermen's Protective Act is relatively simple. The owner of a vessel need only complete Form No. 2-298, Application for Guarantee Agreement, and mail it to the Division of Financial Assistance, National Marine Fisheries Service, 1801 North Moore Street, Arlington, Virginia 22209. When the application is received, and provided it is eligible on its face, the application serves as a binder to provide owners the benefits of the Guarantee Agreement as of the date received. Vessel owners who wish to have continuous coverage should submit their application each year prior to June 30.

This program has met with considerable enthusiasm and support by the U.S. fishing industry, first by operators of tuna vessels in California, and now by shrimp vessel operators in the Gulf and Caribbean areas. As of June 1969, 45 fishing vessels were covered under agreements. Of these, 42 were owned by California operators. By October 31, 1970, however, the situation had changed considerably. Of the 138 Guarantee Agreements in effect, 101 of the vessels were owned by companies located in the South Atlantic or Gulf coasts; 29 vessels were operated by owners in California; and 8 vessels were owned by companies located in the Pacific Northwest.

DISCUSSION

Mergers and Investment Session

Discussion Leader: T. H. Shepard
Discussion Panel: Gordon Campleman, J. R. Clegg, Clifford Varin

Comments on Economic and Financial Aspects of the Gulf Fisheries

A. H. Kantner

Q. Clegg: Don't you find that fishing companies need longer term vessel financing than in previous years?

A. Kantner: They probably need up to 10 years under present conditions. Generally, experienced fishermen and boatmen need longer terms for items such as boats, because the costs are so much higher now. Interest rates are not as satisfactory as we would like.

Q. Styron: With such variation in the prime interest rate, will it level off in the future or will money rates still go up and down?

A. Kantner: Yes, rates will fluctuate. Considering the highly developed part of the world, investments have a good basis for pay out. We are getting more tightly tied into the world money market. Interest rates over the world are inter-related. Rates are currently going down, the prime rate is down to 7.5 percent and I believe there will be a further reduction which could bring it back to 4.0 or 5.0 percent.

Why Merge?

J. Saliba

Q. Varin:	What benefits, if any, do conglomerates contribute to the general business climate?
A. Saliba:	Conglomerate is probably the most abused word in business, for it encompasses too much. Very few businesses can escape being classified as conglomerates; for example, a good fishing operation will have a net shop, a processing plant, a repair yard and so forth. These are all related or conglomerate functions that help make this fishing operation a more efficient enterprise. Although we are basically engaged in the function of operating a railroad, we nevertheless have a number of diversified subsidiaries that historically have helped our railroad as other railroads such as the Northwestern, the Santa Fe and the Illinois Central have been helped by their non-railroad operations. In the long run these railroads have ended far ahead because of these diversified operations. In my judgement the best chance for a railroad to prosper and survive will be through such diversification.
Q. Campleman:	Do you believe that through internal growth and improvements you can get the same advantage as by merging?
A. Saliba:	I agree in part, but merging can enable one to add product lines and therefore greatly speed up this process of improvement, and I gave examples as above where railroads were helped by such consolidation. Furthermore, I indicated that in many cases people merge because of estate or other personal requirements. I also added that when a major company acquires a small personally-held company, such mergers can only succeed if the acquirer allows the company that is acquired to function along the lines that assured it of success in the past.
Q. Ripley:	Do you have any idea when you might consider overseas investments?
A. Saliba:	I believe that any major company should have overseas investments. We do not have overseas investments because our tax-loss carry forward is not applicable to earnings from overseas investments, and consequently there would be very little advantage to our having such investments. I did add one final word of caution, however, an American company should not attempt to work anywhere in any overseas area without good strong local connections. Many concerns have floundered because of their inability to understand foreign customs and regulations.

Optimal Investment and Financial Strategies in Shrimp Fishing

R. R. Wilson

Q. Clegg:	What rate of interest was used for boat payments in your example of a boat costing $100,000 with a down payment of 25 percent?
A. Wilson:	Eight and one-half percent based on a boat purchased in 1968 with payments continuing through 1978.
Q. Campleman:	Success in operating fishing vessels is largely in selling them before maintenance and operating costs become excessive. This condition usually occurs in less than 10 years, while payments are still being made in your model. What criteria are used to make the decision to sell vessels?
A. Wilson:	We have considered including in our model the sale of boats at the time major maintenance problems commence. We have not refined the model to this extent yet, but hope to obtain information permitting this during the coming year.

TUESDAY P.M. – NOVEMBER 10, 1970

Chairman – R. A. Erkins, *Snake River Trout Company, Buhl, Idaho*

A Food Technologist Looks at Fish Protein Concentrate

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Fish Protein Concentrate (FPC) seems to cover a rather broad spectrum of products and processes when viewed by the average research worker in the field. On the other hand, the U.S. Food & Drug Administration has written extremely tight specifications for the product as they see it.

As originally written, the only allowable raw material was red hake which was extracted to remove water and oils with isopropyl alcohol (IPA). The residual solvent was not to exceed 250 parts per million (ppm). The fluoride (F) content must be below 100 ppm F, which means that some bone has to be removed. Finally, the end product is highly restricted in sales, packaging and use. It may be sold directly to the consumer only in one pound packages. There is no provision to permit its use as an ingredient in foods, even if it were so declared.

The first relaxation of this specification permitted the use of ethylene chloride, provided this was following with an isopropyl alcohol wash. The latest revision of the regulations issued August 4, 1970, permits the use of herring and menhaden as sources of raw material.

One of the great appeals for FPC was to make use of the fish species that are not normally harvested for food purposes. It would then be possible to improve the utilization of marine resources in any given area. As long as there was a restriction of red hake only as a raw material there was no organized element of the fishing industry which could get behind the project and give it the needed support.

This new regulation corrects two problems at the same time. A much greater supply of fish as raw material is made available and organized industry is brought into the picture.

Further widening of the scope of raw materials seems to be in order. For example, the anchovy needs to be included. However, the real break-through that will give a truly low cost raw material are the "trash" fishes that are taken by the shrimpers and others or can be caught during off-season.

Canada has liberalized their outlook some time earlier this year.

What is most needed now is a relaxation of the restriction of end use. This would bring in the food industry people with a real incentive to solve some of the problems rather than maintain a more or less academic interest.

TABLE 1

Percentages of essential amino acids for several proteins

Essential Amino Acids	(FAO) Reference Protein (a)	(FPC) Red Hake (b)	Soymeal (a)	Yeast (a)	Algae (a)
Lysine	4.2	8.3	6.5	7.0	2.7
Threonine	2.8	4.2	4.0	3.9	2.2
Methionine	2.2	3.2	1.4	1.2	.8
Cystine	2.0	.9	1.4	-	.2
Valine	4.2	4.9	5.0	4.0	2.7
Isoleucine	4.2	4.3	5.4	3.6	1.8
Leucine	4.8	7.5	7.7	5.9	3.6
Phenylalanine	2.8	4.5	5.1	3.7	2.0
Tryptophan	1.4	1.0	1.5	0.5	1.0

(a) Dabbah, R., Food Technology 24, 659, June 1970
(b) Sidwell, V. D., et al, ibid 24, 867, August 1970

As can be seen from Table 1 FPC is an excellent protein when compared to FAO's reference protein. It is one of the best sources of lysine and methionine which are the amino acids most likely to be deficient or low in most vegetable proteins. Included in Table 1 are similar analyses of what may be the principal competitors of FPC.

Clearly its advantage as a nutritional supplement stands out. However, many problems exist making it difficult to bring the product to the needy countries. The villages where the fish protein is most needed are far from the sea and little or no transportation exists. The coastal villages with a fish economy seldom need additional protein for their diet.

Most of the material which has been made and demonstrated so far is a long way from being the "bland and odorless" product which can be incorporated into food products at almost any level. It just plain doesn't taste good. In most areas there is a national pride which says that no one is so poor that he has to eat "poor man's" food. It must therefore be in a form acceptable to the potential user. If we are dealing with a "give away" program then it has to be a food that North Americans eat, not something we ship off to other lands.

The food must also be a familiar form as the nutritionists and food technologists are now finding out after a number of abject failures in foreign lands. It is not enough that a food is good for someone, he must like it and consume it.

When one tries to incorporate present day FPC into products he finds it is almost wholly inert. One might as well be dealing with sand as far as any functionality is concerned. By virtue of the treatment in the process the protein is almost entirely denatured. The heat and the alcohol have so altered the protein structure that one is faced with the problem of trying to "unfry" an egg.

This has not damaged its nutritional value in any way. It has simply taken away the properties that the food technologist needs to build new foods.

In brief these are: FPC does not go into solution or dispersion, FPC does not swell and bind significant amounts of water, FPC no longer has the ability to coagulate when heat is applied, FPC has no capacity for forming gels, FPC will not or cannot interact with other materials to regain some functionality, FPC has little capacity to emulsify oils and bind them in systems and FPC has no or at best little ability to form foams.

With a series of indictments such as this, it is a wonder that even the product concept is still with us. The National Center for Protein Concentrate at College Park, Maryland, stands as a monument to those persistent people who just wouldn't give up. Time will tell us whether FPC was only the enchantment of the sea and the technical challenge of developing a product and process with such great promise. It most probably will come to pass that the work is timely and will go on to a brilliant future. In any event, dedicated persons are needed to move such a massive program to completion.

Things are beginning to happen. Astra in Sweden has developed a process which can be used on shipboard which by chopping and washing the fish removes the aesthetic stigma of filth contamination. Since very fresh fish are used, this product should have a very low level of fishy odor when first made. We will have to see what happens in storage. Until and unless the basic process is changed, it is unlikely that much functionality will be left in the product. This development may tend to stiffen the position of FDA with respect to filth. It is only fair to point out that this product has to be an expensive one based on yield alone.

The more liberal outlook by the U.S. FDA should bring a great deal more support for the product from the fishing industry. Further liberalization of the allowable species to include anchovies will add another segment of the fishing industry.

What is needed most is to permit FPC as a food ingredient in order to enlist the support of the food processors and their research and product development skills.

John Spinelli at the Seattle Laboratory of the Bureau of Commercial Fisheries is working at making functional proteins by mild conditions of protein precipitation. He has been able to demonstrate benchtop samples of great interest.

Cost, as happens so often, has not met the expectations of the early workers and it is doubtful if it can. Time and process studies are on the side of reducing costs, but it looks as if the $0.40 to 0.50 per pound is a much more realistic figure than the $0.10 originally forecast. This higher price is probably quite tolerable for product development in the U.S., but tends to move the potentially good, nutritionally sound products further from the reach of the hungry.

In summary then: Fish Protein Concentrate is an excellent nutritional supplement which is today out of the reach of the people who most need it because of high cost, lack of distribution and lack of satisfactory products incorporating it.

FPC is not entirely acceptable to the U.S. FDA regulatory body because of filth adulteration and fluoride content.

FPC is not acceptable to the product development scientists, since it has no functional properties that can help to incorporate it into products, and is excluded as an ingredient by regulation.

FPC is not acceptable to the consumer because of the high frequency of bad flavor and sometimes degradation of texture and color.

FPC has a great potential in spite of all these adverse comments, if new processes and therefore products are developed which meet the needs and requirements of all interested parties.

Fish Protein Concentrate: the Growth of an Industry

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INTRODUCTION

Fish protein concentrates (FPC's) have been used in various parts of the world for several centuries. It has only been within the past 30 years, however, that the production of FPC's has been investigated on a scientific basis. Furthermore, it has only been within the past 10 years that serious consideration has been given to the production of the products on an industrial scale.

Today several pilot plants and full-scale industrial plants have been built. Some are now in operation and others will be within a matter of months. Most of these plants produce FPC by solvent (usually isopropyl alcohol) extraction procedures. The purpose of this paper is to describe these plants and to discuss the type of FPC produced. Only those processes which are now in commercial operation, or in the author's judgment soon will be, are reported.

Before discussing FPC's, they must be defined adequately. Most people tend to think of FPC as the nearly white, bland, highly nutritive product produced by isopropyl alcohol (IPA) extraction of whole fish. This product is an FPC; however, it is only one type of FPC. Fish protein concentrates are defined as those products resulting when water, oil and sometimes bone or other non-proteinaceous materials are wholly or partially removed from whole fish or parts of fish. The products (FPC's) thus produced may be in the form of pastes or dry solids, they may be high in nutritive value, or only intermediate in nutritive value. To avoid confusion, the type of FPC produced by isopropyl alcohol extraction (IPA) will be referred to as IPA-FPC.

AVAILABILITY OF FISH

Before an industry can be started, a continuing supply of raw material must be available. Adequate fish resources do exist on a world-wide basis; however, several limitations must be mentioned that have a direct effect on the industrial production of FPC's.

United States Resources — In the United States, the only species of fish that are permitted to be processed into FPC under present Food and Drug Administration regulations are whole hake and hakelike fish, herring of the genus *Clupea*, and menhaden.

Canada — In Canada, three families of fish have been approved for making FPC by IPA extraction. These families are Clupeidae (herring and herringlike species, such as alewives, menhaden, pilchards and sardines), Osmeridae (capelin and smelt species) and Gadidae (cod, haddock, hake and pollock).

Other Countries — In other countries, no regulations are known to be in effect. Therefore it is presumed that any wholesome food grade fish could be used in any "safe" process.

METHODS OF PROCESSING

There are two general methods of making fish protein concentrates: chemical and biological. Chemical methods use solvents alone or in combination to remove water and lipids from the protein. Biological methods use enzymes, natural or added, or microorganisms to degrade the protein into water-soluble components. The oil and solid residues are removed mechanically (by filtration and/or centrifugation) and the water-soluble fraction is concentrated by partial or complete drying.

Chemical (solvent extraction)

Most research efforts have been expended on solvent extraction methods. A wide variety of solvents has been investigated for use in making FPC. These range from non-polar solvents, such as hexane, to very polar solvents, such as methyl alcohol, and from chlorinated hydro-carbons to ketones and esters. It is interesting to note, however, that every commercial or near commercial procedure makes use of isopropyl alcohol somewhere in the process.

A description of each commercial or near commercial operation will serve to illustrate the extensive use of isopropyl alcohol for making FPC.

Alpine Marine Protein Industries, Inc.— Alpine Marine Protein Industries, Inc., New Bedford, Massachusetts, uses a two-solvent system. The process is based on the VioBin method of extraction of whole fish with ethylene dichloride resulting in a dehydrated and partially defatted material. This material is further extracted with IPA in a continuous countercurrent procedure. The final solids are dried, steam stripped, and milled. This company currently is test marketing a product called "Instant Protein," sold in quarter-pound packages. Each package contains eight one-half ounce packages of FPC along with some recipes. This material, reportedly, sells for $0.79 per box. The IPA-FPC produced was made exclusively from hake *(Urophycis chuss)*.

Nabisco-Astra Nutritional Development Corporation— This Corporation, with headquarters in New York City, is a joint venture between the National Biscuit Company, U.S.A., and the Astra Company of Sweden (Lawler, 1970). Astra Nutrition has developed a process for making IPA-FPC and Nabisco is experienced in the production and marketing of protein-enriched food products. The two companies united to form the Nabisco-Astra Nutrition Development Corporation.

The process for making EFP-90 (eviscerated fish protein) as it is called, is a modified IPA process.

Fish are cut into segments, washed to remove viscera and blood, and slurried in water and cooked. The cooked material passes through a deboner, a desludging centrifuge, a hot water treatment, and a second centrifuge. From there it enters a continuous extractor where fat is removed by isopropyl alcohol. On discharge, the IPA is centrifuged to clarify it for return to the solvent recovery plant. The extracted fish is passed through a steam-heated agitating desolventizer where any remaining solvent is removed. The operation is completed by drying in a steam-heated unit, milling, and bagging the finished protein. The EFP-90 contains between 92-94% protein with an IPA residue of less than 100 ppm. At present herring is used to make EFP-90. Reportedly, the EFP-90 is offered for sale at about $0.49 per pound.

Cardinal Proteins, Ltd. — Cardinal Proteins, Ltd., Nova Scotia, Canada, is constructing a multimillion dollar IPA-FPC plant with a capacity of 200 tons of fish daily. This plant, being built in Canso, Nova Scotia, will use the IPA process, probably as developed in Halifax, Canada, which means that the initial slurry is acidified with phosphoric acid. Cardinal's representatives have stated that the plant construction is nearly completed, but operation was delayed because of a fishermen's strike in Canada. It is expected, however, to begin operation in early 1971.

The plant is located next to an established fish processing plant. Cardinal expects to meet one-third of its daily requirement for raw material by fluming cod and haddock trimmings directly from the processing plant. These trimmings currently are being used in fish meal production. However, this material, having been handled under sanitary conditions, is considered superior to fish normally used for making fish meal. This ability to obtain sanitary fish trimmings will help hold down the cost of raw material. No firm cost figures for IPA-FPC are available at this time.

Societe Nationale Farine Alimentaire Poisson (SONAFAP), Agadir, Morocco — The Agadir plant uses batch extraction procedures. This plant operated for a few weeks in 1965 and for several months in 1966. About 170 tons of product were produced using hexane and ethyl alcohol, but because of poor odor and color the product was unacceptable. The plant remained idle until about a year ago when operations were once again resumed and an acceptable FPC was made by IPA extraction of sardines *(Sardinia pilchardus).*

This plant will be used to produce IPA-FPC for acceptability studies in Morocco. No cost figures are available.

FPC Experiment and Demonstration Plant — The Experiment and Demonstration Plant now under construction at Aberdeen, Washington, was authorized by the 89th Congress in Public Law 89-701. It is designed to demonstrate the feasibility of commercially producing FPC, by a countercurrent isopropyl alcohol extraction technique developed by the National Marine Fisheries Service. The plant will be completed in December 1970 at a cost of approximately $2 million. The plant is being constructed under Government contract by Ocean Harvesters, Inc., a company formed through equal capitalization of Star-Kist, Inc., a subsidiary of Heinz, Inc., and SWECO, a company specializing in construction of shaker screens. SWECO, as a subcontractor to Ocean Harvesters, is constructing the plant. Star-Kist, acting in a similar capacity, will operate the plant after it is constructed. The plant is designed to process 50 tons of raw fish into approximately 7-1/2 tons of FPC in a 24-hour period.

Fish to be utilized will include hake *(Merluccius productus),* anchovy *(Engraulis mordax),* and possibly Pacific herring *(Clupea harengus pallasi).* Using data obtained from plant operation, the cost of producing FPC via this method will be calculated for varying sizes of commercial plants.

Heat Transfer Method

This method is one that might be called "half completed." The half that has been completed on a commercial scale removes water from the fish and removes part of the oil. Experimental work is now underway to develop an economical method to further extract the partially defatted product with either IPA, hexane, or both. This process is potentially valuable for two reasons: (1) the intermediate product can be sold as is for animal feed, and (2) the intermediate product can be stored for long periods of time (at least a year) without noticeable deterioration. Thus, the market for the product is diversified (animals and humans) and the intermediate product will be available for further processing on a steady basis throughout the year. This steady state year round operation is very favorable from an economic standpoint.

Raw fish are charged into a prebreaker, cutting the whole fish into roughly 1-inch chunks. From here the chunks are fed into disintegrators, previously produced hot fish oil is added and the whole mass is slurried into a pea soup consistency. The slurry is now pumped to large two-stage vacuum evaporators, and the slurry is almost instantaneously dehydrated under reduced pressure, leaving protein, solids, bones and oil in a fine suspension. The oil and solids are then partially separated by centrifugation, producing the intermediate product. Following this, the oil content may be lowered further, either by the use of expellers or by solvents.

Biological Methods

These methods, while not as well developed or publicized as solvent extraction methods, produce FPC's with a wide variety of flavors, odors and functional characteristics. Most of the work thus far has been limited to small scale efforts and will not be reported here.

TYPES OF FPC'S

Chemical (solvent extraction)

In general these types of FPC's are bland tasting and vary in color from white to dark tan. They contain between 75 and 95% high-quality protein. FPC's made from different species of fish have different textures, different colors and, in some cases, different odors. As experimentation proceeds and we become more knowledgeable in our manufacture of IPA-FPC's, these differences will be minimized. The nutritive values of the IPA-FPC's are equal to or better than casein when fed as a sole source of protein. IPA-FPC is intended for use, however, mainly as a protein supplement and not as a sole source of protein. This cannot be emphasized strongly enough. For this market, numerous nutritional studies have been conducted on the effect of supplementing various vegetable protein sources with IPA-FPC. Substantial increases in nutritive value have been obtained in all cases.

Much has been said about FPC being non-functional. If non-functional is defined as not changing the product characteristics of that foodstuff to which it is added, then, indeed, FPC can be termed non-functional. This characteristic of limited functional properties, far from being a drawback, is in many circumstances advantageous since FPC can be added to existing food products, markedly improving the nutritional quality without significantly altering other characteristics.

In addition to chemical analyses and animal-feeding studies, we have also tested various IPA-FPC's in food products. IPA-FPC can be used in relatively small amounts to increase the quality and quantity of protein in a variety of commercial foodstuffs. We have studied the use of IPA-FPC in such products as bread, pasta, crackers, cookies, soups, tortillas and beverages. In all cases the nutritive quality has been increased tremendously.

The product characteristics of breads containing IPA-FPC from various species of fish, including hake, Atlantic menhaden, Atlantic herring, Northern anchovy, ocean pout and alewife, were acceptable with no exception.

For pasta, the same thing might be said–that as far as flavor and odor evaluations were concerned no significant differences were found.

In crackers, a sensory evaluation was conducted using 50 panelists. No significant differences were found in the texture or flavor of crackers with no IPA-FPC and those fortified with IPA-FPC. Differences were, however, detected in the appearance of the crackers in that those containing IPA-FPC were slightly darker than the unfortified cracker.

For cookies, a bland sugar cookie was used to evaluate the sensory characteristics of IPA-FPC prepared from the various species of fish. No significant differences were found in flavor and texture. However, the appearance of the cookies made from anchovy and alewife was slightly less acceptable than that of the control.

From our investigations, it appears that perhaps FPC is not quite as non-functional as one might have first suspected. We have indications, although no proof at this time, that certain products have an increased shelf life upon the addition of IPA-FPC. Furthermore, it appears that some products are more resistant to breakage. We found, for example, that crackers containing IPA-FPC appear to be less apt to crumb in the box or to be damaged in shipping. These observations will be investigated further.

Biological

Most of the work done at the NCFPC on biological methods has been oriented toward development of a totally water soluble FPC through the use of enzymatic hydrolysis. The basic process includes enzymatic digestion of the whole fish slurry with control of pH and temperature, screening out the bones and scales, and separation of undigested solids by centrifugation, followed by spray drying of the clarified hydrolysate to yield a soluble product consisting of peptides, polypeptides and some free amino acids. More work needs to be done in this area before these FPC's are ready for commercial production.

Markets

United States —According to Hammonds and Call (1970) the market for FPC's depends upon price-functionality relationships.

An FPC with no functional properties will have to be lower in cost than a more functional FPC.

Hammonds and Call assumed a price range for FPC of between \$0.288 to 0.538 per pound of protein. They state that this price range would place FPC costwise between soy flour (\$0.126 to 0.164 per pound of protein) and nonfat dry milk (\$0.556 - 0.694 per pound of protein). Furthermore, since this range is neither clearly lower than that of present protein ingredients, nor clearly higher, the functional characteristics of FPC then becomes crucial in determining the market potential. Starting at the low price range (\$0.29 per pound of protein) they conclude that FPC could compete with soy flour providing taste advantages are realized (soy flour has a bitter-beany taste when present in concentrations of greater than 4 to 5% by weight of finished product).

FPC priced between \$0.40 - 0.50 per pound of protein with a very bland taste but a low level of functionality could penetrate the following U.S. markets:

". . .baby food at 2.4 million pounds of protein yearly; breakfast cereal at 1.4 million pounds; candy at 16.6 million pounds; and diet drink at 2.2 million pounds. These markets total to a potential volume of 22.6 million pounds of protein or 28.3 million pounds of FPC." They add however: "If functional properties can be developed along with acceptable taste, FPC in the $0.40 - 0.50 per pound protein price range could also compete in a number of other markets currently using nonfat dry milk. Moderate fat absorption would open the canned and processed meat markets using 16.1 million pounds of protein yearly. The ability to prolong freshness and shelf life would open the baked goods market at 68.3 million pounds of protein yearly. Whippability and emulsion stabilization would open the desserts and toppings market at 28.6 million pounds of protein yearly."

One other market potential is the U.S. school lunch program--notably the "Type A" school lunch. It has been stated (Hines, 1970), that in a few years there will be 55,000,000 children getting school lunches at a cost of $7 billion at 1968 price levels. The animal protein in the lunches represents 60% of the cost. Fish protein concentrate is now being investigated as a source of protein for these lunches.

Other Countries—Outside the United States, the competitive market for FPC will be subject to essentially the same type economic analyses as reported by Hammonds and Call. Some countries, however, have plans to require FPC supplementation in bread and baked goods. This could lead to a sizeable market for FPC.

In addition, Nabisco-Astra reported the following: "Fish protein is marketable wherever protein is in short supply: in industrial countries, developing countries, and among people of different ages, social conditions and customs. Until today there was little awareness of the protein needs of the developing countries so it is important that these areas receive our initial attention. However, significant markets for fish protein also exist in prosperous countries with a high degree of industrialization.

"Nabisco will develop food products that lend themselves to enrichment with high-level protein, provide high-grade nutrients for such products, and market them with necessary adjustments to local eating habits."

It appears, then, that potential markets do exist for a bland type IPA-FPC. Obviously, however, if more functional FPC's can be developed, the market potential will be expanded.

PRESENT RESEARCH

Efforts are now being directed toward development of FPC's with improved functional properties. Extraction with a combination of hexane and isopropyl alcohol markedly improves protein solubility. Also, FPC with markedly improved functional properties--especially oil emulsifying capacity--can be produced by extracting fish with isopropyl alcohol at room temperatures instead of at 70C.

Research at our Seattle Laboratory has been directed toward the development of an aqueous extraction process including a short enzyme digestion followed by separation and isolation of the partially digested protein. Reportedly, the spray-dried material is stable as well as having desirable functional properties.

The biological processes also hold promise for producing highly functional

FPC's, and research in this area will be continued.

SUMMARY

In summary, an FPC industry has been established and is growing. Several plants are either now in operation or under construction. Isopropyl alcohol is used, in each instance, as the solvent to remove water and lipids. The IPA-FPC produced is essentially a "non-functional" product, but has a place on the world market. FPC's with improved functional properties are desirable and research is underway to develop functional FPC's. Barring unforeseen circumstances, the FPC industry should continue to grow.

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Nightlighting — A Harvesting Strategy for Underutilized Coastal Pelagic Schoolfishes [1]

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Abstract

A fishing strategy is presented which proposes utilizing nightlighting techniques as a means for economically harvesting underutilized coastal pelagic fishery resources. Results of preliminary fishing trials are presented and the feasibility of introducing nightlighting techniques to supplement conventional fishing gear and methods are discussed. Nightlighting field experiments are also discussed which will contribute to the development of a netless harvesting system for use with the National Marine Fisheries Service proposed automated fishing platform.

INTRODUCTION

Coastal pelagic schooling fishes (i.e., herring, sardines, anchovies) are Gulf and Caribbean resources of considerable latent potential. Bullis and Carpenter (1968) estimated that the coastal pelagic fishes in the Gulf of Mexico represent a latent resource of more than 4 million tons, a potential 8 times larger than the present Gulf production of 0.5 million tons. The thread herring *(Opisthonema oglinum)* stocks alone have been estimated at about 1 million tons (Bullis and Thompson, 1967).

Early attempts at harvesting Gulf thread herring were reviewed by Butler (1961) and recent developments in this fishery were reported by Fuss (1968) and Fuss, Kelly, and Prest (1969). These reports point out that the behavioral characteristics of coastal pelagic fishes limit the times and places where they can be harvested with conventional gear.

This report summarizes the progress of light attraction field studies conducted by the National Marine Fisheries Service, Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi. Our immediate objective was to determine the feasibility of developing light attraction techniques tó supplement conventional fishing methods. Our long term obective was to develop a NMFS proposed netless harvesting system (Klima 1970 (a), 1970 (b)). Briefly, this system would utilize artificial lights, an electric field, and a fish pump to capture fish for automated processing aboard a containerized vessel.

PRELIMINARY STUDIES – REVIEW

Prior to the studies discussed in this report we participated in numerous

[1] Contribution No. 241.

nightlighting stations and gained considerable experience with a variety of light sources and sampling gear. Subjective observations indicated that fish could be attracted by a wide range of lamps and light intensities. A single high wattage point-source lamp created the most controllable aggregations. Underwater lamps were more efficient and effective than lamps deployed above the surface.

During nightlighting stations we used a 5-meter lift net in combination with a 1,000 watt underwater mercury vapor lamp and a 1,000 watt underwater quartz-iodide lamp (Wickham, 1970). The spectral radiation from the mercury vapor lamp is strongest in the blue-green region of the spectrum where the greatest light transmission for seawater occurs. This lamp creates a large light field and was used as our primary attraction source. The quartz-iodide lamp has its strongest radiation at the red end of the spectrum which is attenuated rapidly in seawater. This lamp, however, has an incandescent filament that can be dimmed with a variable power transformer. After enough fish aggregated around the mercury vapor lamp, we would switch over to the quartz-iodide lamp which would then be slowly dimmed to reduce the size of the light field and concentrate the fish above the 5-meter lift net. Although qualitative estimates were obtained, fish often extended beyond the capture zone or avoided capture and could not be sampled with this method.

Quantitative samples were needed before we could evaluate the commercial applicability of light attraction to develop harvesting methods for coastal pelagics. We had to determine the species and quantities of each that could be attracted by a single light source. Quantitative samples were also needed to establish the expected variability of fish available to light. We also needed to determine whether fish could be led with lights from separate attraction sites to a single point for more efficient harvesting.

EXPERIMENTAL FISHING TRIALS

We began our quantitative evaluation of light attraction in St. Joseph Bay, Florida during August and September 1969. This work (Wickham, 1971) provided the first quantitative species inventory on the variability of light attraction effectiveness and confirmation of its suitability for use with conventional purse seines.

The *Gulf Ranger*, a 49-foot single-boat rig bait purse seiner, was chartered for this study. Its purse seine was a "tom weight" type, 1,545 feet long and 71 feet deep, with a 1-1/4 inch stretched mesh webbing. A 1,000 watt underwater mercury vapor lamp and echo sounder transducer to monitor fish below the light were mounted on a frame suspended beneath a 16-foot outboard used as a light skiff during fishing operations. Power for the lamp and echo sounder was supplied by a portable gasoline powered 2.5 kilowatt, 115 volt A.C. generator mounted in the skiff. Communications between the skiff and purse seiner were maintained by portable FM radios.

Two charter periods during the new moon and one during the full moon were scheduled to provide data on the effects of the lunar phase on artificial lights. To assess the intranight variability in the attraction by artificial lights, sets were made at about 3-hour intervals following sunset.

The purse seiner made sets, with its lights off, around the anchored light skiff. During the set, the light skiff anchor would be pulled up and the skiff would drift to the corkline away from the net opening. The skiff would remain inside the net with the light on until pursing was completed. The light skiff would then move over the cork line, reanchor clear of the seiner, and resume fishing the light. The total weight of each catch was estimated by the vessel captain and a sample was weighed, sorted, and identified.

Over 50 species of fishes and numerous invertebrates were identified in these sets. Three species, Spanish sardine *(Sardinella anchovia)*, Atlantic thread herring *(Opisthonema oglinum)*, and scaled sardine *(Harengula pensacolae)*, usually comprised the bulk of the larger catches. These species are estimated as having the greatest commercial potential among the latent coastal pelagic resources in the Gulf. The combined contribution of the three species alone was 50% or more by weight in 71% of the catches from our experimental sets.

There was considerable intranight variability among each night's sets, with differences from 100 to over 3,000 pounds between sequential sets. However, when the catch data for the entire study was averaged by the set time it was found that the 1,000 watt mercury vapor light was about equally effective for attracting fish throughout the night. The variability observed for individual sets probably resulted from variations in fish concentrations within the effective range of the light during the 3-hour experimental attraction period.

Nightly differences in total catch ranged from 500 to more than 6,000 pounds. This internight variability appeared to result primarily from differences in environmental factors such as location, water turbidity, and thunderstorms, to mention only a few. The present data are insufficient for an analysis of the effects of environmental factors on light attraction.

Although nightly catch totals from the single attraction source were not all based on a full night's fishing of three sets, they still averaged slightly better than 2,500 pounds per night for the entire study period. Catches made during the new moon periods alone averaged better than 3,000 pounds per night although only two of the seven nights fished consisted of a full three sets. Full moon catches were roughly one-third as large as those for the new moon, averaging 1,200 pounds per night. In terms of the potential fishing applications it should be noted that fish were successfully attracted during both the new and full moon. The full importance of moon phase in the commercial application of light attraction, however, will require considerably more comparative catch data.

This study also showed that a purse seine can be set around fish aggregations attracted to light and that the fish are not greatly disturbed by the encircling net. Purse seine sets around night lights, therefore, can be made slowly and since the fish remain relatively undisturbed in the light field, unsuccessful sets could almost be eliminated. An additional advantage of using light fishing in selected areas would be reduced search time. Despite its advantages, however, the use of light as an accessory technique to purse seining is not likely to be accepted by the fishing industry until the size of the catches can be increased and their variability reduced. One of the methods of solving these problems would be to lead the fish aggregations from multiple attraction sites into a single location for harvesting. The capability to lead fish with lights would also be useful for the development of the proposed netless harvesting system.

Preliminary observations made during this study indicated that fish aggregations follow a slowly moving light for short distances. This led to studies to evaluate the feasibility of leading fish with lights.

LEADING FISH WITH LIGHTS

Light leading experiments were undertaken in the summer of 1970 to determine the feasibility of leading fish both by lines of sequentially deployed lamps and by a single moving lamp.

To establish the possibility of leading fish from one light to another by sequentially turning the lamps on and off, we had to determine the maximum distance the lights could be separated without losing the fish.

We used two identical 1,000 watt mercury vapor lamps and two identical portable echo sounders. Lamp-echo sounder Unit No. 1 was deployed from the R/V *George M. Bowers* and Unit 2 from a 16-foot out-board skiff. Distance between the two lights was controlled by a line, marked at 10-meter intervals, attached to the light skiff and deployed from the *Bowers*. Simultaneous monitoring by echo sounder and visual observation at both lights was used to establish the successful movement of fish between lights.

Light No. 1 was used to attract the fish. The skiff would be allowed to drift out to a selected distance controlled by the measured line. No. 2 lamp would then be turned on at a preselected time and after a 5 minute warm-up period No. 1 lamp would be turned off. The fish were given 10 minutes to aggregate around the No. 2 lamp. Then No. 1 lamp was turned on again and following a 5-minute warm-up period, the No. 2 lamp was turned off. The skiff would then drift back to the next experimental position and the above procedure was repeated. Controls were conducted by separating the lamps at various distances and turning both lamps on and off simultaneously following the experimental time pattern.

Sequential light-leading experiments, conducted in the turbid waters of St. Andrews Bay, Panama City, Florida, revealed that both lights were acting as independent attraction sites. Sequential leading, therefore, was not possible in these turbid conditions but the two aggregations could be brought together and merged under a single light source by slowly pulling the two lights together.

Sea conditions and other program commitments permitted only one night of sequential light-leading experiments in clear Gulf waters at Stage II, a Navy research platform located off Panama City, Florida. A series of control periods revealed that only scattered individual fish were attracted to the lights. Fish attracted at Stage II were led to the *Bowers;* the methods will be described below. The same procedure used in the Bay was repeated, with fish being successfully transferred between the two light sources at distances up to 20 meters. Visual observations indicated that 20 meters was probably close to the maximum separation for these light sources and water conditions.

Observations during earlier light attraction studies indicated that fish aggregations would remain with a moving light for short times and distances. To further evaluate the effectiveness of using a moving light for leading fish, we conducted a series of trials in the Gulf of Mexico off Panama City, Florida. These trials indicated that large aggregations of fish could be led over 0.5 mile with either a drifting light or one moving at several knots independent of wind or current direction. When light leading with the skiff under power, it was necessary to start moving slowly until the fish stopped circling and moved along with the light. The skiff was then gradually speeded up and the fish were watched closely to prevent losing them. On two occasions there were barriers, probably tide rips or thermoclines, through which the fish would not pass. At these times the light had to be quickly brought back to the fish or they would disperse and be lost. The first time we experienced these barriers almost the entire school was lost before it was noticed that the fish had stopped. Spanish sardine appeared to be more sensitive to these barriers than blue runner *(Caranx crysos)*.

LIGHTS AND ARTIFICIAL STRUCTURES

Passive fishing gear (i.e., traps, bait and nightlights) require that fish pass within the effective zone of attraction before they can be captured. The catch depends on the size of the zone of attraction and the fish density therein. The characteristics of a nightlight's capture zone and the resulting catch are not consistent. Variables such as turbidity, ambient light, current velocity, fish density, biological rhythms and many others influence the effectiveness of the gear and/or the susceptibility of the fish to capture.

The catch variability observed in our experiments probably resulted from different fish densities in the water mass within which the light was an effective attraction stimulus. Consequently, we became interested in methods for increasing fish densities in the areas where the nightlights would be deployed.

Coastal pelagic fishes are known to form large aggregations around various types of structures, (i.e., drilling platforms, floating logs).

We have recently conducted successful studies on their attraction to artificial structures (Klima and Wickham, 1971).

A series of trials were conducted at Stage II to determine whether the dense fish aggregations that form around drilling platforms and artificial structures during the day could be led away from these structures with lights after dark. We discovered that during the new moon these aggregations dispersed at night away from the structures, and that an hour after sunset lights usually attracted few fish. If the lights were turned on before sunset, however, large numbers of fish remained around the structure after dark. These aggregations could then be led .away from the structures with a moving light. On one occasion we led a large aggregation to 0.5 mile from Stage II. A purse seine set made on this aggregation produced about 10,000 pounds of coastal pelagic fishes, 80% Spanish sardine, and 20% mixed scaled sardine, round scad and blue runner, after an estimated 5,000 pounds of fish were lost over the cork line.

PROTOTYPE LIGHT ATTRACTION HARDWARE

We have begun to design and develop prototype light attraction equipment for application with conventional fishing gear and the netless harvesting system. Two self contained systems, the Fish Light Attraction Catamaran (FLAC I), and the Fish Light Attraction Buoy (FLAB I), were given preliminary field tests. Patents have been filed for both systems. FLAC I was designed for use with conventional purse seine gear. Its underwater lamp can be raised for towing and to facilitate passage over a purse seine cork line. Since the FLAC I system is designed for towing, it would be suitable for leading fish away from artificial structures, drilling platforms, and other areas with high density fish concentrations inaccessible to purse seines and other conventional gear. The FLAB I system is a stationary light buoy intended as a component in the sequential light leading array envisioned for the netless harvesting system. During field tests the performance of both FLAC and FLAB met our original expectations. Additional self-contained light sources are scheduled for construction and these will be used during experimental fishing trials.

SUMMARY AND CONCLUSIONS

Our experiments and field trials have established the feasibility of utilizing light attraction for harvesting coastal pelagic fishes in the Gulf of Mexico. Light attraction can be used with conventional purse seines and the proposed netless harvesting system. We have caught upwards of 4,000 pounds of fish in 3 hours from a single light with nightly totals exceeding 6,000 pounds. Multiple lights properly spaced acted as independent attraction points and the fish attracted to them can be led together by either sequentially deployed lamps or with a single moving light. Light attraction was significantly improved through the use of artificial structures to increase the density of fish. We have shown that aggregations of fishes in areas inaccessible to harvesting gear can be held together after sunset and led to suitable harvesting areas by lights. Also, prototype light attraction systems are being developed which will improve harvesting of coastal pelagic schoolfish. Before the fishing industry can be encouraged to invest in light attraction hardware, however, we must conduct experimental fishing trials to determine the production levels which can be expected and to evaluate the effects of environmental and biological variables.

We are now planning experimental fishing trials using light attraction with a conventional purse seiner to obtain production estimates and develop fishing procedures. We are also planning to assemble the various components of the netless harvesting system and begin experimental fishing to test and evaluate design concepts and hardware and to provide production data for system comparison with conventional harvesting methods.

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Results of Cooperative Investigations — A Pilot Study of the Eastern Gulf of Mexico

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INTRODUCTION

The Loop Current of the eastern Gulf of Mexico is a mesoscale, hydrodynamic, temporal and spatial dependent phenomenon. In general terms, it might be described as a "river of Caribbean water" entering through the Yucatan Channel and proceeding northward into the eastern Gulf of Mexico, wherein it turns eastward in a semi-circular course until it flows southward along the western continental shelf of Florida to re-enter the Florida current in the Straits of Florida.

Over the last 30 years this "river" has been studied mainly by the physical oceanographers as a series of individual, independent cruises, rather than coordinated, cooperative, near synoptic investigations. A review of past studies indicates that this "river" may have eddies, which break off along its westward boundary to enter the western Gulf of Mexico. However, the extent and number of these eddies, their structural details, and their continuity throughout the year will require a more systematic, snyoptic type of approach. Too, if the varied effect of this "river" on the overall environment of the Gulf of Mexico is to be understood, additional studies must be conducted of an interdisciplinary, multiple-ship, cooperative nature.

Heretofore the current structure has been characterized by the classical definitions of geostrophic calculations, since adequate direct current measurements are extremely difficult and expensive to conduct. These calculations, as is true with many scientific methods, have inherent reservations which are dependent on the existing accepted methods, state-of-the-art of available equipment or instrumentation and operational factors. Ideally these calculations should be based on data where temperature is measured to within ± 0.02C and salinity within ± 0.03 parts per thousand ($^o/_{oo}$); with their profiles measured *in situ* and all relevant measurements made snyoptically. While oceanographic stations can generate this accuracy, only STD systems can provide *in situ* measurements.

Except for micro scaled pilot studies, no major attempts have been made to determine the structure and features of the Loop Current other than by the oceanographic station type of physical oceanography. No integrated, near-synoptic, interdisciplinary examinations have been made which would allow the inter-relationship of current with the other environmental features of the Gulf of Mexico.

During 1970, a set of unique conditions occurred which resulted in three such interdisciplinary studies of the Loop Current phenomenon. We feel these might be used as pilot studies for future interdisciplinary projects; too, they have served to generate background data for future detailed investigations in the field of physical, biological and chemical oceanography in the area. Members of the

U.S. Planning Group for Cooperative Investigations of the Caribbean and Adjacent Regions (CICAR) officially assigned the acronym EGMEX '70 to these expeditions. The conditions are: (1) The existence, in the State of Florida, of a coordinated oceanographic program and an agency, the State University System Florida Institute of Oceanography (SUSIO), to support cooperative activities between the various oceanographic activities in the State of Florida, with other oceanographic institutions outside of the state and at the federal level. (2) The ability to conduct the required coordinating activities at the working scientist level rather than the administrative level. This is, and was, vital. (3) The application in the planning of EGMEX of a total data management approach to the operation, data reduction and data documentation stages of the program. (4) The existence of a number of actively, or planned to be, funded individual projects to study this phenomenon. (5) The increasing awareness, within the universities, of the need for training graduate students in the requirements, problems of, and need for interdisciplinary programs.

EGMEX '70

EGMEX I '70

Under the State University System's FY '70 program, Dr. James I. Jones, Florida State University (FSU), submitted to SUSIO a proposal entitled, "Characterization, Definition, and Distribution of Selected Water Masses and Currents in Eastern and Central Gulf of Mexico and the Western Straits of Florida." This project required sampling across the Loop Current. Realizing the operational and financial limitations customarily imposed on the geostrophic method, he proposed to surmount these in part by using a biological indicator approach. Biological indicators were to be used in conjunction with geostrophic calculations to define the structure and location of the Loop Current.

In the past, Dr. Jones has related biological indicators to the results of direct current measurements in the Equatorial Atlantic undercurrent. This work has clearly shown that the concentrations of certain Foraminifera define the existence and location of the Equatorial Atlantic undercurrent (Jones, 1967, 1969). He has conducted a series of cruises on the Florida west coast continental shelf (Florida Middle Ground, 28° 30' N; 84° 20' W), in the Straits of Florida, and in the western Caribbean, which indicate that the same techniques could be used to define the location of the Loop Current (Jones, 1968). Based on the scientific merit of his proposal, it was approved by the Board of Regents Proposal Evaluation Panel for ship time, and his study was assigned to the R/V *Tursiops* (SUSIO FY '70 Program).

Dr. Jones, realizing that the study would require extremely close spatial sampling and near synoptic observations, requested that SUSIO attempt to arrange a multiple-ship operation across the Loop Current for this purpose. Fortunately, a series of events occurred which allowed SUSIO to arrange this: May 1-12, 1970, EGMEX I; June 1-14, 1970, EGMEX II; and October 24-November 2, 1970, EGMEX III. A listing of the vessels and their institutions or operating agencies, scientific parties, and industrial support is presented in Table 1.

Dr. Eugene Corcoran, University of Miami (UM), over the past decade, has been conducting a study of the discharge of trace elements and insecticides of the major river systems of the world. The final study in this series, the

Mississippi River, was scheduled for April-May, 1970, using the University of Miami's R/V *Pillsbury*.

Dr. Corcoran, during the EQUALANT cruises, had indications that the trace elements could be used as identifiers of the Equatorial Atlantic undercurrent. Based on these past observations, he believed that if the discharge from the Mississippi River was entering into the Loop Current the trace elements might be used as an indicator of this occurrence.

As a member of the SUSIO FY '70 Proposal Evaluation Panel, he was aware of Dr. Jones' proposed study. And, since he had in the past participated in interdisciplinary studies with Dr. Jones in EQUALANT, he recognized the mutual gains that would result from a similar cooperative investigation of the Loop Current in the eastern Gulf of Mexico. He stressed to SUSIO the importance of such a study and agreed to participate in it if adequate ships could be rallied for the purpose.

TABLE 1
Participants in EGMEX '70 [1]

Vessel	Cruise	Operating university or agency	Scientific party
Alaminos	I–II–III	Texas A & M University	Texas A&M–FSU
Discoverer	I–III	National Oceanic and Atmospheric Administration	NOAA - FSU
Gulfstream	I–II–III	Nova University	Nova
Hernan Cortez	I–II	Florida Department of Natural Resources	DNR-NMFS-FSU
Island Waters	I–II–III	National Youth Science Foundation	SUSIO-USF-FSU HTI-UWF-NMFS
Joie de Vivre	I–III	Florida Institute of Technology	UF-UWF-FSU–HTI-NMFS
Peirce	III	National Oceanic and Atmospheric Administration	NOAA
Pillsbury	I	University of Miami	UM-AOML-FSU-HTI-NSF
Tursiops	I–III	Florida State University	FSU-UM
Virgilio Uribe	III	Mexican Government	Mexican Government

[1]The following organizations participated in EGMEX by loan of equipment or personnel not shown in Table 1: Bissett-Berman Corporation, CM2 Incorporated, General Oceanics and Mote Marine Laboratory.

During the period of discussion with Drs. Jones and Corcoran, SUSIO arranged with the National Youth Science Foundation (NYSF) to use its 82-foot *Island Waters* in the State University System of Florida Cooperative Oceanographic Teaching and Research Program. SUSIO then planned a three-ship operation.

SUSIO realized that in a cooperative investigation of this nature the density parameters, i.e., temperature and salinity, would represent a common environmental boundary condition to each of the interdisciplinary approaches. For this reason it was imperative that a thorough descriptive analysis be made of the geostrophic calculations and temperature and salinity distributions. SUSIO contacted Dr. Saul Broida (UM) to determine if he would coordinate such a descriptive endeavor under his Office of Naval Research (ONR) funding. He expressed an interest, as an extension of his study of the Florida current, and requested permission to discuss the entire study with Dr. John Cochrane, Texas A & M University (TAMU) (a longtime investigator of the current), as he knew that the R/V *Alaminos* would be operating within the eastern Gulf of Mexico and Caribbean during the time of the proposed study. This type of response, incidentally, is a prime example of the benefits of coordinating at the individual working scientist's level. Dr. Cochrane realized that the simultaneous operation of four ships across the Loop Current represented a unique opportunity to obtain a near synoptic description of the density field. He agreed to participate in the program and assist in the geostrophic description of the Loop Current. He also agreed to conduct the necessary biological and chemical sampling in support of the interdisciplinary studies in return for the logarithmic increase in density measurements.

At this stage in the development of EGMEX, it was realized that a critical mass of vessels and personnel had been reached which would result in a major interdisciplinary study. SUSIO therefore arranged a meeting of the scientists in St. Petersburg to agree on: the necessary pre-planning responsibilities; a common environmental sampling program; proper documentation of the data collection methods; standard data reduction techniques of the common sampling program; and a definition of the responsibilities of the individual investigators in the final scientific analysis of the EGMEX data.

The scientists agreed on the necessity of a synoptic determination of the density field of the current. In order to get this as near synoptic as practical, they agreed to conduct a rapid STD survey. The resulting description of the density field could enhance the proper sampling of the biological and chemical parameters of the current by a follow-up survey. This would allow the geographic and vertical locations of these samples to be based on temperature and salinity distribution and on the major inflection points of their vertical profiles. In short, the biological and chemical sampling would be directly related to the geographical location and the physical properties of the current.

To assure that these data were actually collected at these critical points, it was agreed that the sampling depth would be based on STD lowerings. Biological sampling was to be conducted at selected inflection points by flights of six plankton nets fitted with opening and closing devices. Water samples were to be collected by 12 to 14 Niskin bottle casts at the major inflection points for oxygen, inorganic phosphate, insecticide and trace element analysis. As an example, the resulting data would then allow both Drs. Corcoran and Jones to inter-relate their individual studies with supplemental data of the density field. It would allow studies of the current, using data from geostrophic calculations and the distribution and concentration of both biological indicators and trace elements.

To reduce the loss of data due to improper STD sampling locations, it was decided that SUSIO should contact the U.S. Coast Guard (USCG) and request Airborne Radiation Thermometer Program (ART) overflight support. Examination of existing historical data from the National Oceanographic Data Center (NODC) files indicated a clear probability that the distribution of the surface isotherms in May could, in fact, depict the boundary conditions of the Loop Current. SUSIO was successful in obtaining USCG aircraft support operations during the period April 24-May 13, 1970.

At the completion of the meeting, SUSIO realized that the unique sampling techniques and coverage would generate data of unusual importance to a number of organizations thus far not associated with this Loop Current study. Individual briefings were scheduled with the State of Florida Department of Natural Resources (DNR), National Oceanic and Atmospheric Administration (NOAA), Atlantic Oceanographic and Meterological Laboratories (AOML), National Marine Fisheries Service (NMFS), Hydrospace Technical Institute (HTI) of Florida Institute of Technology (FIT) and Nova University to explain this study of the Loop Current and the potential of the resulting data and samples for each of their organizations. From these briefings a number of agreements were made which resulted in the participation of these organizations in the sampling program; in the reduction, compression, and the analysis of the resulting data; the placing of personnel aboard vessels or aircraft; or by making available large amounts of equipment to the participating vessels.

During these briefings, members of the U. S. Planning Group for CICAR reviewed the planned Loop Current study and it was recommended and accepted as the first U. S. project of CICAR.

Because of the increased number of participants in EGMEX, a final planning session was convened in St. Petersburg by SUSIO to formalize an overall program management scheme. The delegation of responsibilities was agreed upon and accepted as follows: (1) SUSIO would coordinate the activities of the different vessels, the exchange of personnel and equipment between them, and transportation of the resulting samples or data. (2) SUSIO would document and transmit to the National Oceanographic Data Center (NODC) information on the standard data collection techniques and data compression methods. (3) SUSIO would coordinate through NODC the inventorying of all collected data on CICARDI forms and charts. (4) NODC would inventory the collections; it would key punch and process the resulting data for list-outs of Sigma T and dynamic heights, prepare a master list-out of station locations and samples, and would prepare plotting sheets compatible to a U. S. Coast and Geodetic Survey 1007 chart size (this would be furnished as part of the U. S. participation in CICAR). (5) To assure data verification for the common sampling program, it was agreed that certain organizations and individuals would be responsible for correcting, processing or analyzing the resulting data from certain collection systems. (a) Since the physical data would be used as the key to sampling in this interdisciplinary study, its compression procedures would have to reflect not only the density distribution but would have to meet the analytical requirements of the other disciplines. SUSIO would either compress or arrange for the compression of the STD data and its transmission to NODC. Since the data recording systems for STD's on the different vessels varied from analog alone to combination analog-digital type records, it was agreed, to assure data verification, that only the analog traces should be compressed. Digital tapes would be processed individually by the collector. Analog compression would consist of values for standard depths, half and whole degrees of temperature. 0.5 $^{o}/oo$ salinity and inflection points of temperature profile defined by a linear relationship of $\pm$ 0.02C. The chemical profile would be reduced to observations at the depth of these STD values unless its profile showed an inflection point not defined by the density field. If this occurred, values for temperature and salinity would be entered for these depths. The processed and listed STD data from NODC would be sent to Drs. Broida (UM) and Cochrane (TAMU) and Mr. Austin (FSU) for geostrophic description of the Loop Current required by the other interdisciplinary studies. (b) Dr. Corcoran (UM) would supply all collection equipment and sample bottles, with the exception of Niskin bottles, for the collection of trace elements and insecticides. All samples would be returned to him for analysis. (c) Dr. Jones (FSU) would supply all plankton nets, open-closing mechanisms, depth recorders, flowmeters, and sample bottles for plankton tows. He would sort the resulting samples for foraminiferans, radiolarians, and pteropods for his biological indicator research. He would also sort out fish larvae for Dr. Richards (NMFS-Tropical Atlantic Biological Laboratory [TABL]), who would further sort the larvae to family. Dr. Richards would then distribute certain families to other participating scientists. (d) Mrs. Williams (DNR) and Mr. Brucks (NMFS–TABL) would supply 8,000 drift bottles and would analyze the returns and prepare same for publication. (e) Dr. Hebard (NMFS–TABL) and Mr. Deavers (USCG) would analyze the ART overflight data. SUSIO would forward to them surface temperature data from the vessels. (f) Dr. Carder, University of South Florida (USF), would arrange for optical samples to be collected for the *Alaminos, Pillsbury, Island Waters* and *Tursiops*.

A number of other sampling programs and analytic efforts were added to the program in support of specific projects. The participating universities and agencies are so numerous that they are summarized in Table 2.

To ensure proper sampling across the Loop Current, a proposed standard grid pattern for station locations was established, based on the examination of historical data from NODC, and on discussions with scientists who had studied the phenomenon in recent years. It was agreed that unless the location of the current could be determined by advance ART overflight, satellite or vessel data, or a combination of these, sampling would occur at these locations.

Since a near-synoptic STD survey would be made of the Loop Current the participants felt that a sampling program on the western continental shelf of Florida should be made to relate the current's effect on this environment. For this reason, and to supply needed baseline data for future studies on the shelf, a series of sections was planned and assigned to the *Joie de Vivre* and *Hernan Cortez*. These sections were to be sampled for temperature and salinity data by either a shallow depth STD, or by Niskin bottle casts and oblique plankton tows to the bottom or the depth of the thermocline. If a thermocline was present, an additional plankton tow would be taken below its depth. The operational procedure, techniques and sampling instructions are documented.

The shelf sections were of major significance if attempts were to be made to relate the effects of the Loop Current on basic physical, chemical, biological, geological and fishery problems of this area. As such, the resulting data would have a very practical application to the universities, government agencies and industry of Florida alike.

The USCG provided 9 days of ART overflights during the period of April 25-27, May 4-6, and May 9-11, 1970. The results of the April 25-27 flights are shown in Chart 1. These data were very important to the study, since they allowed a determination of the boundaries of the Loop Current. The scientists' ability to examine these data before the departure of the vessels on the May 4-6 STD survey allowed them to revise the proposed tracks to cover the meandering of the northern edge of the current and concentrate stations within it.

This survey to 1,000 meters was conducted aboard the *Pillsbury, Island Waters, Tursiops* and *Alaminos*. Examples of the resulting sections of temperature are shown in Figure 1 across the meandering northern boundary of the current, and Figure 2 in the more steady state conditions to the south. It is most

TABLE 2

Sources of Data or Analytical Results from EGMEX '70
by Organization and Investigator

	Florida Department of Natural Resources
E. Joyce	Fish larvae; Hourglass study
S. Kennedy	Physalia
J. Williams	Drift bottles
	Florida State University
H. Austin	Biological indicators/Loop Current*; Loop Current description
J. Cruise	Sergisted shrimp distribution+
A. Hanke	Boron in sediments*
J. Jones	Biological indicators; Training personnel
L. Kadar	Copepoda indicators+
R. Thomas	Squid larvae distribution+
S. Williams	Middle Ground larvae+
	Hydrospace Technological Institute (FIT)
T. Tealey	Marine technician training
	Mote Marine Laboratory
P. Gilbert	Elasmobranch distribution and habits
	NOAA - Atlantic Oceanographic and Meteorological Laboratories
F. Chew	Loop Current drogue measurements
D. Hansen	STD data reduction; Direct current measurements; Yucatan Straits bottom current measurements
G. Maul	ART satellite
	NOAA - National Marine Fisheries Service
J. Brucks	Drift bottles
T. Costello	Shrimp larvae
J. Finucane	Threadfin herring and pompano larvae
P. Ford	Clupeid larvae other than threadfin herring
F. Hebard	ART overflights; Loop Current geostrophy; Shelf currents, temperature, salinity and oxygen
W. Richards	Tuna larvae

TABLE 2 (Continued)

Staff	
	NOAA - National Oceanographic Data Center
	CICARDI
	Nova University
W. Richardson	Florida current total transport
	St. Petersburg Beach Aquatarium
L. Kephart	Turtle migrations
T. Nickerson	Turtle migrations
	Texas A & M University
J. Cochrane	Direct current measurements; Loop Current; Caribbean currents, Campeche Bank upwelling
	U. S. Coast Guard
J. Deavers	ART overflights
	University of Florida
P. Brezonik	Inorganic phosphates EGMEX I
H. Brooks	Training personnel
J. Dinsmore	Sooty terns*
	University of Miami
S. Broida	Florida Current; Loop Current
E. Corcoran	Trace elements and insecticides; Inorganic phosphates*
E. Houde	Clupeid eggs, distribution and abundance
	University of South Florida
R. Baird	Midwater fish
K. Carder	Particle-biological relationships and distribution; Training of personnel
T. Hopkins	Micronekton
F. Schlemmer	Particle current indicator+
	University of West Florida
T. Hopkins	Training of personnel

*Subject for Ph.D. dissertation; +subject for M.S. thesis

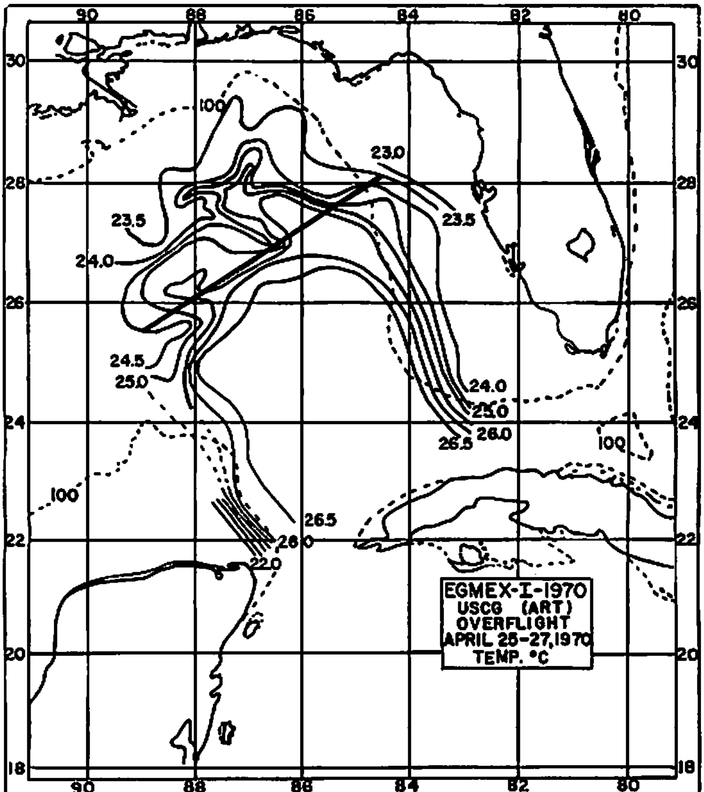


CHART I

significant that the surface temperature perturbations along the northern edge shown in the ART overflight data (Chart 1) are not merely a surface phenomenon. Figure 1 (taken along the heavy line on Chart 1) shows that this persists down to 1,000 meters. Without the change in the station sampling interval as the result of the ART overflight data, before this survey, these features might have been missed in the sampling.

On the basis of an examination of the vertical temperature and salinity section from this survey, the EGMEX station locations along the sections and section locations themselves were readjusted for the May 7-11 STD-biological-chemical survey. This allowed the appropriate sampling of the biological and chemical parameters across the current and in its well identified boundary areas. STD's, plankton tows, and oceanographic station casts were to a depth of 500 meters. Chart 2 shows the actual vessel tracks on EGMEX I '70. The flexibility of altering section locations and station intervals has been demonstrated in EGMEX.

The surface flow in the Loop Current is not a direct wind driven current. A 2 1/2-knot surface current was measured in one of these perturbations moving against a 25-knot wind. This indicates that the Loop Current is similar to the Gulf Stream in its perturbations and is a definite water mass in transit through an area.

Again, there is a most interesting correlation between the Loop Current and the biology of the Gulf, as most of the scientists felt there would be. Even in an elementary feature, such as standing crop measurements, there is an apparent relationship. Chart 3 depicts the surface distribution of biomass measured in total displacement, in milliliters, of plankton materials sampled per cubic meter of water. Note the association between the perturbations of Chart 1 and certain of the concentrations on Chart 3. The concentration on Campeche Banks will be discussed later.

Approximately 80% of the EGMEX I operation was successfully completed. The major deletions were not across the Loop Current itself, which was 100% complete, but in the work on the continental shelf. This was directly accountable to weather conditions and partial break down of one of the research vessels.

At NODC there is an inventory of all data taken during the cruises on CICARDI forms. In addition, there is a master station file. NODC has constructed Station Location Plotting Sheets for: (1) STD stations, oceanographic station casts, and expendable BT's; (2) drift bottle releases; (3) plankton tows; (4) geological samples. These can be obtained from SUSIO or NODC.

The physical data have been reduced and submitted to NODC with values at standard depths and at the selected temperature and salinity contour intervals.

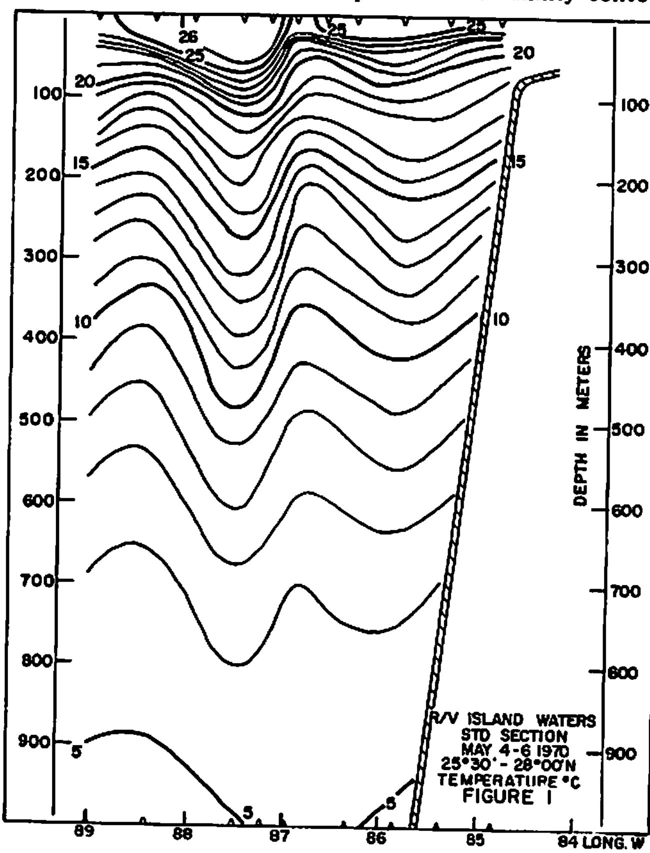
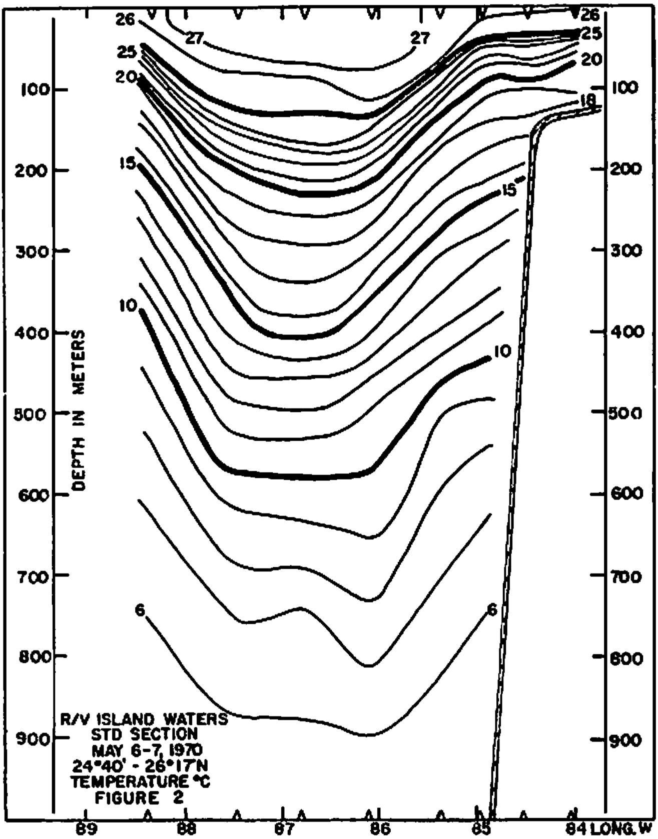


FIGURE I



The drift bottle release locations have been inventoried and sent to NODC; copies to DNR and NMFS–TABL. The ART overflight data and surface temperature values have been sent to NMFS–TABL and the USCG for analytical work. FSU has sorted the plankton samples for the *Pillsbury, Island Waters, Tursiops, Hernan Cortez, Joie de Vivre* and *Alaminos* for foraminiferans and fish larvae. The fish larvae have been sent to Dr. Richards (NMFS–TABL) for reduction to families. The optical samples (particle) are under analysis by Dr. Carder (USF). Trace elements and insecticide samples are presently under analysis by Dr. Corcoran (UM).

The preliminary results of the physical data indicate that surface isotherms in May can be used as an approximation of the location of the Loop Current. While the boundaries are well defined in the southern extremities, the northern edge consists of fingers and eddies of considerable disconformity. These protuberances have relatively strong currents within their boundaries, up to 2 to 3 knots, and the water mass structure is affected to considerable depths. Since this is the first nearly synoptic study of the Loop Current the participants are most interested in determining its time variations, the degrees of its steady or non steady state, and movements of the fingers and eddies.

There was feeling among some of the scientists that not only could the 22-degree isotherm, as represented by Leipper (1968) be used to locate the Loop

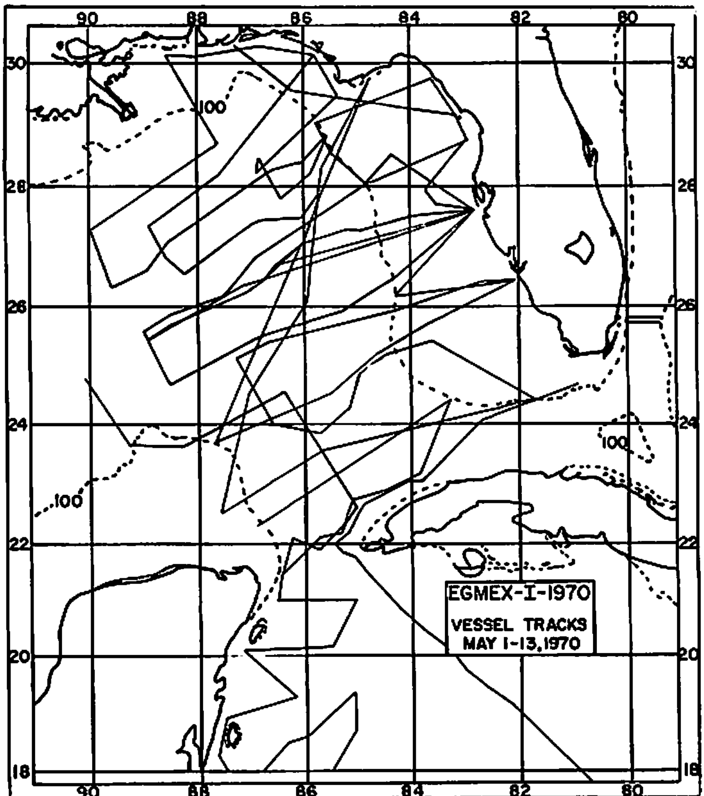


CHART 2

Current, but also possibly the 16-degree isotherm, when used in May. The existence of the perturbations and the associated concentrations of standing crops of plankton as biological indicators were very encouraging. The existence of shelf type foraminiferans at great depths along the western edge of the Campeche Banks and eastern edge of the continental shelf of Florida between Tampa and Ft. Myers indicates the presence of a phenomenon as yet unstudied. These concentrations of foraminiferans apparently have not mixed into the Loop Current, and yet were collected at a depth of 200 meters (personal communication, H. Austin).

The existence of a cold pocket of water on the continental shelf near the Crystal River area apparently represents a separation in the shelf transport. The preliminary results of an over 15% recovery of the drift bottles show that north of this pocket the bottles are drifting north and westward with recoveries as far west as Louisiana. South of the pocket the bottles are drifting southward and entering into the Florida current (personal communication, J. Brucks). This pocket of cold water covers an area known as the Florida Middle Ground, a major fishing area of Florida. For a period of some 18 months, a cooperative ecological study has been conducted at a fixed location, within these grounds, by Florida State University, University of West Florida, University of Florida and University of South Florida. The examination of the foraminiferans from this area which indicates the periodic presence of Caribbean water was the basis for Dr. Jones' original request to SUSIO to study the Loop Current (Austin, 1970).

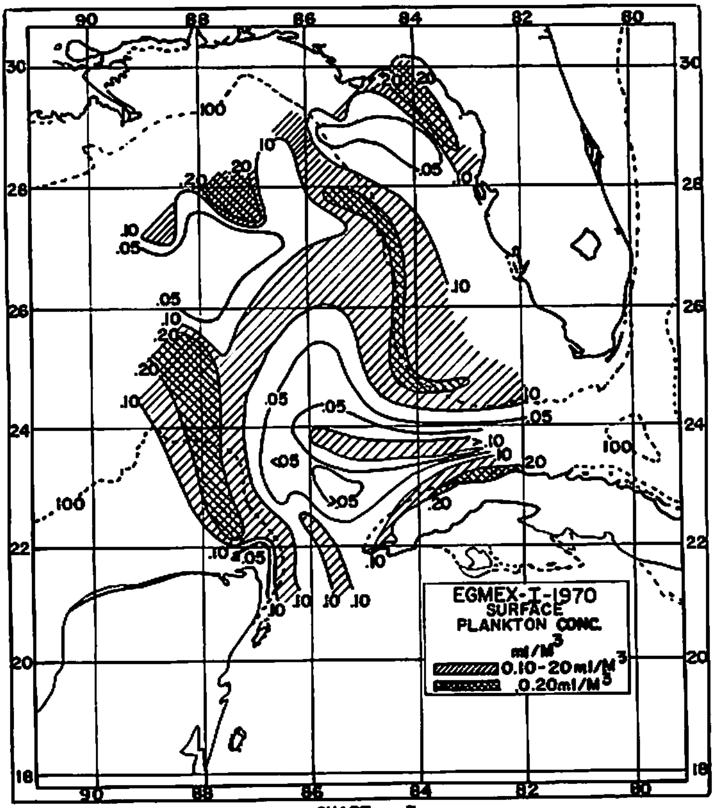


CHART 3

As was hoped, detailed information, as described above, of the association of the Loop Current with other environmental structures, will surely lead to new and varied types of investigations by the scientists in the eastern Gulf of Mexico. While the purpose of EGMEX I was to provide a monitoring of the Loop Current, it is these interrelated interface problems which represent the major interest within the State University System.

EGMEX II '70

As EGMEX I neared completion, Dr. Cochrane (TAMU) felt that the preliminary results were scientifically interesting and operationally significant enough to warrant a follow-up study if practical. He contacted SUSIO to determine the acceptability and feasibility of having another interdisciplinary, multi-ship operation during June. He felt that the quasi-synoptic data resulting from the STD's and ART overflights on EGMEX type operations presented a unique opportunity to determine time changes in the boundary conditions of the Loop Current, i.e., north-south seasonal movement and east-west displacement. SUSIO, by quickly polling other participants, learned this represented the consensus and interest of all.

Four ships, the *Alaminos, Island Waters, Hernan Cortez* and *Gulfstream,* participated in the study. Because of the reduced number of ships, the coverage and synoptic survey of the collections are not as complete as in EGMEX I, even though the data were taken over a 14-day period. The common sampling programs were the same as those in EGMEX I except for the deletion of inorganic phosphate and ART overflight.

Because of the limited number of vessels, it was agreed that the *Alaminos* would cover the western portion of the Loop Current while the *Island Waters* covered the eastern, and the *Hernan Cortez* sampled the low temperature pocket near Cedar Key. Modifications were made to the biological sampling program whereby samples were taken at fixed locations on the *Alaminos* sections, but varied on the *Island Waters* according to the results of the STD lowerings.

Although all areas were sampled, there was a subsequent modification to the *Island Waters* sections due to delays caused by the flooding of the STD unit; this mishap resulted in biological-chemical sampling along each section run, with their geographic locations dependent on examination of the observed vertical temperature and salinity field. The actual vessel tracks are shown in Chart 4.

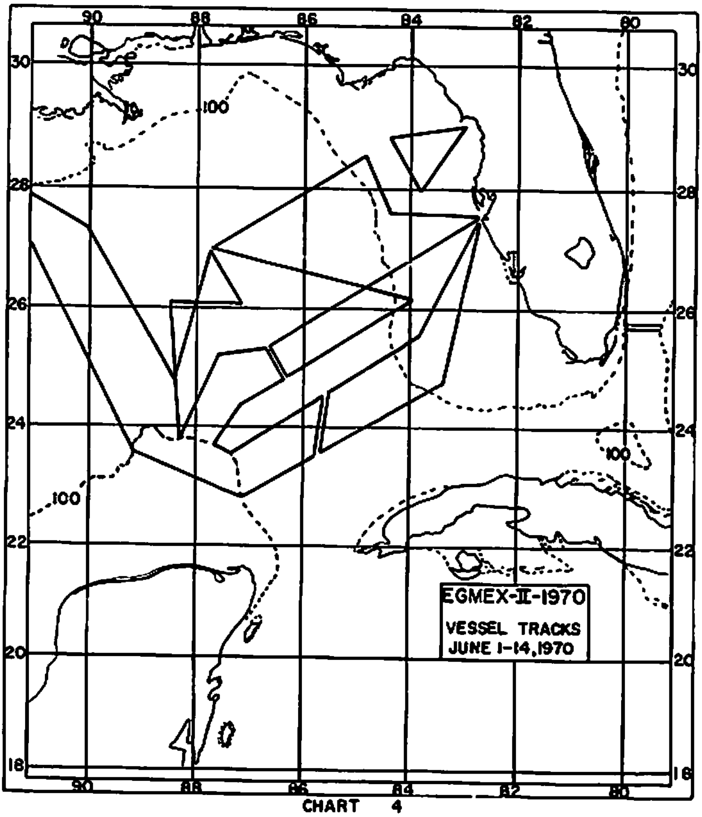


CHART 4

The results of EGMEX II are still under investigation. However, a rather detailed sampling of the unusual concentrations of foraminiferans described in EGMEX I by both optical and planktonic sampling has confirmed the concentration of shelf foraminiferans at 200 meters. This material is not mixing into the Loop Current. There is a similarity of the biological concentrations and the optical properties. This study has resulted in an accomplishment that SUSIO has continually fostered in the Loop Current investigations. Dr. Jones (biological indicators) and Dr. Carder (optical properties) have discovered that their work is complementary. The exchange of environmental information and proper sampling techniques have resulted in these two individuals realizing that to study this particular phenomenon it is beneficial, even essential, to coordinate their studies.

NMFS–TABL has agreed to sort all of the planktonic samples resulting from EGMEX II and III down to families.

The processing of the results of EGMEX II has been delayed because of a lack of adequate funds to reduce the data.

EGMEX III '70

Because of the successes of EGMEX I and II, NOAA-AOML requested a meeting of the participating scientists to determine if a multiple survey could be conducted during the period October-November 1970. This meeting was combined with the Physical Oceanographic Planning Section of CICAR. It was determined that a total of eight vessels was available for operation within the Loop Current area. Again, SUSIO was asked to coordinate the ship activities and assist in portions of the data reduction. At this meeting it was decided to repeat the sampling techniques and programs as conducted on EGMEX I and II with the following inclusions and deletions: (1) Deletion of the trace elements and insecticide program because of a lack of funds to reduce the data; (2) Inclusion of a joint inorganic phosphate program between the University of Miami and AOML; (3) Inclusion of a pre-EGMEX expendable BT and drogue measuring program by AOML to determine the location of the Loop Current in September; (4) The assumption by AOML of the reduction of the physical oceanographic data; and (5) The occupation of an inter-comparison ocean station at which simultaneous casts by the STD units and oceanographic station casts for temperature, salinity, oxygen and inorganic phosphate would be taken.

It was agreed that AOML would exchange with the participating vessels the results of their September XBT survey. On the basis of this survey the sampling program would be altered if necessary to coincide with the present location of the Loop Current.

EGMEX III was completed as planned, including the intercalibration stations between the *Alaminos*, *Discoverer*, *Island Waters*, and *Tursiops*. This operation has been completed such a short time that little or no results are forthcoming as yet. The processing of these collections is also limited by lack of funds to reduce certain of the physical, chemical and biological parameters.

Chart 5 shows the tracks of the vessels. The doubled lines are the sections on which plankton and oceanographic station casts were taken. The square is the location of the *inter-calibration* station. The dashed and dashed-dot lines represent the boundary of the Loop Current during September and October, based on the work of the R/V *Peirce* (October) and R/V *Island Waters* (October).

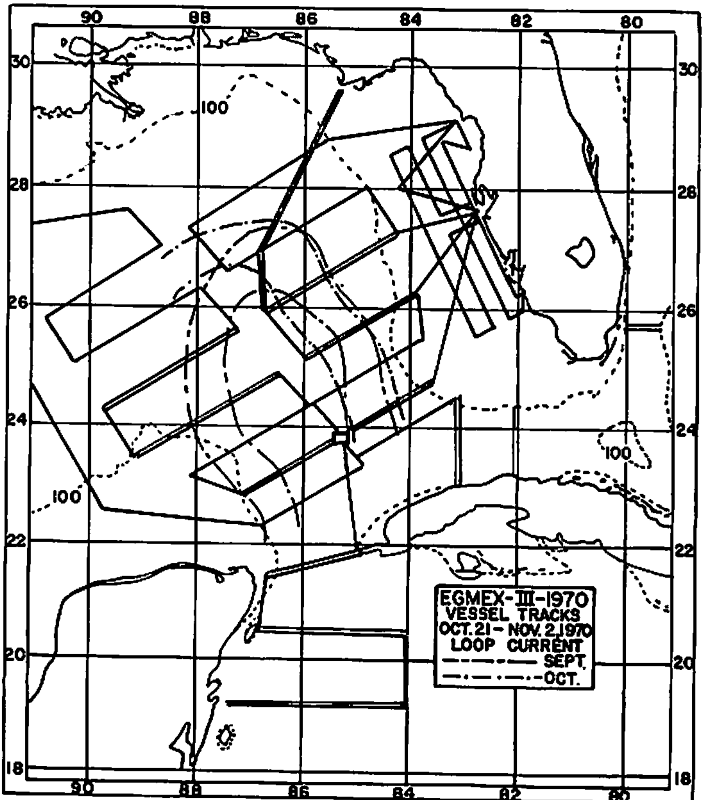


CHART 5

The importance of having a coordinating office whose principal purpose is to assist the scientists within the Gulf area has been adequately demonstrated by SUSIO during the planning and conduct of the EGMEX series. The removal of the major burdens of administrative and operational details from the participating scientists allows them to continue their productive work with minimal interruption.

Numbers of mutual gains have resulted from the EGMEX '70 series; some having been cited in preceding paragraphs. But to focus on the real importance of such studies to individual research scientists, let us use Dr. Jones, the initial instigator of the EGMEX operation, as an example.

Dr. Jones and his students now have data for geostrophic calculations having been collected with the required degree of accuracy of *in situ* measurements (each major vessel employed STD units); these are as near synoptic measurements as practical and can be used for inter-comparison with his biological indicators. In addition, he has received supplemental information that depicts the location and structure of the Loop Current derived from trace elements and optical clarity data.

An added feature of EGMEX is that arrangements have been established for loan of equipment between state and private universities, state and federal government agencies, and industries. And a liaison has been developed whereby data and samples are exchanged for individual uses in specialized projects of respective mission orientation.

It is significant to reiterate that:

The EGMEX operation was designed by the investigators and participants or both.

Most of the participants in the study had already planned to be in the EGMEX area for teaching or research purposes, consequently, with the added ingredient of coordination, an important and productive comprehensive study was molded from a broad cross section of disjunct projects, schedules, interests and needs.

The participating vessels, aircraft and personnel were funded from a variety of sources. However, the whole result of their efforts is much greater than the independent parts; the shared samples and data far exceeded what the individual projects could have yielded separately. As a consequence, each sponsor received substantially more than had been initially planned. For example, trace element samples were collected over the entire eastern Gulf area by the assistance of the other participants -- samples not limited to the cruise track of principal investigator.

Academic, industrial and state and federal organizations took active parts in the study; they shared costs, funding, personnel, equipment, samples and data.

The study involved teaching and research; the research represents both basic and applied.

The samples and data were reported to NODC, thus other potential users of these will become aware of their existence and availability through NAMDI and CICARDI.

The biological specimens collected during the numerous plankton tows are being shared by public universities, private universities, state and federal laboratories.

The biological collections have complementary-supplementary chemical and physical data taken at the same time and location; all data are available to all participants through appropriate data management.

The 8,000 drift bottles were supplied jointly by a state and a federal organization, and these were disbursed by the participants over a widespread area during a short time period; the results will be published as a co-authored report by scientists of the two organizations.

The physical data will be published in a co-authored report by scientists of Texas A & M University, Florida State University, University of Miami, and AOML.

Within the State University System alone, samples and data collected during the study are being used as major parts of at least eight master theses and doctoral dissertations.

The ships had interdisciplinary and multi-organizational scientific parties -- better understanding of one another's work, interests and problems is being fostered.

Substantial amounts of scientific equipment were furnished by participants to one another in order to provide each ship with adequate equipment suits -- truly a joint involvement.

Additional points could be reiterated, however, it is apparent that much good will continue to come out of EGMEX; scientists will work together; cooperative programs can be developed with proper coordination. Samples and data can and will be shared for multiple purposes.

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DISCUSSION

Management and Resources Utilization Session

Discussion Leader: W. C. Foster
Discussion Panel: J. Smith, J. Styron, R. Wildman

A Food Technologist Looks at Fish Protein Concentrate

H. M. Burgess

Q. Wildman: You listed a variety of political problems associated with FPC. Do you feel the government is doing what it should?

A. Burgess: Expanding the number of available fish species is a great step forward. However, only when FPC can be accepted as a food ingredient will the problem be solved.

Q. Foster: Are you supporting any research or applications using protein supplements?

A. Burgess: Yes, cereals is a good example. Pet foods probably make the greatest use of protein supplements. No one protein has all of the protein nutrition we would like to have, so we use a number of sources of protein such as soy, meat scrap, fish meal, wheat and other sources which give a final product of good nutritional value. As the amount of meat protein available becomes less, we must turn more to vegetable sources. Fish protein complements the nutritional aspects of these vegetable proteins nicely. Use of a little of the leaf proteins may become important in the more distant future. The competition for FPC may well come from the "single cell proteins". These are yeast or bacteria grown on petroleum products or agricultural wastes.

Q. Weddig: We might be able to meet an increased demand for the more desirable fish by using FPC as a supplement. Are there any facts about this?

A. Burgess: If an FPC which swells, holds water and eats well can be developed, one can visualize extending the desirable fish or even creating new fish products.

Q. Schaefers: Based on the extent of the work done to date, is there just not enough information on the fish supplement?

A. Burgess: We are beginning work on practical applications and it is going well in spite of the limitations already discussed.

Q. Idyll: Does it seem to you that FPC had a dim future and did not do anything? Is it possible to produce FPC?

A. Burgess: I think FPC had and still has a bright future. It has run into some stumbling blocks which are not insurmountable. Other approaches to the making of FPC have been tried, such as the Ezia Levin process at New Bedford, using methylene chloride as the solvent. The important factor is to find very cheap fish and perhaps to be able to operate at sea.

Q. Erkins: Are we not talking about a product with low cost marketing?

A. Burgess: The fish meal business is at an all time high both in terms of consumption and price. With the mounting prices for protein to feed people we need to break into the food chain and eliminate one step. Currently we feed the fish meal to other animals or even fish, and then eat these animals. The efficiency of this process is obviously not very good. So to be able to feed the fishes that made the fish meal directly to people would be the preferred route to follow. However, we need that product development that will put the fish meal or the FPC into a form that will be acceptable to the consumer.

Fish Protein Concentrate: the Growth of an Industry

E. Schaefers[1]

Q. Smith: Will United States plants be able to compete with foreign producers?

A. Schaefers: Based on present information, I would say we can expect to

[1] E. A. Schaefers presented this paper and answered discussion questions in the absence of the author, G. M. Knobl, Jr.

be competitive in the marketplace. While at present there is no large-scale FPC production, we feel that the demonstrated ability of the closest U.S. product to FPC, fish meal, to compete successfully on a worldwide basis with foreign producers is a good sign.

Q. Styron: The original estimates of the cost of FPC per pound of protein were made several years ago. Since then, costs associated with FPC production have risen considerably. Do you have a current estimate on the necessary price range of FPC if it is to be competitive cost-wise with other protein sources? Also, do you have estimates of the current market potential?

A. Schaefers: On both questions: Yes we do. Actually, Dr. Knobl had a section on this in his paper which I didn't have time to give. It follows: In the United States, according to a report by Hammonds and Call, the market for FPC's depends upon price-functionality relationships.

An FPC with no functional properties will have to be lower in cost than a more functional FPC.

Hammonds and Call assumed a price range for FPC of between 28.8 to 53.8 cents per pound of protein. They state that this price range would place FPC, cost-wise, between soy flour (12.6 to 16.4 cents per pound of protein) and nonfat dry milk (55.6 to 69.4 cents per pound of protein). Furthermore, since this range is neither clearly lower than that of present protein ingredients, nor clearly higher, the functional characteristics of FPC then becomes crucial in determining the market potential. Starting at the low price range (29 cents per pound of protein) they conclude that FPC could compete with soy flour providing taste advantages are realized (soy flour has a bitter-beany taste when present in concentrations of greater than 4 to 5 percent by weight of finished product).

FPC priced between 40-50 cents per pound of protein with a very bland taste but a low level of functionality could penetrate the following U.S. markets:

"... baby food at 2.4 million pounds of protein yearly; breakfast cereal at 1.4 million pounds; candy at 16.6 million pounds; and diet drink at 2.2 million pounds. These markets total to a potential volume of 22.6 million pounds of protein or 28.3 million pounds of FPC." They add however: "If functional properties can be developed along with acceptable taste, FPC in the 40-50 cents per pound protein price range could also compete in a number of other markets currently using nonfat dry milk. Moderate fat absorption would open the canned and processed meat markets using 16.1 million pounds of protein yearly. The abil'ty to prolong freshness and shelf life would open the baked goods market at 68.3 million pounds of protein yearly. Whippability and emulsion stabilization would open the desserts and toppings market at 28.6 million pounds of protein yearly."

One other market potential is the U.S. school lunch program – notably the "Type A" school lunch. It has been stated that in a few years there will be 55,000,000 children getting school lunches at a cost of $7 billion at 1968 price levels. The animal protein in the lunches represents 60 percent of the cost. Fish protein concentrate is now being investigated as a source of protein for these lunches.

Q. Wildman: You mentioned that Canada has approved more types of fish than the U.S. Food and Drug has for us. Why is this?

A. Schaefers: The U. S. Food and Drug Administration gave authority to use only those species on which toxicological data had been presented. The Canadian Food and Drug Directorate permits the use of all fish in the family in which toxicological data for species had been submitted.

Q. Foster: You showed slides of and discussed four FPC plants. Where are their products being marketed?

A. Schaefers: We really haven't been able to get a handle on this, and it appears to be in the category of a "trade secret". We are quite certain, however, that much of the present production is going into products which are being test marketed in various countries throughout the world.

Nightlighting – A Harvesting Strategy for Underutilized Coastal Pelagic Schoolfishes

D. A. Wickham

Q. Smith: Would you comment on the reality of the methods described in your paper?

A. Wickham: Nightlighting is successfully used with many types of fishing gear in many fisheries around the world. For example, the Japanese saury catch is obtained primarily by fishing with lights and the Russians use nightlights with nets and fish pumps to capture kilka, sprat and anchovies. We feel the results from our field studies indicate nightlighting is a realistic approach for broadening the existing purse seine fishery to include the large stocks of fish which are presently unavailable to the conventional fishing gear used in the Gulf of Mexico. Nightlighting does require further development, however, especially experimental production fishing to establish production levels and procedures, before we can recommend that commercial fishermen adopt these techniques or invest in the necessary hardware. Regarding the netless fishing concept; although our preliminary studies indicate its soundness it especially requires further development.

Q. Styron: What would be the cost of a netless harvesting system?

A. Wickham: The figures projected by Dr. Klima indicate a netless harvesting system would be comparable in cost with a conventional menhaden vessel with the advantage of reduced manpower requirements.

Q. McKee: Are there laws against nightlighting and electric fishing?

A. Wickham: I do not know of any laws restricting the use of nightlighting techniques, however, several Gulf states do have laws concerning electro fishing. Our field studies in state waters are conducted under experimental permits and have not been restricted by these laws. I am presently not familiar with the various state fishing laws, however, as part of our program, we are planning to contract for a survey of the laws which may restrict the introduction of these techniques.

Bullis: (Comment) Laws restricting electric fishing apply only to state waters and these techniques can be used outside these limits. Some states make provision for commercial fishermen to conduct projection fishing with experimental gear. If these experimental methods present no real risk to the fish stocks, the restricting laws can be modified or lifted to permit their use.

Q. Idyll: How many species of fish within the 12-mile limit can be harvested with light attraction techniques?

A. Wickham: We have captured over 50 species in the light field during our field experiments in the northern Gulf but less than 10 species, primarily Clupeids and Engraulids, appear in potentially commercial quantities. The species and their numbers change during the year and the type and quantity of fish in any one area depends on the time of year. Commercial production with a netless harvesting system would require moving it at regular intervals to remain in high density fish areas throughout the year.

WEDNESDAY–NOVEMBER 11, 1970

Chairman - L. Shafer, *St. George Packing Company, Fort Myers, Florida*

Some Economic Aspects of Pink Shrimp Farming in Florida[1]

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INTRODUCTION

As with most other business ventures, shrimp culture can be operated at different levels of output and with different qualities of final output. A firm or individual interested in investing in shrimp culture would want to know whether he should grow shrimp for bait or for food and what scale of plant he should operate. To get some insights as to the answer to these questions, six types of shrimp culture operations were studied. Since land makes up such a large portion of the initial investment in operations such as these and since shorefront land has such a wide range of prices, each of these six types was studied as to the effect of changes in land prices. The six types studied were: a 100-acre, a 500-acre, and a 1,000-acre operation used to produce shrimp for food (i.e., 36 count which is equivalent to 36 shrimp tails per pound) and also a 100-acre, a 500-acre, and a 1,000-acre operation used to produce bait shrimp. The acreage given here refers to the ponds. About 20% more land will be required in each case for levees and buildings.

The internal rate of return was found for each of the six types at various land prices. The internal rate of return is the interest rate that discounts the annual net cash flow (in this case for the first 15 years of the investment) to an amount in the base period that is equal to the investment. Put another way, it is the rate of compound interest at which the present value of the project investment would have to be invested at the current time to yield the earnings of the project investment over its life.

[1] This study was sponsored by a Sea Grant Institutional Program of the National Science Foundation, Contract Number GH-100.

[2] Contribution No. 1334 from the Rosenstiel School of Marine and Atmospheric Science, University of Miami.

DATA

Because there are no operations in existence like the ones proposed here, the cost data, especially labor costs, are estimates. It is very difficult to predict exactly the number of man hours that will be needed to run the different types of operations until they have been in use for a period of time. Nevertheless, it is felt that the cost estimates used are fair and do not bias the study in either direction.

The capital investment, which is the same for both a food or a bait shrimp outfit, except for the fact that the latter will require live holding tanks, can be broken into three parts: land, pond construction and hatchery construction. As mentioned earlier various prices for land were used; they were: $15,000; $12,500; $4,100; $3,500; $3,000; $2,500; $2,000; $1,500; $1,000; $500 and $250. The first four are actual estimates for suitable acreage in Flagler, Volusia, Brevard and Levy counties respectively.[3]

Pond construction cost was estimated to be $850 per each 1 acre pond. After about 10 years 10% of this amount will be required for maintenance purposes. Also, there would be an expenditure of $0.50 per year per acre for pump expenditure, etc. It also was estimated that the cost of a hatchery capable of handling a 1,000-acre operation was $82,500. Such a hatchery would normally require $1,000 a year for such things as utilities and another $5,000 every 3 years for repairs, painting and replacement of equipment. This figure was also used as the hatchery cost for both the 500- and 100-acre projects because of the indivisability of such an item. The effect of this will be to underestimate the profitability of the smaller projects, but because of the relative size of this expense in comparison with total investment, it is doubtful that this underestimation would "make or break" a project.

Although capital costs are the same regardless of what type of shrimp is raised, the revenues and operating costs (except for the labor and maintenance cost for the hatchery and the maintenance costs of the ponds) are different.

The revenue for food shrimp was estimated to be $720 an acre based on the current ex-vessel price of $0.72 a lb. for one crop of 1,000 lb. of 36 count shrimp per acre.

The revenue for a bait shrimp operation was estimated to be $1,800 an acre based on a price of $15 a thousand (a quite conservative estimate) for four crops of 30,000.

As far as costs are concerned, a complete description of the labor costs can be found in the tables. The food cost for a food shrimp operation was based on 20 lb. of feed (at $0.0525 per lb.) per acre for 180 days or $189 an acre. For each crop in a bait shrimp operation, food costs were estimated at 25 lb. per day per acre for 90 days or $118 an acre. These low food costs are based on a new concept of feeding which will be discussed upon completion of present experiments.

The egg acquisition cost listed in the tables is based on labor and boat charges for the average number of nights fishing necessary to capture enough females to support the acreage assumed. (For example, at the peak of the season it should take two nights to obtain sufficient females for a 1,000-acre operation while at

[3] These estimates were given to the authors by the James S. Billings Investment Firm which was recently an agent for a large company interested in beach front property.

TABLE 1
Balance Sheet for 1,000 Acre Food Shrimp Farm

	Capital			Operating Costs					
Yr.	Ponds	Hatchery	Land	Labor for ponds	Labor for hatchery & management	Food	Egg acquisition	Total revenue	Net Cash flow
1	$850,000	$82,500	Range from $18,000,000 to $300,000						Range from -$18,932,500 to -$1,232,500
2	500	1,000		$337,500	$147,500	$189,000	$3,510	$720,000	40,990
3	500	1,000							40,990
4	500	6,000							35,990
5	500	1,000							40,990
6	500	1,000							40,990
7	500	6,000							35,990
8	500	1,000							40,990
9	500	1,000							40,990
10	85,500	6,000							49,010
11	500	1,000							40,990
12	500	1,000							40,990
13	500	6,000							35,990
14	500	1,000							40,990
15	500	1,000							40,990
16									Range from $14,400,000 to $240,000

TABLE 2
Balance Sheet for 500 Acre Food Shrimp Farm

Yr.	Capital			Operating Costs					
	Ponds	Hatchery	Land	Labor for ponds	Labor for hatchery & management	Food	Egg acquisition	Total revenue	Net Cash flow
1	$425,000	$82,500	Range from $9,000,000 to $150,000						Range from –$9,507,500 to –$657,500
2	250	1,000		$245,100	$123,000	$94,500	$2,730	$360,000	-$183,080
3	250	1,000							-$183,080
4	250	6,000							-$188,000
5	250	1,000							-$183,090
6	250	1,000							-$183,080
7	250	6,000							-$188,080
8	250	1,000							-$183,080
9	250	1,000							-$183,080
10	42,750	6,000							-$226,080
11	250	1,000							-$183,080
12	250	1,000							-$183,080
13	250	6,000							-$188,080
14	250	1,000							-$183,080
15	250	1,000							-$183,080
16									Range from $7,200,000 to $120,000

TABLE 3
Balance Sheet for 100 Acre Food Shrimp Farm

	Capital			Operating Costs					
Yr.	Ponds	Hatchery	Land	Labor for ponds	Labor for hatchery & management	Food	Egg acquisition	Total revenue	Net Cash flow
1	$85,000	$82,500	Range from $1,800,000 to $30,000						Range from -$1,967,500 to -$297,500
2	50	1,000		$200,700	$106,000	$18,900	$2,340	$72,000	-$256,990
3	50	1,000						72,000	-$256,990
4	50	6,000						72,000	-$261,990
5	50	1,000						72,000	-$256,990
6	50	1,000						72,000	-$256,990
7	50	6,000						72,000	-$261,990
8	50	1,000						72,000	-$256,996
9	50	1,000						72,000	-$256,990
10	8,550	6,000						72,000	-$270,490
11	50	1,000						72,000	-$256,990
12	50	1,000						72,000	-$256,990
13	50	6,000						72,000	-$261,990
14	50	1,000						72,000	-$256,990
15	50	1,000						72,000	-$256,990
16									Range from $1,440,000 to $24,000

TABLE 4
Balance Sheet for 1,000 Acre Bait Shrimp Farm

Yr.	Capital				Operating Costs					
	Live holding tank	Ponds	Hatchery	Land	Labor for ponds	Labor for hatchery & management	Food	Egg acquisition	Total revenue	Net Cash flow
1	$60,000	$850,000	$82,500	Range from $18,000,000 to $300,000						Range from –$18,992,500 to -$1,292,500
2		500	1,000		$507,000	$147,500	$472,000	$14,040	$1,800,000	1,114,260
3		500	1,000							1,114,260
4		500	6,000							1,109,260
5		500	1,000							1,114,260
6		500	1,000							1,114,260
7		500	6,000							1,109,260
8		500	1,000							1,114,260
9		500	1,000							1,114,260
10		85,500	6,000							1,024,260
11		500	1,000							1,114,260
12		500	1,000							1,114,260
13		500	6,000							1,109,260
14		500	1,000							1,114,260
15		500	1,000							1,114,260
16										Range from $14,400,000 to $240,000

TABLE 5
Balance Sheet for 500 Acre Bait Shrimp Farm

Yr.	Capital				Operating Costs					
	Live holding tank	Ponds	Hatchery	Land	Labor for ponds	Labor for hatchery & management	Food	Egg acquisition	Total revenue	Net Cash flow
1	$30,000	$425,000	$82,500	Range from $9,000,000 to $150,000						Range from -$9,537,500 to -$687,500
2		250	1,000		$359,700	$123,000	$236,000	$10,920	$900,000	$169,230
3		250	1,000		↓	↓	↓	↓	↓	$169,230
4		250	6,000							$164,230
5		250	1,000							$169,230
6		250	1,000							$169,230
7		250	6,000							$164,230
8		250	1,000							$169,230
9		250	1,000							$169,230
10		42,250	6,000							$121,230
11		250	1,000							$169,230
12		250	1,000							$169,230
13		250	6,000							$164,230
14		250	1,000							$169,230
15		250	1,000							Range from
16										$7,200,000 to $120,000

TABLE 6
Balance Sheet for 100 Acre Bait Shrimp Farm

Yr.	Capital: Live holding tank	Capital: Ponds	Capital: Hatchery	Capital: Land	Operating Costs: Labor for ponds	Operating Costs: Labor for hatchery & management	Operating Costs: Food	Egg acquisition	Total revenue	Net Cash flow
1	$6,000	$85,000	$82,500	Range from $1,800,000 to $30,000						Range from -$1,973,500 to -$303,500
2		50	1,000		$270,900	$106,000	$47,200	$9,360	$180,000	-$254,510
3		50	1,000							-$254,510
4		50	6,000							-$259,510
5		50	1,000							-$254,510
6		50	1,000							-$254,510
7		50	6,000							-$259,510
8		50	1,000							-$254,510
9		50	1,000							-$254,510
10		8,550	6,000							-$260,010
11		50	1,000							-$254,510
12		50	1,000							-$254,510
13		50	6,000							-$259,510
14		50	1,000							-$254,510
15		50	1,000							-$254,510
16										Range from $1,440,000 to $24,000

other times it may take as many as five or six nights.) The egg acquisition costs for bait farms of comparable acreages are four times as large as those of comparable sized food shrimp farms.

The balance sheets in Tables 1 through 6 contain summaries of the above information for 1,000-, 500- and 100-acre food and bait shrimp farms respectively. All of the revenues and costs are kept in current prices. Since shrimp prices have been known to grow at a faster rate than normal prices (Cleary, 1969) it was felt that, if anything, such an assumption would bias the study in a downward direction.

The figure in the sixteenth year is the "scrap value" of land figured at 80% of its initial price. The 80% value was chosen because work will be necessary before the land can be used for something else. One might argue, and rightly so, that land of this type will probably increase in value. But since this is a study of shrimp culture and not of land speculation, this aspect was ignored. This consideration should be kept in mind by a firm when considering a certain piece of land for use, however.

The above costs are those of the private investor, but from society's point of view the social cost of such an operation should be considered. That is, how will the ecological balance be affected by altering large amounts of shorefront and marsh land, and what are the social and economic implications of this alteration?

RESULTS

Food shrimp is not profitable at any level of operation at any land price. The sum of the net cash flows in Table 1 is only $468,860 which is smaller than the initial outlay even when the price of land is only $250 an acre. The net cash flows for both the 500-acre and the 100-acre food shrimp farms are negative.

It may be argued that this gloomy picture is the result of the assumption of one crop of 36 count shrimp per year. This is partly true. Switching to three crops of 110 count (heads off) shrimp which is physically possible will not help, since revenues only increase a small amount but food costs increase by about one-half. (The price per pound of 110 count heads off shrimp is slightly more than one third of that of 36 count and three crops of the smaller shrimp would mean feeding for about 9 or 10 months rather than 6 or 7.) Our current information leads us to believe that two crops of 36 count shrimp are not possible, and even if it were possible it would only be economically significant in the 1,000-acre farm. Two crops would double revenues, but seasonal pond labor, food, and egg acquisition costs would also double. The net cash flows of the 100-and the 500-acre farms will still be negative, while the net cash flows of the 1,000-acre farm will increase by $358,990. The latter would be profitable under these conditions, but much less so than the comparable sized bait shrimp farm. See Table 7 for a comparison of the relative profitability of the two types of farms.

Since labor costs make up the major portion of operating costs and because of their tentative nature in this study, it is logical to assume that if a one crop food shrimp farm is ever to be profitable, it will come about because labor costs are actually lower than estimated here. That is, a smaller labor force is necessary or lower wages are required, or a combination of the two.

The 100-acre bait shrimp farm has negative cash flows and hence would not be profitable. But the 500- and the 1,000-acre bait shrimp farms have sufficiently large positive cash flows to make them profitable operations. Just how profitable they are for different prices of land is shown in Table 7. Internal rates of return of less than 5% were not listed since that is the interest commonly available at commercial banks.

TABLE 7
Internal Rate of Return in Percent for Various Prices of Land of Bait Shrimp Farm

	Rate of Return		
Price/Acre	500 Acres	1000 Acres	
$15,000	>5	>5	(>5)*
12,000	>5	>5	(>5)
4,100	>5	17	(>5)
3,500	>5	19	(>5)
3,000	5	23	(5)
2,500	6	27	(7)
2,000	7	33	(9)
1,500	9	39	(11)
1,000	13	51	(19)
500	19	69	(24)
250	27	93	(31)

* The figures in parenthesis are the returns in percent on 1000 acre food shrimp farms producing two crops a year, which is not physically possible at the present time.

CONCLUSIONS

Of the six types of operations studied, only two, the 1,000-acre and the 500-acre bait shrimp operations appeared to be profitable and they were profitable indeed at low land prices.

As one would expect from the cost data there are economies of scale. It would be interesting to expand the present work to see how far these increasing returns go. That is, how much bigger (or smaller, for that matter) than 1,000 acres should the optimum farm be.

It must be remembered that returns here are gross of any taxes, and so when comparing this project to other possible investments a comparison should be made on gross rates of return. The corporate income tax of 52% will not necessarily cut the returns in half, however, because most of the write-off of the capital will be in the early years which has the effect of shifting taxes to the later years where they will be paid with dollars that are more highly discounted.

EFFECTS OF SHRIMP FARMING ON THE PRICE OF SHRIMP

It is well known that as more units of a product are put on the market, the price of the product decreases. The relationship between this change in output and the change in price is called the elasticity of demand, which is the percentage change in output divided by the percentage change in price. The Bureau of Commercial Fisheries has estimated the ex-vessel price elasticity of food shrimp to be −0.3099(Anon., 1970, p.22), which means that by increasing the output by 0.3099% the price would fall by 1%. In 1968 total consumption of food shrimp in the U.S. was 474 million pounds (Anon., 1970, p.24),

TABLE 8
Labor Cost for Hatchery and Management

Personnel	Unit Cost	1000 Acres Number	1000 Acres Cost	500 Acres Number	500 Acres Cost	100 Acres Number	100 Acres Cost
Hatchery							
Technicians	$ 7,500	3	$22,500	2	$15,000	2	$15,000
Supervisors	$18,000	1	$18,000	1	$18,000	1	$18,000
Mechanics	$11,000	2	$22,000	2	$22,000	2	$22,000
Maintenance Men	$ 7,500	1	$ 7,500	1	$ 7,500	1	$ 7,500
Labor Sub-Total			$70,000		$62,500		$62,500
Secretaries	$ 6,500	1	$ 6,500	1	$ 6,500	1	$ 6,500
	$ 5,000	2	$10,000	1	$ 5,000		
Sr. Manager	$25,000	1	$25,000	1	$25,000	1	$25,000
Jr. Manager	$12,000	3	$36,000	2	$24,000	1	$12,000
Management Sub-Total			$77,500		$60,500		$43,500
TOTAL COSTS			$147,500		$123,000		$106,000

therefore, it would take an increase of about 1.4 million pounds to cause a decrease in price of 1%. Thus, since a 1,000-acre food shrimp farm produces 1 million lb., output will affect price. This puts food shrimp production in even a worse light, if many large farms are anticipated.

To the best of our knowledge, there is no estimate of the price elasticity of demand for bait shrimp, although one would expect that it would be higher than that of food shrimp, since there are fewer substitutes for the former. The total output of bait shrimp in 1968 in Florida was 96.4 million[4] which means that one 1,000-acre farm would increase output by 120%.

This is a large amount indeed, but it is felt that since the wholesale price of shrimp runs as high as $25.00 per thousand, and a figure of $15.00 a thousand was used in this study, the results, shown here, are valid for *one* farm at least.

TABLE 9
Labor Cost for Ponds in Food Shrimp Operation

Personnel	Cost Unit Cost	1000 Acres Number	1000 Acres Cost	500 Acres Number	500 Acres Cost	100 Acres Number	100 Acres Cost
Permanent Skilled	$ 7,500 yr.	20	$150,000	15	$112,500	15	$112,500
Seasonal (6 mos.)	$ 350/mo.	70	$147,000	45	$ 96,600	27	$ 56,700
Seasonal Foreman (6 mos.)	$ 750/mo.	5	$ 22,500	4	$ 18,000	3	$ 13,500
Supervisor	$18,000/yr.	1	$ 18,000	1	$ 18,000	1	$ 18,000
TOTAL COSTS			$337,500		$245,100		$200,700

[4]Source: Lloyd Johnson, Marketing Specialist, Bureau of Commercial Fisheries, Miami, Florida

The effects of such a large increase in supply on the price and other conditions in the bait shrimp market should be investigated more closely.

TABLE 10
Labor Cost for Ponds in Bait Shrimp Operation

	Cost	1000 Acres		500 Acres		100 Acres	
Personnel	Unit Cost	Number	Cost	Number	Cost	Number	Cost
Permanent Skilled	$ 7,500	20	$150,000	15	$112,500	15	$112,500
Permanent Unskilled	$ 4,200	70	$294,000	46	$193,200	27	$113,400
Foreman	$ 9,000	5	$ 45,000	4	$ 36,000	3	$ 27,000
Supervisor	$18,000/yr.	1	$ 18,000	1	$ 18,000	1	$ 18,000
TOTAL COSTS			$507,000		$359,700		$270,900

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Refining Shrimp Culture Methods: The Effect of Temperature on Early Stages of the Commercial Pink Shrimp [1]

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INTRODUCTION

Temperature has been thought to be the most important factor in the marine environment (Gunter, 1957; Hedgepeth, 1957; Moore, 1958; Morowitz, 1968). Moreover, tropical species appear to be particularly sensitive to their upper temperature limits as it becomes increasingly apparent that certain of these organisms live within a few degrees of their upper limit during the summer months. This was first seen by Mayer, 1914, and has recently been discussed for a few species (Thorhaug, 1969, 1970 and 1971; Moore, in press). One very important application of the study of temperature limits is to aid mariculture efforts to find optimum and safe ranges for rearing of the delicate larval forms and to devise methods which will allow the larvae to grow rapidly but not approach the lethal limits. The first stages of aquaculture of the pink shrimp, *Penaeus duorarum*, have been successfully carried out by Idyll, Tabb and Yang, 1970; Ewald, 1965; and Cook, 1969. The next step after these basic methods is refining various aspects of rearing of larvae to produce a maximum yield. Since one of the most important factors for rate of growth as well as survival is temperature (Zein-Eldin and Griffith, 1966) we examined the temperature limits of stages from newly hatched nauplii through juvenile shrimp.

METHODS

The more than 2,000 experimental specimens of *Penaeus duorarum* were obtained from the University of Miami mariculture facility at Turkey Point, Florida. They were hatched from females captured on commercial shrimp grounds and spawned in the laboratory.

The specimens were reared according to the methods of Idyll et al (1970) and, when the appropriate larval stages were reached, transported to our laboratory (1 hour away) under optimum conditions of aeration and temperature control.

The instrument used to produce the temperature array was a polythermostat, which is basically an aluminum bar, precision bored to fit tubes (Thorhaug, 1969). It is heated at one end and cooled at the other with mercury thermoregulators so that the precision is ±0.01C. The temperature range examined for most of the experiments was 10 to 40C with about 1 degree C between tubes, which range is that of environmental interest in the tropics. Oxygen was provided by bubbling air through pipettes fitted into the tubes by

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corks. Salinity was 31 parts per thousand (o/oo). Feeding was administered according to Idyll et al (1970). Conditions in general were kept at an optimum for the larvae so that temperature would be the important variable, since stress in one factor often combines with a second stress factor to cause less tolerance of temperature. It should be emphasized that these results were at a series of sustained temperatures and therefore are not necessarily consistent with fluctuating temperature limits, but rather show danger points to be avoided.

Measurements of lethal limits all contain one particularly poorly defined criterion: i.e., what is death for the individuals in question? Since biology offers us no precise general definition, we chose an empirical definition as follows: death of an organism occurred when no movement could be observed microscopically for 3 minutes even when the specimen was prodded. Discoloration or opaqueness often accompanied this. At higher temperatures disintegration occurred within a short time. This empirical criterion was selected after consultations with experts with long experience dealing with shrimp larvae; our definition proved workable.

RESULTS

The results of these experiments were surprising, especially for the first larval stage of the nauplii. The limits in all the larval stages examined occurred abruptly and the difference between all alive and all dead often was within only 1 to 2C which would indicate more abrupt limits than had been expected.

The newly-hatched nauplii from females collected in the field were able to metamorphose successfully into the protozoea only between 24 to 25 and 30.5

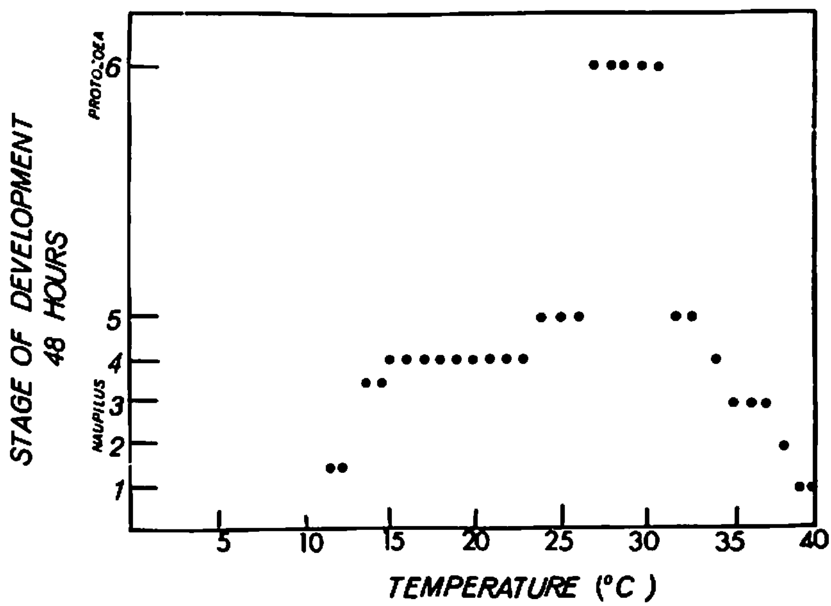

Fig. 1 Stage of development versus temperature for the commercial pink shrimp *Penaeus duorarum*. Each point represents 18 shrimp.

to 31.5C (as seen in Fig. 1 where each dot represents 18 organisms) which is a narrow range. Interestingly, the first few hours were marked by vigorous swimming activity in the tubes up to 37C, which might appear to be that of a vigorous population. After ten hours the ability to survive above 33 to 34C had severely lessened (Fig. 2). The shrimp at the lower end were alive by our criteria of movement, but they sat on the bottom and had very weak movement, which may well indicate that for shrimp at this stage they were not normal. One might also note in this experiment as well as the later stage experiments that cannibalism was markedly greater at temperatures just sublethally. This is a behavioral pattern which has been noted by mariculturists also. The optimum temperature used by Idyll et al (1970) (27 to 28C) then, is a real and necessary optimum. In the Turkey Point hatchery this is controlled by room air conditioners. It would plainly be better to control temperature as accurately as finances allow in this critical stage.

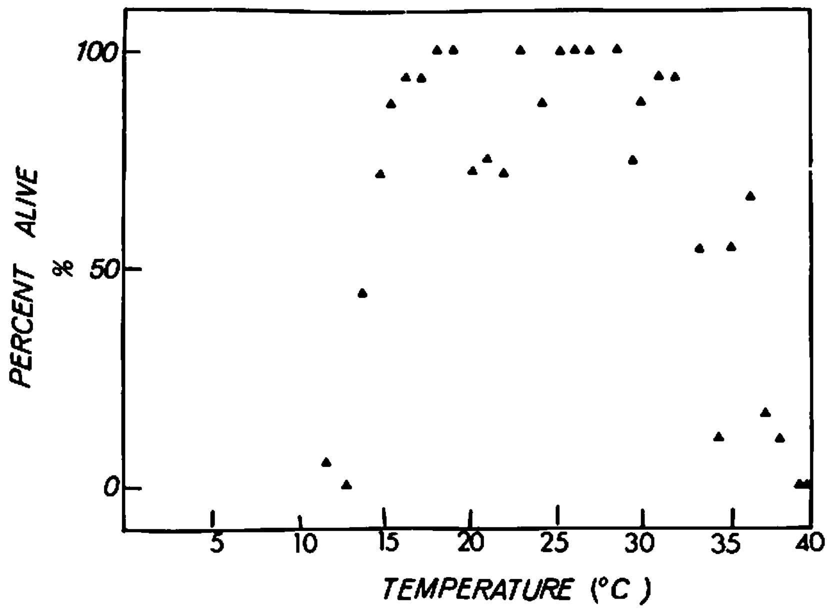

Fig. 2. *Penaeus duorarum* nauplii, percentage survival versus temperature after 10 hours.

The first protozoeal stage appeared to be much hardier with respect to lethal limits temperature than were the naupliar. After an 18 hour exposure (this stage lasts 18 to 24 hours) all organisms above 37 to 37.8C had died, while those below this temperature remained surprisingly active (Fig. 3 where each point represents 10 organisms). It should be emphasized that the time period used is an equilibrium time. During the first few minutes death will occur at the very hot temperatures. Finally, an equilibrium period is reached in many organisms, after which all those organisms which are going to die have died and the rest remain alive (Thorhaug, 1969; Bader, Roessler and Thorhaug, 1970). Of course, with regards to the shrimp larvae, these time periods are necessarily restricted by the time for each larval stage, whereas in some of our algal work we can keep the specimens alive for months. Unfortunately, we are still in the process of obtaining the precise lower limit for each larval stage. However, this probably is not important to the mariculturist since higher temperatures cause faster growth and development.

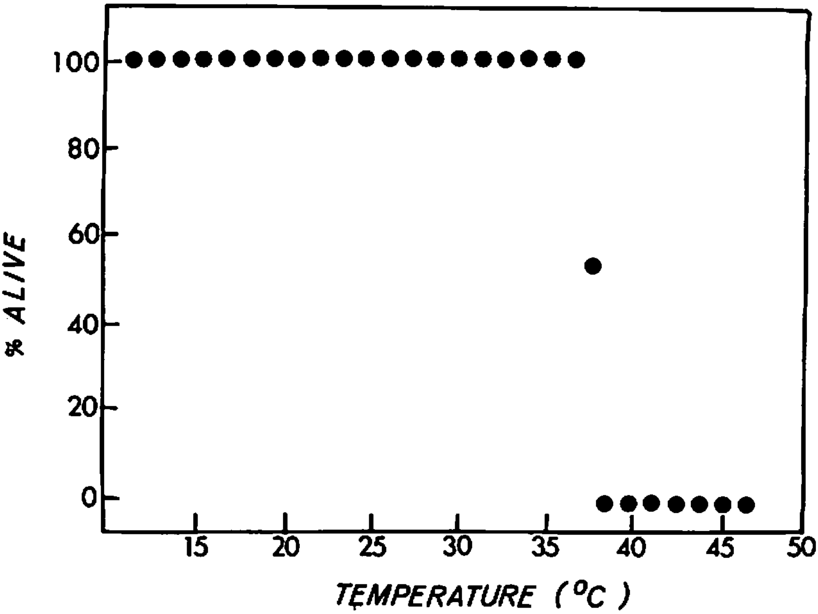

Fig. 3 *Penaeus duorarum* first protozoea. Percentage survival versus temperature. Each point represents 10 organisms.

The third protozoeae were not able to live above 35.7 to 36.7C after 22 hours (this stage is 18 to 24 hours in duration). Figure 4 represents 12 organisms per point.

The mysis stage was not able to develop to the postlarval or survive above 36.9 to 37.4C or below 14.6C as seen in Figure 5 where each point represents 12 organisms.

The first postlarva had very similar lethal limits of 36.8 to 37.8C (Fig. 6 where each point represents 12 organisms.) The "safe" limit was up to 33.5C for this stage.

One should note that these are sustained, not fluctuating temperatures, however, the temperature is similar to those environmentally derived temperatures (Jones et al, 1970).

DISCUSSION

The obvious warning from these results is that the mariculturist rearing pink shrimp must keep strict watch on the temperature of the water in which his specimens are kept, especially during mid-day in the summer when temperatures in a small body of water such as culture tanks may well reach temperatures near those discussed in the results.

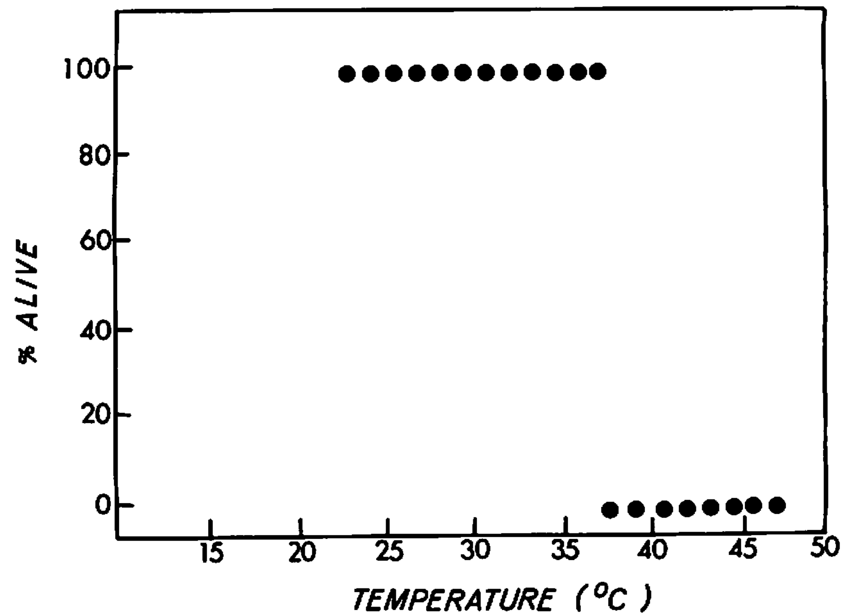

Fig. 4. *Penaeus duorarum* third protozoea. Percentage survival versus temperature. Each point represents 12 organisms.

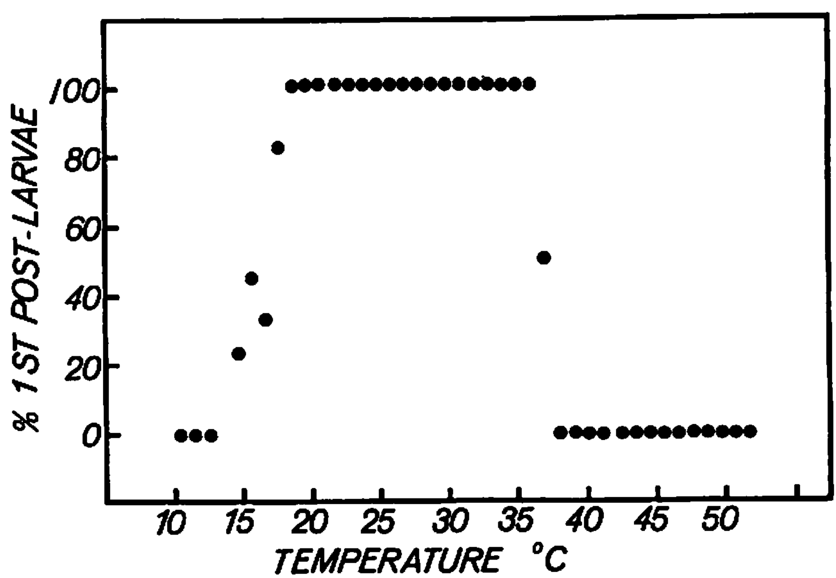

Fig. 5. *Penaeus duorarum* mysis development to postlarval stage. Percentage survival versus temperature. Each point represents 12 organisms.

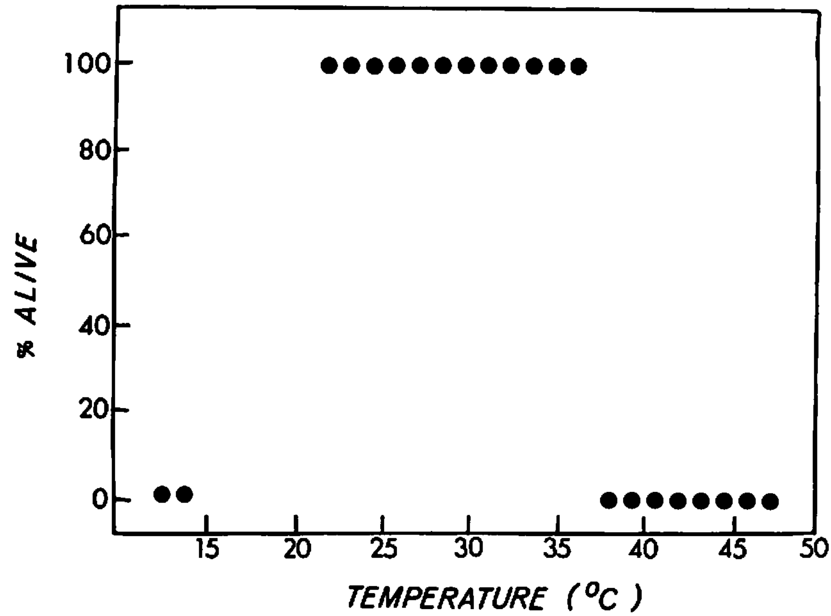

Fig. 6. *Penaeus duorarum*, lethal limits of the first postlarval stage. Each point represents 12 organisms.

We deduce from these results that newly-hatched nauplii are more delicate than the later stages. An expensive, but effective, method of controlling temperature for the napuliar stage of Idyll et al (1970) is to hold them in large 20 metric ton tanks indoors with room air-conditioning maintaining the temperature at 27 to 29C, which would appear to be the optimum temperature. One should be very careful that the temperature does not exceed 30.5C for any considerable length of time (for instance, several hours). This temperature would be well within mid-day temperatures of a shallow tropical pond or enclosed bay not protected from summer insolation.

There will be two problems depending on the location of the mariculture facility. The first will be that sub-tropical locations will have to keep the shrimp warm and thus use the natural heating of the sun. Second, tropical regions may run the risk of the water getting too warm thus approaching the upper lethal limits; in this case, protection from the sun will be necessary. Summer sun in some parts of the sub-tropics may also heat pools so that problems of maintaining 27-29C temperatures may be the same as in the tropics.

If indoor control of the first stage is impossible, our suggestion is that a greenhouse could be built with either a glass or, more economically, a heavy plastic "bubble" top. This could be cut in the form of a circle and enclosed with such simple materials as sand. A compressor could be used to pump this up. The heat from the compressor might also be added to the greenhouse. If this included fans in four directions, it would be simple to keep cool air coming in and hot air pushed out to cool the greenhouse in the middle of the day. This would allow cooling and heating.

A second out-of-doors alternative for the tropics where the lower temperatures would not be important would be to shade the ponds with a reflecting roof or canopy suspended about 4 to 10 feet above the pond in such a way that wind could enter and cause cooling by evaporation, thus the sun would not cause heating above the thermal limit. Prudent use of prevailing breeze or breezes plus fans could aid in evaporative cooling.

Of course, estuarine culture pen situations where one has the ability to cool or heat by regulating gates for the water flowing into or out of the mariculture area would not require the above devices. One should keep in mind in all these methods that the first stage is by far the most delicate.

The later stages from protozoeae to adult are able to withstand temperatures safely up to 33 to 35C. In fluctuating temperature situations they may well be able to withstand 36C for several hours. The basic problem is to regulate the temperature so that growth will be fastest (thus requiring fewer days to mature) and size greatest. The expense of keeping the shrimp at optimum temperatures will have to be weighed against the amount of labor to care for the shrimp for a longer period of time and the lower yield when temperatures become lethal or near lethal and many specimens die. For instance, at 20C organisms are less active, feed less actively, and do not appear as hardy from the protozoeae to the juvenile. If temperatures were to be ideally controlled, one might advise 27 to 29C in the first (nauplii) larvae and 27 to 30C fluctuating (day-night) for optimum growth and feeding for the later stage.

The above temperatures correlate well with the work of others (Lindner and Cook, 1968) using several species.

ACKNOWLEDGMENTS

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Advances in Pacific Shrimp Culture

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INTRODUCTION

The culture of shrimp in the Pacific has been practiced for many years especially in the Indo-Pacific region. The method of semi-culture consists of allowing shrimp fry to enter artificial ponds during incoming tides and then grow utilizing natural foods produced in the ponds. The natural production of foods may be enhanced by the addition of fertilizers and tilling of the bottom when the ponds are completely drained. In the Philippines, shrimp fry are collected and transported to the ponds. These methods have been amply described by Kesteven (1958), Simpson and Hancock (1968), Tham Ah Kow (1968), Caces et al (1968), George et al (1968), and Pannikar (1968).

In the states of Sinaloa and Nayarit, on the Pacific coast of Mexico,shrimp are produced and captured in coastal lagoons and estuaries through the use of fixed structures "Tapos and Sierra". Shrimp postlarvae and juveniles enter protected waters during the first part of the year with incoming tides; later the Tapos retain the shrimp while they feed on natural food and reach market size. Traditionally the Tapos were constructed by driving wooden piles into the bottom across channels communicating coastal lagoons and estuaries with the sea. A woven mat of branches and palm fronds between the piles forms a wall permitting water flow but retaining the shrimp. At the center of the Tapo, a gate opens into the "Chiquero" a heart or kidney shaped enclosure. The shrimp are attracted into the enclosure at night by lights behind the gate. After capture they are removed with dipnets. This method has been described by Mercado (1959), Núñez and Chapa (1950, 1951 and 1952), and Chapa (1963).

More recently, the artificial culture of shrimp has flourished in the Pacific, especially in Japan. In 1933, Dr. Fujinaga succeeded in the artificial spawning and hatching of *Penaeus japonicus* but it was in 1959 that he established the first commercial scale shrimp farm in Takamatsu (Fujinaga, 1969). The artificial culture of shrimp as developed in Japan by Fujinaga, consisted of placing female shrimp in aquaria measuring 2 m x 1 m x 1 m filled with filtered seawater. The females were removed after spawning and when the larvae reached the protozoeal stage they were fed pure cultures of diatoms, mainly *Skeletonema costatum*. After the mysis stage, nauplii of *Artemia salina* were fed to the larvae; and after the postlarval stage, the shrimp were fed on crushed clam meat (Idyll, 1965; Fujinaga, 1969). When the small shrimp reached 15 mm in length they were placed in outdoor ponds where they grew to market size. At Fujinaga's Takamatsu farm, there are several types of ponds: small concrete ponds with a false bottom about 6 inches above the concrete slab, large concrete ponds without the false bottom and two large tidal ponds. The tidal ponds cover an area of 40,000 m^2. At his Aio farm, the ponds have an area of about 40,000 m^2 each (Idyll, 1965).

The artificial culture methods developed for *Penaeus japonicus* from the egg to the juvenile stage have been applied to *P. semisulcatus* and *Metapenaeus monoceros* (Simpson and Hancock, 1968). Since 1964, Fujinaga (1969) has modified the methods of rearing shrimp postlarvae from eggs. The new method utilizes large outdoor concrete tanks, 2 m deep and 10 m per side. Bay water is introduced through 80- to 100-mesh screens directly into the tanks. The mature female shrimp are placed in the tanks, allowed to spawn overnight and removed the next day. The number of females per tank during a series of experiments conducted in 1963 varied from 18 to 198. No direct correlation between the number of females per tank and the number of young shrimp produced was evident, but Fujinaga recommends the use of more than 30 females per tank. The production of diatoms is stimulated by adding potassium nitrate and dibasic potassium phosphate at the rate of 200 g and 20 g per day per tank from the day after hatching. *Artemia* and crushed baby clam meat were fed to the shrimp, but the larvae were apparently feeding on natural zooplankton also. Fujinaga cites the following advantages for the new method over the old: average production of young shrimp per tank 1000×10^3 over 10×10^3 and on the same number of shrimp fry basis, the use of one-fifth to one-tenth the number of gravid females, a survival rate from nauplii to young shrimp of 24% as compared to from 2.5 to 5%, a reduction of 72% in the amount of *Artemia* eggs and of 56% in the amount of baby clam meat needed in raising postlarvae, the elimination of separate diatom cultures, and a reduction in labor costs.

RECENT DEVELOPMENTS

Mexico

In Mexico, new Tapos are being constructed of concrete and net panels. The new type consists of concrete pilings driven into the bottom, the pilings are held together by cross members of reinforced concrete and a concrete walk on top. On the sides of the piles there are double grooves into which the net panels can be inserted. This permits inserting new net panels while others are removed for repairs or cleaning. By law the Tapos must be open during part of the year to permit migrations of shrimp. In this case the net panels in the concrete Tapos are removed, but the main structure is permanent.

In 1964, the shrimp fishermen's cooperative association, La Sinaloense, constructed a primitive canal from the Presidio River to the Huizache lagoon, did some dredging on the Ostial estuary and opened a new mouth connecting this estuary with the ocean. According to Chapa (1966), shrimp catches in Huizache lagoon increased by a factor of seven. In view of these results, he recommended the construction of a freshwater canal from the Baluarte River to the Caimanero lagoon and dredging the Agua Dulce estuary communicating this lagoon with the Chametla mouth at the ocean. This lagoon is joined to Huizache lagoon by a narrow chanel at Pozo de la Hacienda.

In 1966, the Federal Department of Hydraulic Resources received a formal request from two cooperative associations exploiting these lagoons, the Alvaro Obregón and the Sinaloense, to construct more efficient canals. The canals were in operation from 1966 to September 1968 when they were destroyed by hurricane Noemi which hit the mainland close to Mazatlán.

At the end of 1968, the Department of Hydraulic Resources initiated the Fisheries Development Pilot Plans for Escuinapa and Yavaros. The plans include constructing canals to bring fresh water to coastal lagoons, improving the access of seawater and postlarvae from the sea to the lagoons, building flow control structures to regulate amounts of water and water levels in lagoons, constructing and improving roads. In connection with these developments, the National University of Mexico and our Institution, the Monterrey Institute of Technology, agreed to undertake research programs which include: rearing commercial shrimp from the eggs to postlarvae; description of larval stages; production of postlarvae in quantities to stock ponds and enclosures in coastal lagoons; studying the effect of temperature and salinity on shrimp larvae, postlarvae and juveniles, to determine the best conditions for growth and development; studies of migrations of postlarvae and juveniles into coastal lagoons; determining hydrographic conditions in coastal lagoons; an evaluation of phytoplankton, zooplankton and benthic communities in coastal lagoons; recording climatic conditions with particular emphasis on winds, rainfall, solar energy, evaporation, temperatures, relative humidity and barometric changes; and determining the amounts and kinds of pesticides introduced into lagoons by drainage water from adjacent agricultural areas.

At the School of Marine and Food Sciences of the Monterrey Institute of Technology located in Guaymas, state of Sonora, we have succeeded in rearing postlarvae of *Penaeus californiensis*, our brown shrimp, and of a rock shrimp of the genus *Eusicyonia*. The rearing of shrimp postlarvae at our school has two main goals, one is the description of larval stages of the commercial species of our Pacific coast and the other is the mass production of postlarvae for shrimp farming.

Our present facilities include small and large aquaria, and rearing tanks. Our source of sea water is the Bay of Bacochibampo which is relatively unpolluted and has a wide open connection with the Sea of Cortez. Water temperatures vary from 17C in winter to 32C in summer and salinities remain fairly constant, from 34.70 $^{o}/oo$ to 37.09 $^{o}/oo$. The water is pumped through PVC piping to two storage tanks with a total capacity of 12 m^3 located on the hillside above our main building. The water is filtered through diatomaceous earth filters. The pumping and filtering systems are duplicated to prevent interruptions in the seawater supply. The water is distributed to the building by gravity through PVC piping.

Our aquaria room occupies an area of 110 m^2 with small aquaria placed in upper and lower rows in three sections. We have eighty 70-liter aquaria, eight 90-liter aquaria, and six large rearing tanks with a capacity of 2 m^3 each constructed of marine plywood reinforced with fiberglass at the joints.

A separate insulated room measuring 3.5 m by 1.5 m occupies the south corner of the aquaria room and is used for the culture of diatoms. One 25,000 BTU/hr. reverse cycle airconditioner maintains temperatures constant in this room. Illumination is provided by twenty-three 74-watt slim-line daylight lamps. The diatoms are cultured in 5 gallon carboys.

One section of small aquaria receives water directly from the main pipe, but the other two sections and the rearing tanks receive water filtered by 4 double batteries of Cuno filters with 50- and 5- micron pores respectively. The filtered water flows through two Karbate heat exchangers, one to warm it the other to cool it. The heat exchangers have automatic temperature controls regulating the flow of hot or cold freshwater through the shells.

Each row of small aquaria is fed through a separate pipe and the amounts of warm and cool seawater can be varied to provide different temperatures to each row of aquaria and to the rearing tanks. Freshwater or brine can be added in varying proportions to change salinities. The same type of Cuno filter is used for the freshwater and the brine solution.

Compressed air is supplied to the aquaria room by a Quincy model FC-325 air compressor, a DeVilbiss type UAN-50-40 model 230 air compressor serves as a stand by. In case of power failure, air from high pressure steel cylinders may be used to provide aeration.

Two 25,000 BTU/hr. reverse cycle air conditioners provide temperature control for the aquaria room.

A research laboratory with 30 m^2 of floor space connects with the aquaria room.

The larval stages of *Penaeus californiensis* have been described by one of our staff members and will be published in the near future. We detected five naupliar stages, three protozoeal stages and three mysis stages.

The eggs hatched 15 hours after spawning at 28C, and 54 hours after spawning the first protozoea appeared; the first mysis developed 190 hours after spawning and the first postlarva at 295 hours. Forty-seven days after spawning the postlarvae had reached a total length of 20 mm. At 23C it took the shrimp five days longer to reach the postlarval stage.

We found the survival rate between stages greatly reduced between first nauplius and first protozoea. Overall survival rates, between first nauplius and postlarvae, averaged 4% with a maximum survival rate of 8.1% which is lower than that reported at present for *P. japonicus* using 200 ton tanks. The experiments were conducted in aquaria at 30C.

The rock shrimp *(Eusicyonia sp.)* is being captured in increasing amounts by our commercial fishermen. We were able to obtain adults from eggs in aquaria and rearing tanks and samples of all larval stages were obtained for study purposes.

Small scale feeding experiments with brown shrimp using artificial foods produced from fishmeal, shrimp heads and commercial feeds were conducted. Apparently a mixture developed from shrimp heads shows some promise. These experiments will be continued on a larger scale on the same species and other commercial shrimps.

We have completed construction of six new concrete outdoor rearing tanks with a capacity of 20 m^3 each. The tanks can be filled with filtered or unfiltered sea water. A roof protects the tanks from direct sunlight and rainfall, but the roofing sheets may be removed if necessary for plankton production.

Japan

During May 1970, we visited the Seto Inland Sea shrimp farming area of Japan. Dr. Tomotoshi Okaichi of Kagawa University accompanied us to the Saibai Gyogyo Center in Yashima and to the Shrimp and Yellowtail Farming Company, Ltd., in Takamatsu where we visited with Dr. Uto Kobayashi, Director of the Center, and later with Dr. Ichiro Sugiura, Director and Treasurer of the Farming Company.

Research is being conducted at this center on the culture of shrimp, crabs, clams and fishes. They have several new shrimp rearing tanks measuring 10 m per side and over 2 m in depth. These tanks will have means for raising the temperature of the sea water. The water supply is pumped from the bay into the tanks through plankton nets that retain most zooplankton.

The tanks are filled with water to one-third their depth before introducing gravid females. After spawning the females are removed and commercial agricultural fertilizers are added to promote phytoplankton growth. Soybean residues are added to the tanks 4 days after spawning. Water is introduced daily to the tanks so that when the first postlarval stage is reached the water depth is 2 m. The optimum concentration of diatoms is regulated by the amounts of fertilizer and seawater added. To reduce the concentration only water is added, and to increase it water and fertilizers are added.

It takes about 2 weeks for the shrimp to reach postlarval stage and the postlarvae are kept in the tanks for an additional week before releasing into net enclosed areas in the Inland Sea. After they reach a length of 25 mm to 30 mm the nets are removed and the fry are released. In one confined area, the survival rate from 13 mm to 30 mm was 63%. While the shrimp were kept confined, they were fed a supplemental diet of non-commercial ground shrimp. There are 14 stations on the Inland Sea conducting similar experiments, but only 4 were successful in increasing production. These were stations located in confined areas where shrimp migrations are restricted.

At the commercial shrimp farm in Takamatsu, production of shrimp postlarvae is still carried out in several 2-ton tanks as originally built by Dr. Fujinaga. The small and large concrete ponds are no longer in use since shrimp farming is conducted mainly in a large tidal pond with an area of 4 hectares. Some concrete ponds are used to hold shrimp for market during winter months

Live shrimp for "Tempura" continues to carry a high price in Japan, offsetting to a certain extent the high cost of feeding shrimp on ground clams and non-commercial shrimp. The cost of producing 1,000 postlarvae, excluding investments, is $0.80 U.S.

We asked our hosts, and later Drs. Ohta and Kirata at the Naikai Regional Fisheries Research Laboratory south of Hiroshima, what they thought the main advances in shrimp culture in Japan had been during the past 5 years. The consensus was that the main advance was an increased efficiency in production of postlarvae brought about by several factors. One is the use of large rearing tanks (200 tons) that permit the production of larval food directly from naturally occurring mixed cultures of phytoplankton. Another factor is that survival rates from the egg to the postlarval stage have increased from 0.8% in 1960 and 4.8% in 1964, to from 30 to 50% in 1970. This increase in survival is due not only to the new rearing techniques, but also to improvements in training and experience of the personnel involved in shrimp culture.

We were told that there are plans in Japan to construct floating plants to rear shrimp postlarvae with a capacity of 1,000 tons of water. The main advantage of this plant is that it could be moved into an area where shrimp fry are needed, eliminating transportation of fry.

The rearing of postlarvae of *P. japonicus* in Japan is now a repeatable process which has been fairly well established and allows production to meet market demands. Since this operation still depends on obtaining gravid females from the natural environment, production of postlarvae is seasonal. Feeding costs from postlarvae to adults are relatively high, but the price commanded by live shrimp for Tempura makes shrimp farming selfsustaining.

In Mexico, we are gaining experience in producing shrimp postlarvae. If we succeed in managing large areas of water and in reducing or eliminating the cost of supplementary feeding, shrimp farming would have a great future since the Pacific coast of Mexico has over 800,000 hectares of coastal lagoons and the Gulf of Mexico and Caribbean coasts over 640,000 hectares. Even if only part of the total area can be properly managed, the potential is promising.

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The Distribution of Sediment Properties and Shrimp Catch on Two Shrimping Grounds on the Continental Shelf of the Gulf of Mexico [1]

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Abstract

During 1966-68 sediment samples were collected on an intensive scale from shrimping grounds of the Dry Tortugas, Florida and off Galveston, Texas. The areas were described by sediment types and organic carbon content. Comparisons were made between the shrimp catches and the distribution of sediment properties.

Sediment properties and distribution differ notably between the Tortugas and Galveston areas. Within the Tortugas grounds a thin veneer of organically derived sediments overlies a limestone substrate. Carbonate sands constitute 78% of the surface sediment. The remaining area is covered principally by a very coarse silt. In contrast, the area off Galveston is a relatively smooth dipping detrital bottom with sediments of terrigenous origin. Sand and sand-silt-clay types are the most abundant sediments present.

Comparison of the distribution of sediment properties outside the grounds with the distribution of sediments within the Tortugas grounds seems to indicate the fishing grounds have a relatively high content of organic matter. Certain sediment types appear in the area of high catch. In the Galveston area the patterns of sediments and organic matter are more diverse and relationships less clear. Further study of the sediment properties and the shrimp catch on the continental shelf is in progress.

INTRODUCTION

The association of adult shrimp of the genus *Penaeus* on the open continental shelf with certain types of bottom sediments has long been recognized by fishermen. Only recently, however, have these sediment types and their distribution over the fishing grounds been investigated (Burkenroad 1939, Gunter 1950, Williams 1955, Hildebrand 1955, and others). From their investigations in the field, Springer and Bullis (1954) and Hildebrand (1954) found pink shrimp abundant on calcareous mud and shell sands, and white and brown shrimp abundant on terrigenous silt. From laboratory experiments Williams (1958) concluded that the distribution of penaeid shrimp over these certain types of substrates was not random and that other factors could qualify this relationship. Of these, the most influential parameter is food. Because of the difficulty of determining the distribution and abundance of shrimp and the total amount of food available on the continental shelf, little progress has been made on the relationship between the distribution of shrimp, particle size, and organic matter.

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[1] Contribution No. 318 from the National Marine Fisheries Service Biological Laboratory, Galveston, Texas.

To determine if a relationship could be shown in the field between the shrimp, sediment types, or organic matter, the distribution of surface sediments on two fishing grounds were compared with the distribution of shrimp based on shrimp catch. In this preliminary report only gross relationships are considered and no distinction was made between the different commercial species of adult shrimp. The study did not include the very productive fishing grounds southwest of Galveston because sampling was incomplete. Collection of samples from this area is continuing with the aid of the Texas Parks and Wildlife Department.

METHODS

Bottom sediments were collected during the 1966-68 cruises of the R/V *Geronimo* in the vicinity of the Dry Tortugas and off Galveston (Fig. 1). Surface sediments were taken with a Van Veen grab and the top centimeter or two of the sample was scraped off for analysis. The coarse fractions - sand to gravel - were separated into grade sizes by sieve, and the fine fractions - silt and clay - were determined by pipette analysis. The percentages of sand, silt, and clay were plotted on triangular diagrams (which accompany the sediment distribution charts) and the sediment types were named after the classification of Shepard (1954) for the Gulf Coast. Sediment types are based on particle size and not qualified by the composition of the sediment. The organic matter is based on the amount of organic carbon present in the sediment. Because organic carbon represents from 50 to 60% of the total organic matter in the sediments, the approximate total organic matter can be estimated by multiplying by 1.8 which is equivalent to a carbon content of 56% (Trask, 1955). Organic carbon was determined by grinding the samples to a size of less than 250 microns, digesting the calcium carbonate with a weak solution of hydrochloric acid, and determining the remaining carbon by use of an induction furnace and direct readout carbon analyzer.

The shrimp catch data for the Dry Tortugas grounds are based on landings that cover 2 years from September 1963 through August 1965 (Lindner, 1965). The shrimp catch data for the Galveston grounds were collected by Galveston laboratory personnel from interviews with fishermen from July through September 1964. The data were plotted in thousands of pounds per hour by areas of 100 square nautical miles.

Tortugas Grounds

In the study of the distribution of the surface sediment types it was advisable to determine the bottom topography in sufficient detail to be of aid in the interpretation of the data. We therefore prepared a bathymetric chart of the southern Florida shelf and Tortugas grounds on a Lambert conformal projection contoured at 1-meter intervals (Fig. 2).

The bottom on the southern Florida shelf is a hard limestone substrate overlaid by a thin veneer of biogenic sediments. Ancient reefs, pinnacles, and ridges are prominent at the edge of the shelf. Water depth at the shelf break, from 70 to 77 meters (38-42 fathoms), is relatively shallow compared to the world average of 137 meters (75 fathoms). The average dip of the shelf from shore to the break is about 3.2 ft. per nautical mile. North of the fishing grounds the bottom is irregular, spotted by algal mounds, coral cappings, pinnacles, and numerous shallow depressions that extend seaward to a depth of 37 meters (20

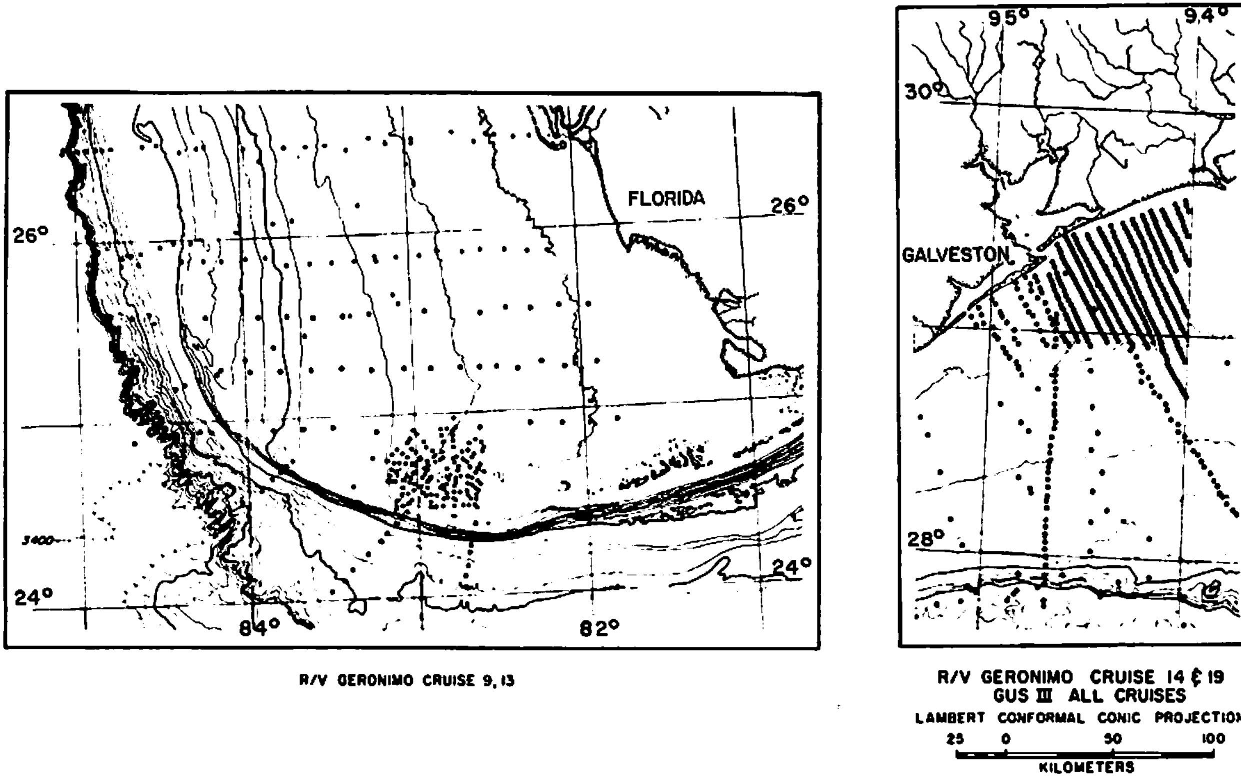

Fig. 1. Station locations of the R/V *Geronimo* on the southern Florida shelf and on the shelf south of Galveston, Texas.

fathoms). Relief of these features does not exceed in general 33 feet. The most abundant sediment type on the southern Florida shelf is sand with widely separated patches of gravel composed principally of coarse shell, coral, and algal fragments.

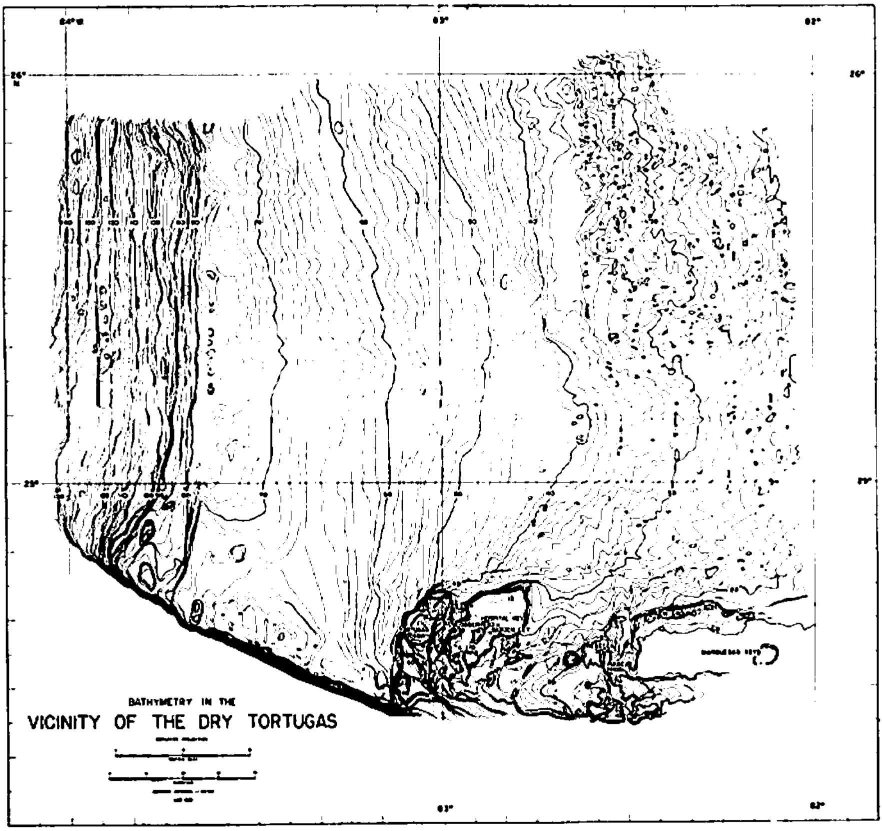

Fig. 2. Bathymetry of the southern Florida shelf.

The distribution of sediment types on the Tortugas fishing grounds is shown in Figure 3. Within the grounds, sand and silty sand are abundant. Sandy silt, the only other abundant sediment type present, occurs in a prominent strip aligned east-west just north of New Ground, Rebecca Shoal, and Dry Tortugas. Several small areas of clayey silt are present north of the Dry Tortugas, but no clay or sand-silt-clay types were dredged.

North of the fishing ground the average value of the total organic carbon content of the sediment based on similar depth intervals is considerably lower than on the fishing ground and increases slightly in deeper water (Fig. 4). Lindner (1965) divided the Tortugas fishing grounds north of New Ground and the Dry Tortugas into four zones, areas A, B, C, and D in Figure 4. The zones are essentially depth intervals and bound approximately, from east to west, the intervals 9-12, 12-18, 18-24, and 24-30 fathoms. Average values of organic carbon are 0.28% for the 9-12 fathom depth interval and 0.32% for the 24-30 fathom interval. Over the same depth intervals within the grounds the average percentages of organic carbon are all higher and more than double in area C. The average organic carbon content within area A, 9-12 fathom interval, is 0.54% which increases to a maximum average of 0.71% in area C, 18-24 fathom interval. In area D, 24-30 fathoms, the organic carbon decreases to 0.70%. This seaward increase in organic carbon results primarily from the occurrence of finer-grained sediments north of the Dry Tortugas. The higher percentages of organic matter in a sample are usually contained in the finer particle sizes of the sediment.

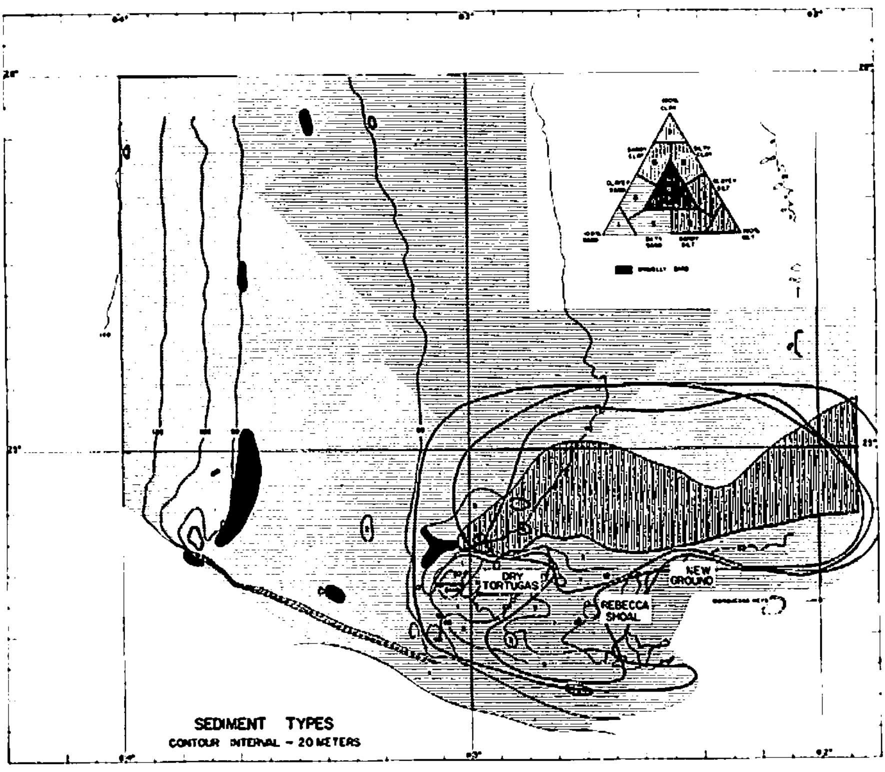

Fig. 3. Distribution of sediment types over the Dry Tortugas fishing grounds. Heavy lines encircling shrimping ground are different versions of its extent.

Shrimp landings for each area, proceeding seaward from A to D, are respectively 25, 68, 6, and 1% of the total landings.

A comparison of the average organic carbon content of sediments within the fishing grounds with the content outside shows the grounds have a considerably higher organic carbon content; some areas contain more than twice as much organic carbon. Sandy silt is the predominant sediment within the grounds.

Galveston Grounds

On the western continental shelf, off Texas, recent terrigenous deposits are in the process of covering the older sands although large areas of the relict surface still remain. Transport of these sediments from bays and rivers has produced a pattern of interfingering sands, silty clays, and sand-silt-clay types near shore. Recent sand is generally not deposited offshore in depths greater than 5 fathoms and the suspended load of the currents does not usually cover the bottom more than 20 to 25 miles offshore (Curray, 1960).

An important process less well known is the transport of sediment across the shelf by sediment plumes. They are similar to rip currents and carry fine detrital material well out on to the shelf. Although widely fluctuating throughout the year, they are believed to be semipermanent features and account in part for the irregular and patchy distribution of modern sediments over the shelf. A

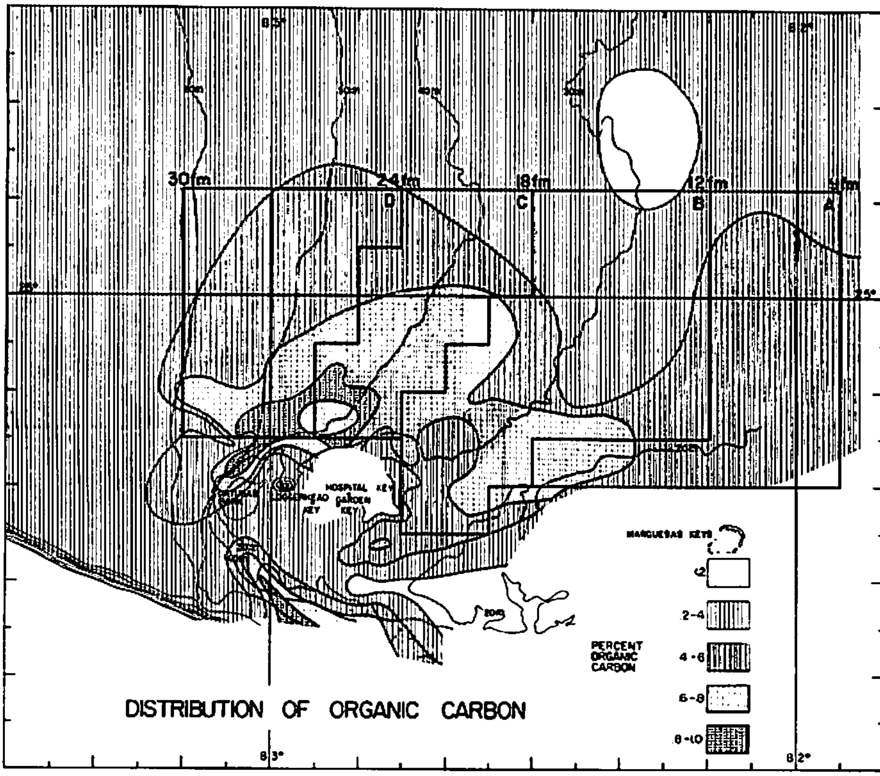

Fig. 4. Distribution of percent organic carbon in the vicinity of the Dry Tortugas. Blocks A, B, C, and D divide the fishing grounds into depth zones.

relationship between shrimp catch and the large plumes south of Galveston Island was established by Lindner and Bailey (1969). Within the shrimp fishing grid zone No. 18 and part of No. 17 south of Galveston Island, more than 57%

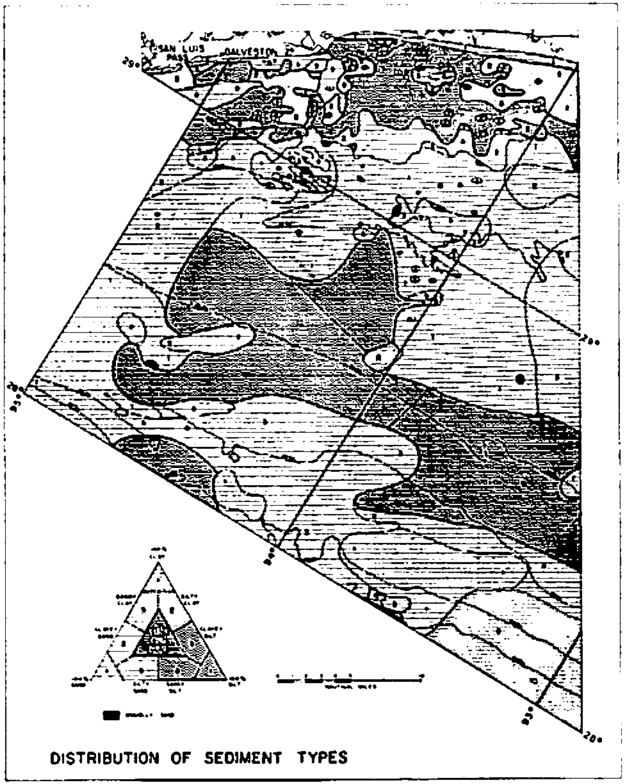

Fig. 5. Distribution of sediment types on the shelf south of Galveston, Texas, in shrimp fishing grid zone 18 and part of 17.

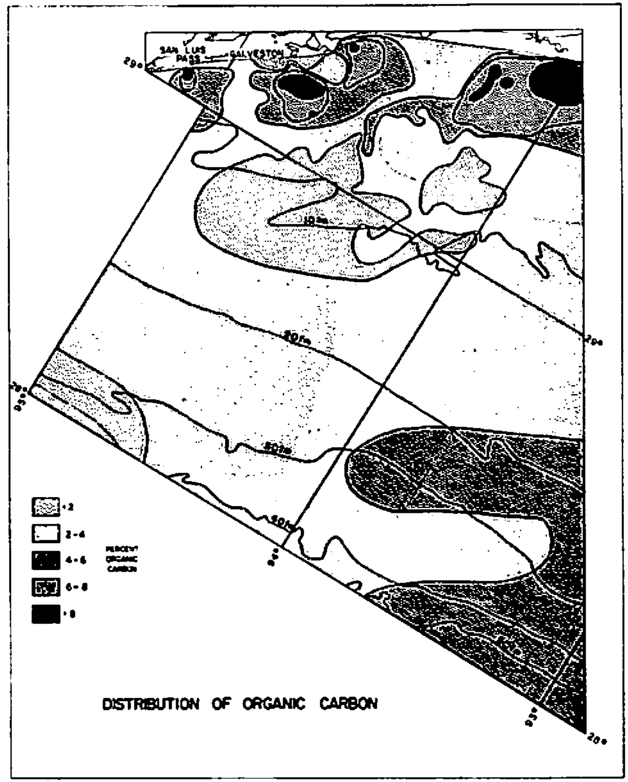

Fig. 6. Distribution of percent organic carbon in sediments over the fishing grounds south of Galveston, Texas.

of the surface sediment is a sand and about 35% is a sand-silt-clay type (Fig. 5). The sand-silt-clay is a type in which all three sediment classes are present in amounts greater than 20%. A small amount of silty clay is present principally among the nearshore sediments and well offshore around the 40 to 50 fathom contours beyond the main fishing area. Silt is almost absent on the grounds.

The distribution of the organic carbon in the sediments is shown in Figure 6. The areas of high organic carbon, greater than 0.4%. are associated with the sand-silt-clay and silty clay. The silty clay, because of its fine particle size, can have areas within its distribution that are high in organic carbon similar to the fine-grained clayey silts of the Dry Tortugas grounds. Sand is low in organic carbon, containing less than 0.4%. The shrimp catches from July through September 1964 are shown in Figure 7. Compared to the Tortugas grounds the relationship between the sediment type, organic content, and catch is more complex. Although the catch is irregularly distributed over the entire grounds, maximum catches occur principally in two areas. The major one is aligned generally in the area of the 20 fathom isobath and the other off Galveston Island. The sediment type sand-silt-clay is present within all the blocks of maximum catch. The organic carbon content is generally high in the areas of maximum catch.

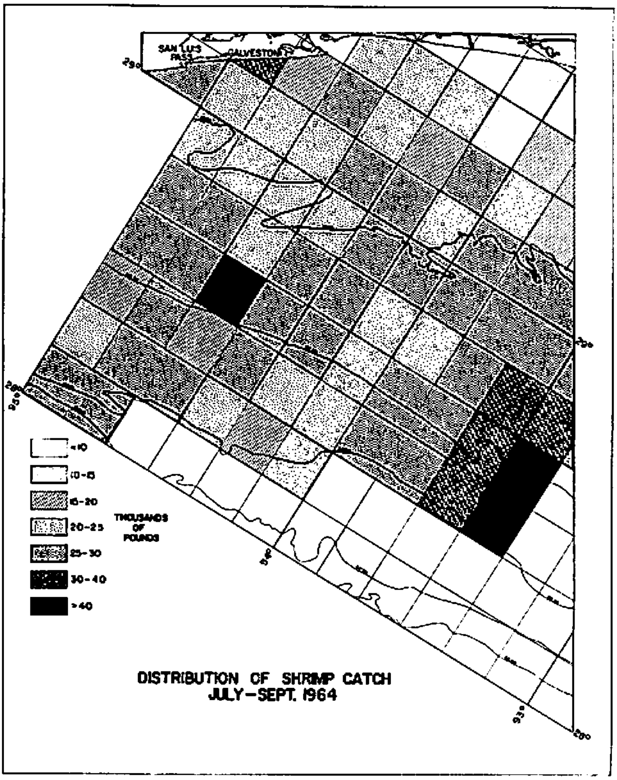

Fig. 7. Distribution of shrimp catch-effort, July-Sept. 1964 in the shrimp fishing grid zone 18 and part of 17.

SUMMARY

The sedimentary type most abundant in both fishing areas is sand. The most abundant catch, however, is associated with a sandy silt in the Dry Tortugas grounds and a sand-silt-clay in the Galveston grounds. The entire fishing grounds seem high in organic matter in comparison to areas outside the grounds.

Although only the gross distribution of commercial adult shrimp and sedimentary properties were considered, the results seem to indicate that fishing areas of large catch may have a high content of organic matter.

Other conditions certainly have an effect on the distribution of shrimp and may be influential in determining their movements over the grounds.

A study to determine if the distribution of particle size and organic matter show a relationship to the shrimp landings over the northern continental shelf of the Gulf of Mexico based on the data from shrimp fishing grid zones is in progress.

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Management Guidelines for Predicting Brown Shrimp, *Penaeus aztecus*, Production in Louisiana

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Abstract

Ten years of field studies on brown shrimp, *Penaeus aztecus*, in the Barataria Bay area of Louisiana, initiated in 1961, with an expansion into other coastal areas in 1966, provided a broad basis for recognizing environmental parameters affecting this species. Factors, such as temperature and salinity, are discussed in relation to their influence on the distribution of postlarval shrimp over the nursery grounds and extent of available, favorable habitat. Likewise, the diminishing effect of low salinity areas is considered in terms of increasing spring temperatures. Dimensions of distribution, relative abundance and growth of juvenile shrimp with respect to the three major coastal zones and the fixing of seasons for inside waters are discussed. Projections of prior years juvenile shrimp studies and landings data provide a useful basis for predicting the range of the new crop's harvest. These data and experiences provided the basis for statutory changes enabling more efficient utilization of the resource.

INTRODUCTION

Intensive field studies on brown shrimp *(Penaeus aztecus)* began in the Barataria Bay area of coastal Louisiana in 1961. This effort was expanded into other coastal areas in 1966. These investigations provided a broad basis for recognizing environmental parameters affecting this species. Previous reports (George, 1962; St. Amant et al., 1962; and, St. Amant et al., 1965) presented specific data concerned with postlarval sampling and recruitment into the Barataria Bay system, juvenile distribution, relative abundance and growth in terms of hydrographic data. A continuation of these studies complemented by the expansion into other coastal areas provided a basis of comparison of differences in predicting brown shrimp production for Louisiana. During this period, years of low, average and above average production were experienced. Hence, selected data are used to illustrate those environmental and other parameters which appear to be more meaningful for brown shrimp management guidelines.

Coastal Louisiana is considered here as having three primary zones -- East, Central and West (Fig. 1). Six study areas were established within these zones. Barataria Bay lies south of New Orleans and was the location of our initial quantitative efforts. Accordingly, these data serve as a reference base for those data from the other areas.

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[1]Currently on leave of absence at Louisiana State University, Baton Rouge, Louisiana

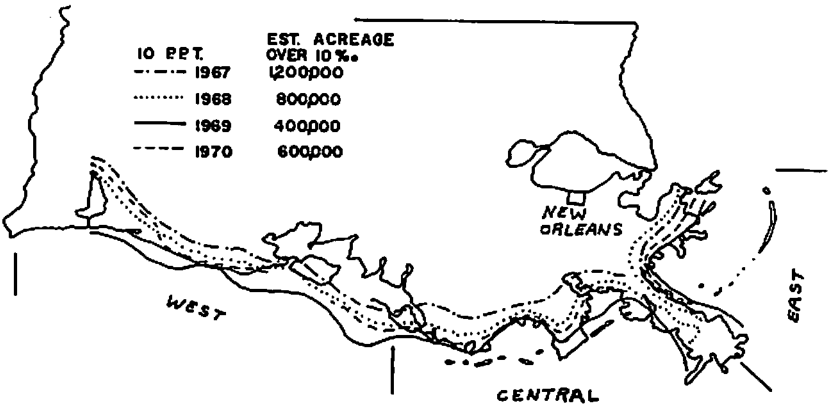

Fig. 1. Coastal Louisiana: March–April average salinity.

PRODUCTION

Brown shrimp production (Fig. 2) in Louisiana averaged approximately 18.4 million pounds (heads off) annually between 1958 and 1970, while preliminary data for 1970 showed it to be above average, on the order of 26 million pounds. It is evident that production during the 1960's for which our data are available was below average in 1962 and 1964, about average in 1963, 1965 and 1966, and above average from 1967 through 1970. By inspection, this figure would suggest that brown shrimp production here may be cyclic. White shrimp, *P. setiferus*, production is plotted to give a dimension to the two major species which comprise about 98% of our commercial shrimp catch. The average heads off total annual production for the two species since 1958 is approximately 41 million pounds. A comparison of production data for these two species suggests that there may be some compensating mechanism functioning between the two if environmental conditions are generally satisfactory–i.e., when brown shrimp

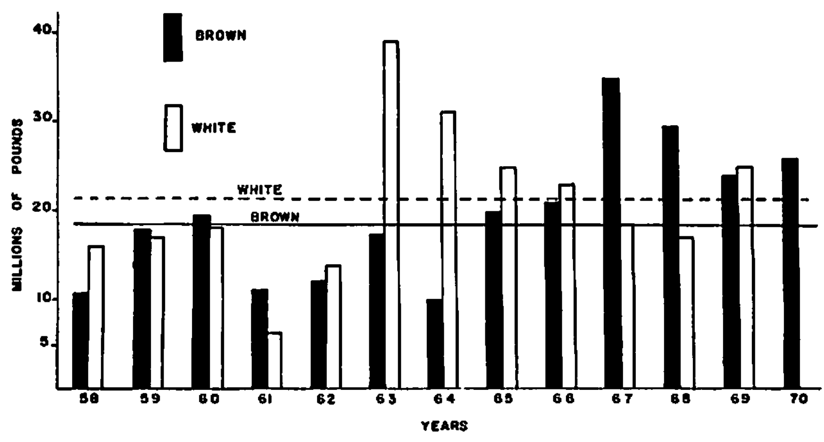

Fig. 2. Louisiana shrimp production – Heads off.

production is low, white shrimp production runs high. Likewise, when white shrimp production is low, brown shrimp production increases, appearing to compensate the annual total crop.

Focusing on brown shrimp production for the Barataria Bay area (Fig. 3) which includes Caminada and several other smaller bays, the 1970 season (May - July) is one of the best on record being approximately 4,980,000 pounds. The average production for the previous twleve years was 2,360,000 pounds annually. This local production generally agrees with the annual totals for the state in being below, average or above average. Such production in the Barataria Bay area for 1970 suggests that postlarval recruitment and survival were good and environmental conditions were excellent for brown shrimp.

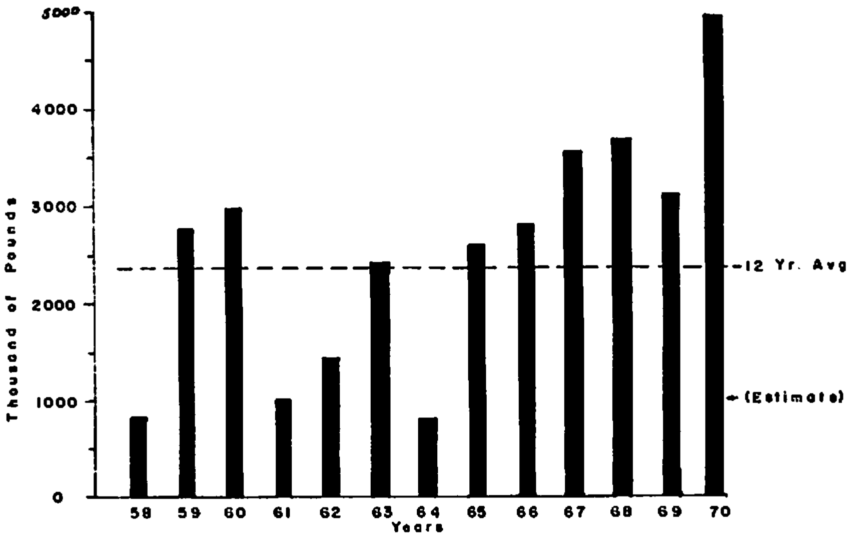

Fig. 3. Brown shrimp production (heads off) May–July: Barataria and Caminada Bays.

FACTORS

Postlarvae

Postlarval brown shrimp were recruited into the bay system in greater numbers between January and April with more peak movements occurring in February and March during these observations. Based upon these studies, the number of postlarval brown shrimp taken in the passes annually from January through May is given in Figure 4. A comparison of these numbers (Fig. 4) with production (Fig. 3) shows that a relatively low order of recruitment as evident for 1967, 1968 and 1970, resulted in above average production. To the contrary, large numbers of postlarvae taken in 1964 and 1966 failed to provide comparable production. Low-level recruitment and below average production was observed in 1962. Thus, factors other than total recruitment must contribute to production.

Peak postlarval movements into this estuary are shown in Figure 5. Time of arrival and condition of the environment appear to be important factors associated with survival of postlarvae on the nursery grounds. For example, in 1964 large numbers were recruited in late February and early March; however, that year was well below average in production. An early arrival of moderate numbers was observed for 1969, and yet production was above average.

Salinity

The salinity regime of the Barataria Bay area is typically estuarine (Fig. 6) as suggested by these data. Northern or upper bay salinities during March through May vary from almost 0 to 25 parts per thousand (°/oo), being substantially influenced by rainfall within the watershed. Those of the southern or lower bay are expectedly higher, ranging from 14 to 28 °/oo. These salinities are influenced more by the offshore littoral waters. During periods of high river, fresh water from the western passes of the Mississippi River requires approximately 8 days to drift across the Gulf and enter the passes of Barataria Bay. This causes salinities of the lower bay to be greatly lowered. In the low production

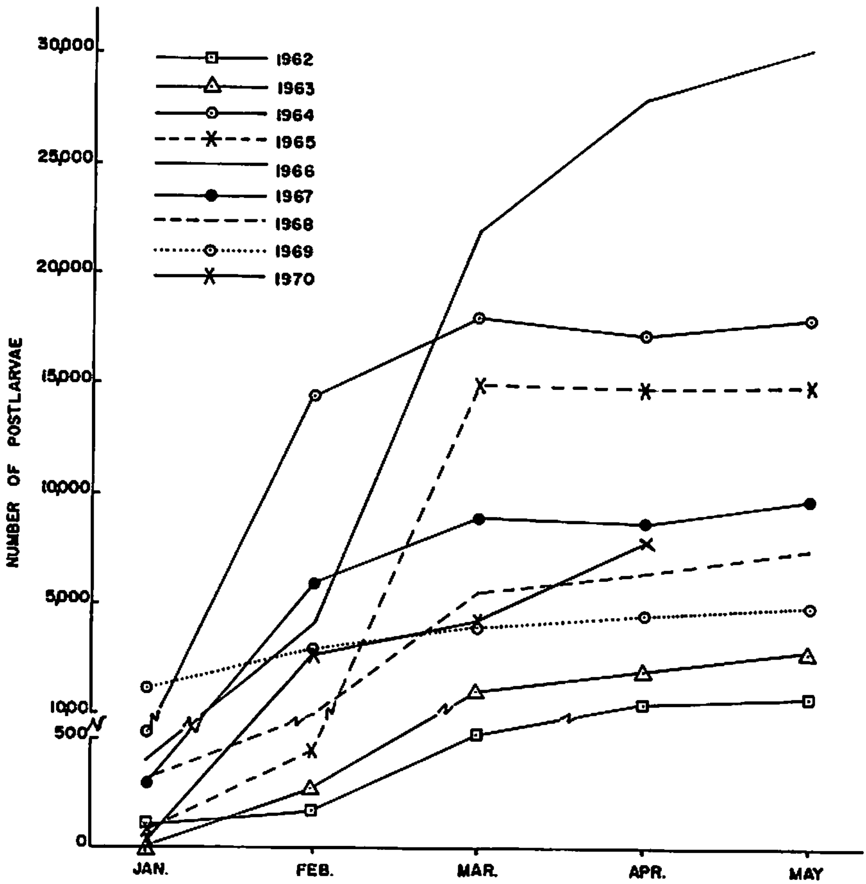

Fig. 4. Number of postlarval brown shrimp: Barataria Bay Passes.

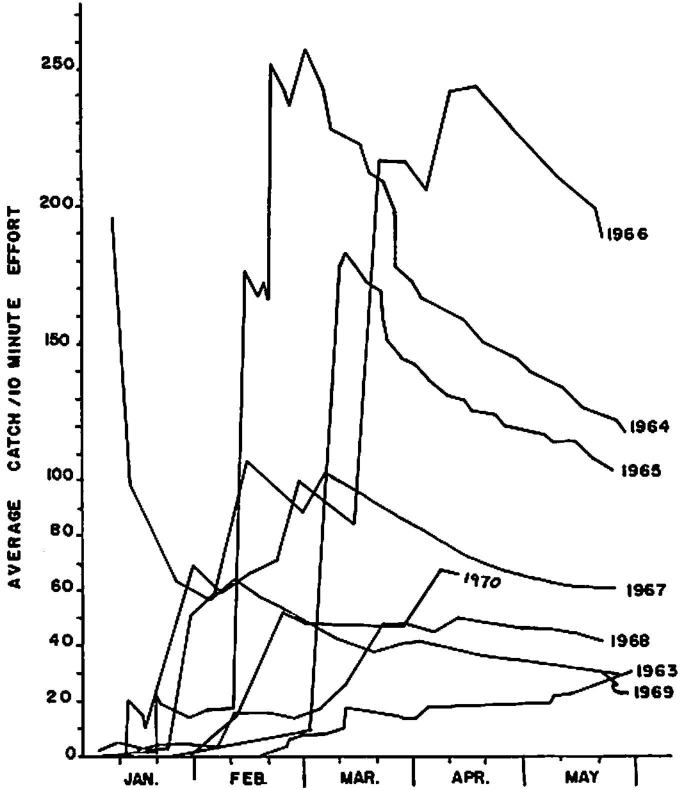

Fig. 5. Barataria Bay – Cumulative postlarval catch.

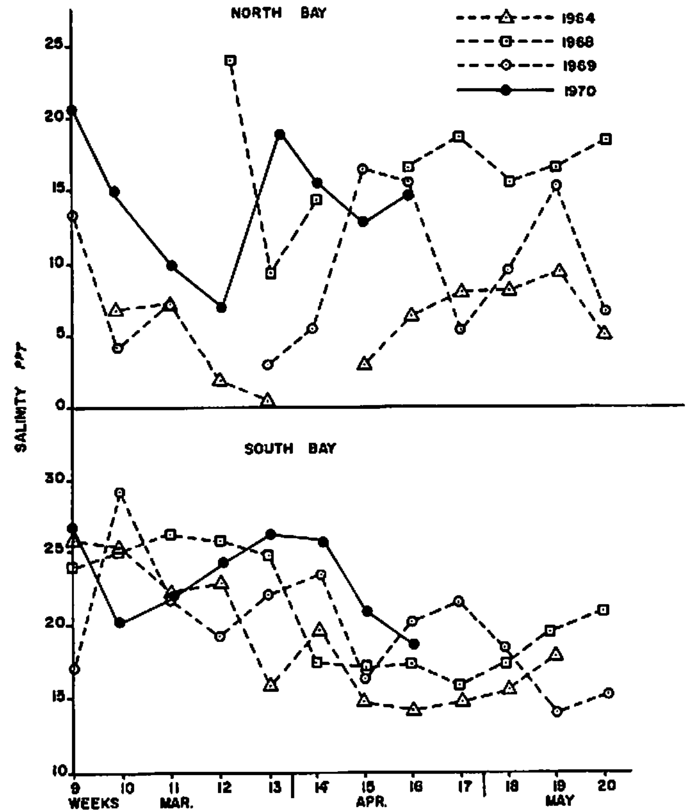

Fig. 6. Comparison of north and south bay salinities in Barataria Bay.

year of 1964 (Fig. 3), salinities were decreasing to their lower range in the south bay during March while becoming virtually fresh in the north bay. In retrospect, the implications were not clearly recognized at the time. A very limited higher salinity habitat remained available to the postlarvae following the peak of recruitment in late February and early March. A late peak of recruitment in 1968 with generally higher salinities ranging from 17 to 26 $^{o}/oo$ in south bay and 9 to 23 $^{o}/oo$ in north bay appears to correlate well with its production. This led to consideration about the extent of available nursery grounds having average salinities of 10 $^{o}/oo$ or higher during March and April since this appeared to be a critical period for survival of postlarvae. Superimposed on the map of coastal Louisiana (Fig. 1) are 10 $^{o}/oo$ average isohalines for March and April with the estimated available acreage of this habitat during the past 4 years. Since these are the only years for this type of projection, this specific isohaline may not be definitive. Nevertheless, during these 2 months it seems to be significant for juvenile shrimp are taken earlier and in greater numbers within this salinity zone of 10 $^{o}/oo$ and higher. Also, above average production fits well for these years.

Temperature

Observations made during the past several years indicate that increasing numbers of juvenile brown shrimp begin to appear when temperatures increase and hold at 15C. At sustaining temperatures of 20C, brown shrimp begin to disperse into areas having a salinity less than 10 $^{o}/oo$. Since sampling data is treated on a weekly basis, temperature data is treated similarly (Fig. 7). It shows that temperatures reached 20C during the first 3 weeks of April each year over the past 13 years. Average or above average production occurred during the years of early warming (April 2 - 8) and the same was true for warming during the second week (April 9 - 15) except during 1962 when production was below average. Warming did not occur until the third week (April 16 - 22) during 4 of these years; production for 3 of these was well below average while that of 1966 was just above average. Hence, early warming without subsequent severe decreases due to late cold fronts appears to support higher shrimp production provided an extensive environment of favorable salinity was available and postlarval recruitment and survival was adequate.

Juvenile brown shrimp growth was compared with temperature (Fig. 8) for 4 years having above average production to illustrate the influence of temperature. It is evident that the earlier warming cumulative temperatures of 1967 in an area estimated to be 1.2 million acres (Fig. 1) having favorable salinities over 10 $^{o}/oo$ showed more rapid growth. Also, a year having a late peak postlarval recruitment as 1970 with steadily warming temperatures suggests that lower salinity has a diminishing effect. Half of the estimated area of salinities of 10 $^{o}/oo$ or over for 1967 (Fig. 1) was seemingly available in 1970; yet, production (Fig. 3) was approximately one-third greater, thereby reinforcing the previously suggested diminishing influence of salinity with increased warming above 20C.

Growth and Density

Growth curves for the years 1962 through 1970 are shown for the Barataria Bay area in Figure 9. Generalizing, relatively slow growth was observed until water temperatures warmed above 20C after which rapid growth occurred as temperatures approached 25C from late April into the latter part of May. The leveling off and negative growth observed for some years in late May is

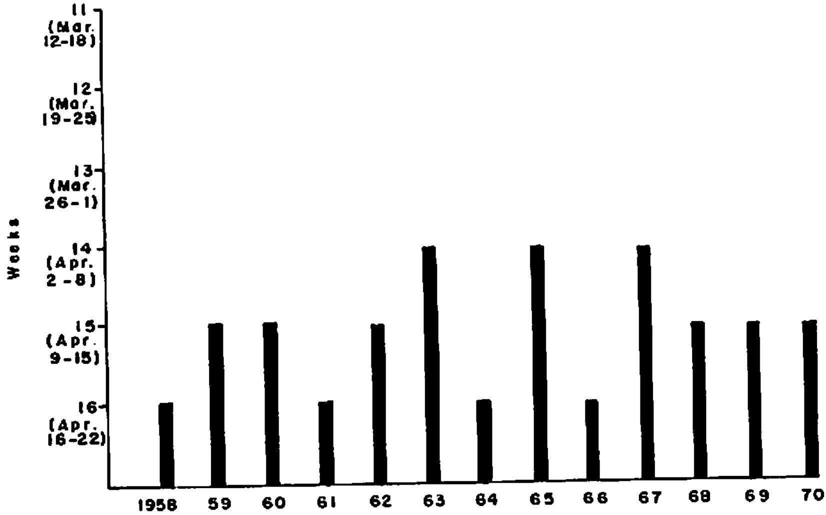

Fig. 7. Weeks water temperature warmed above 20C.

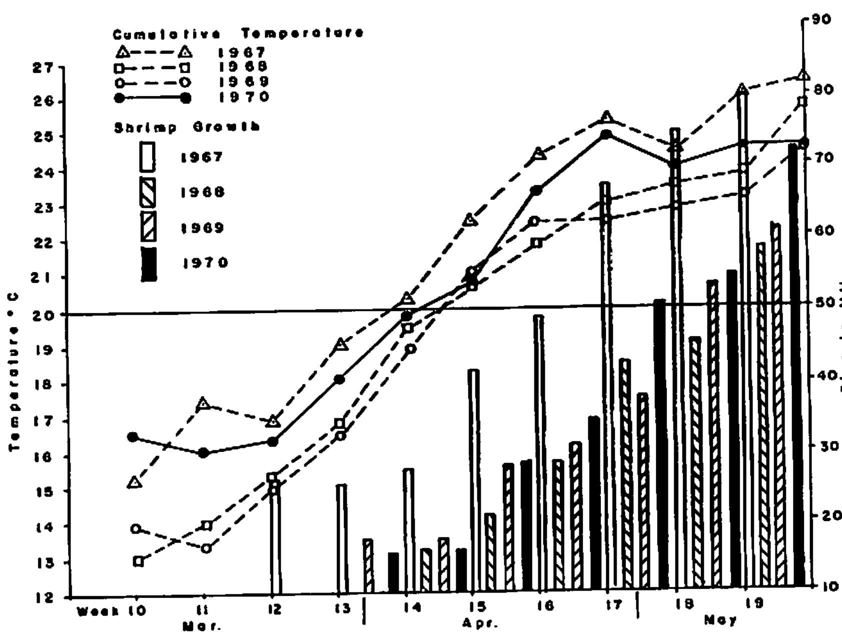

Fig. 8. Comparison of juvenile brown shrimp growth with temperature.

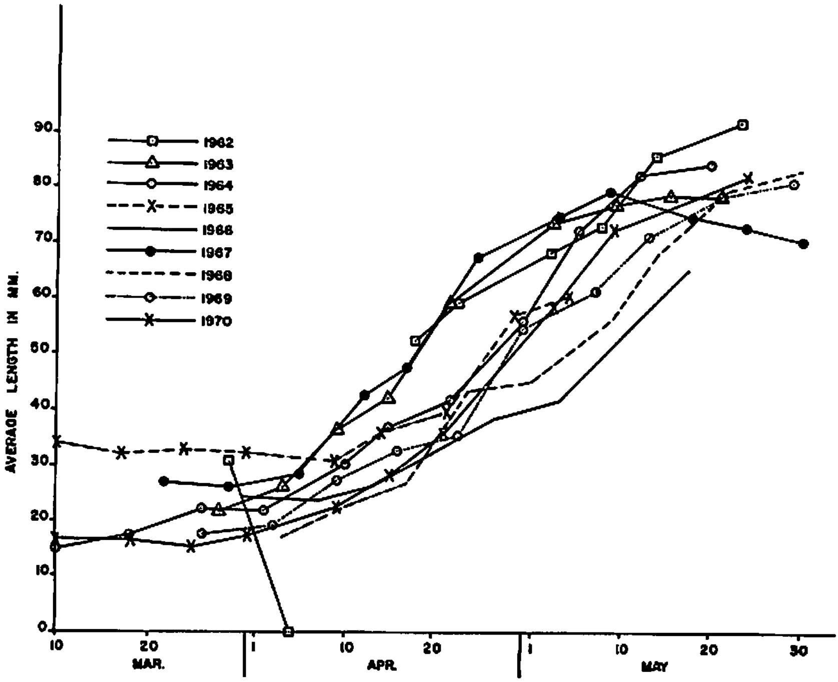

Fig. 9. Barataria Bay – Average length of juvenile brown shrimp.

attributed to two factors since sampling stations remained fixed: (1) Migration of the larger shrimp to the lower bay areas and offshore, and (2) An increase of smaller juveniles resulting from postlarval recruitment to the nursery grounds. Growth observed for 1962, 1963 and 1967, is associated with temperatures having warmed above 20C by the second week of April. Other curves lag by 1 to 3 weeks and this appears to be temperature-related in part.

Selected years of catch data are presented in Figure 10 to illustrate generally (1) the year to year variance, (2) the absence of a steady state within a year, and, (3) the build-up of numbers. Represented by these 5 years are less than average production for 1964, about average for 1966, and above average for 1968, 1969 and 1970. Our predictions for each annual brown shrimp crop are based upon data accumulated through mid-April and those data of prior years. At this time we feel that it is possible to predict the crop whereas, in 1964 juvenile brown shrimp catch data were of a low order of magnitude and remained so. However, postlarval catch data were excellent and it appeared as though the crop was just slow in developing. Based chiefly upon the postlarvae, an above average crop was predicted. In retrospect, it is obvious that the postlarvae experienced a high mortality which may be attributed to an early arrival having too long a period on the nursery grounds under adverse environmental conditions of low salinities and low temperatures. The effect of predation under such circumstances is not well understood.

Even so, it may be stated that an average density of postlarvae arriving in late March or early April in an estuary having salinities of 10 ‰ and greater with increasingly warming temperatures above 15C will provide for good survival of the postlarvae and an average to above average production of brown shrimp. To the contrary, early arrival of large numbers of postlarvae in an estuary having low salinities below 10 ‰ and low temperatures results in poor survival and a below average production. As postlarval numbers and conditions vary between those given above, production also varies within these limits.

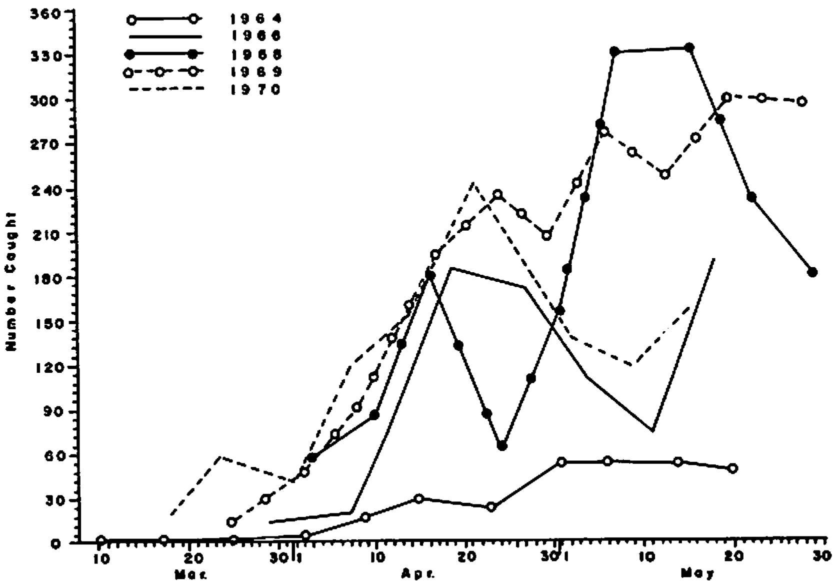

Fig. 10. Juvenile brown shrimp – Average catch per 10 minute sample.

The 1964 curve (Fig. 10) in contrast with the others more closely, but incompletely, approaches a steady state. The other curves more strongly suggest a pulsing effect which allows for a continuing periodic recruitment of postlarvae thereby providing for replacement stock on the nursery grounds for those migrating out as sub-adults.

Based upon catch data of previous years, improved sampling confidence and general distribution within the Barataria Bay area, the build-up of numbers by mid-April with respect to previously discussed parameters now provides a basis of dimension for this area. Also, it serves as a reference for other zones of coastal Louisiana.

Catch and growth data for 1969, which are characteristic of most years for coastal Louisiana, are shown in Figure 11. Area 1 essentially represents the East zone (Fig. 1), Areas 2 to 5 comprise the Central zone, and Area 6 the West zone. By inspection of the catch curves, it is evident that .Areas 1 and 6 (East and West zones) lag some 2 to 4 weeks behind that of the Central zone. Interestingly, catches generally run much higher in mid-April for Areas 2 and 3 than those of Areas 4 and 5. Usually, catches of the latter two increase rapidly in late April

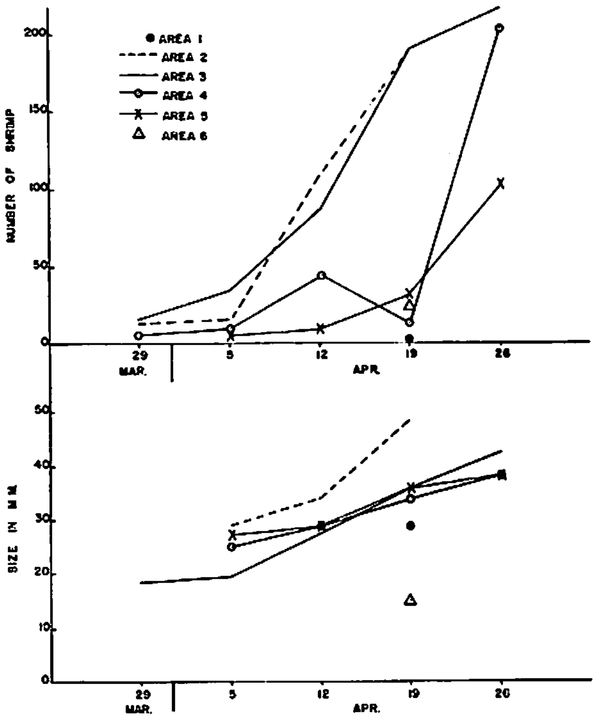

Fig. 11. Coastwide juvenile brown shrimp by size and number in 1969.

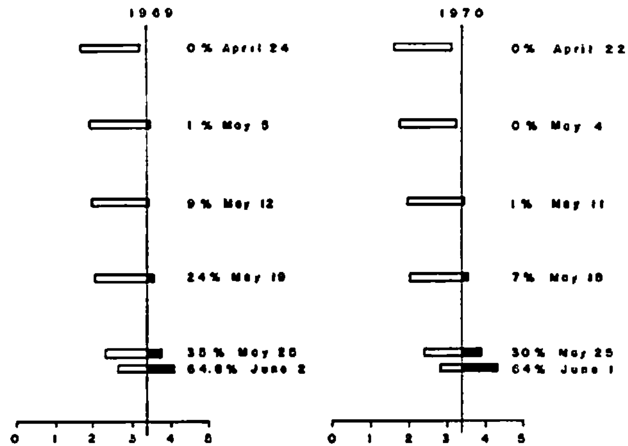

Fig. 12. Projected growth rate at 1.5 mm per day.

and early May, approximating those of Areas 2 and 3. Growth curves for each of these areas generally are similar to the catch curves with the exception of Area 2. Here, the shrimp usually average 10 to 15 mm larger than those of the other areas in the Central zone in late April.

Projected Growth Rate and Fixing of Seasons

Since brown shrimp can grow rapidly (up to 2.5 mm/day, although usually less) as water temperatures warm to 25C or more in late April and most observed sustained field growth rates fit during this period, we use 1.5 mm/day as a projected growth rate. The purpose is to develop recommendations for consideration by the Louisiana Wild Life and Fisheries Commission in fixing the opening and closing dates of the brown shrimp season for inside waters. These are waters lying inside of the barrier islands and beaches. Representatives of the shrimp industry advised us that a 100-count heads-on shrimp is a useful size (about 86 mm) for processing. Based upon observed growth characteristics of the current year for the Barataria Bay area, projected growth rates are calculated to indicate when more than 50% of the first major group of shrimp will achieve this size. Projections for 1969 and 1970 are given in Figure 12. The calculated growth lag between comparable periods of 1969 and 1970 illustrates the crop's capability in maturing by early June. From Figure 9, it becomes obvious that in recent years the crop becomes usefully available sometime betwen May 10 and June 1. Generally, these projections fit the Central sector from which the majority of Louisiana's sub-adult brown shrimp are produced.

Data of the types given herein are presented to representatives of the shrimp industry including the fishermen in mid-April. The following week on the fourth Tuesday in April, these same data with our recommendations are presented to the Commission for its consideration. At times, some fishermen urge modification of our recommendations. The Commission has the responsibility of fixing the opening and closing dates of the season within a statutory framework. Since 1962, our management recommendations for brown shrimp were accepted; infrequently, nominal modifications were made.

MANAGEMENT PROBLEMS AND STATUTORY CHANGES

Undersized white shrimp (68-count heads-on is legal size) frequently overwinter in near offshore waters. In the spring as temperatures begin to rise, these shrimp move into estuarine waters to complete this part of their life cycle. Good numbers of these large shrimp occur during some years. When this happens, some fishermen quite naturally want to catch them. Keeping in mind that the late spring shrimp season was designed for catching brown shrimp and statutorially had a 15 day variance for opening between May 1 and 15, to extend for 60 continuous days and to close by July 15, it was virtually impossible to permit fishing for an estimated 0.5 million pounds of white shrimp without jeopardizing the loss of several million pounds of brown shrimp. This would be attributed to a loss of fishing time in the latter part of the season and possibly some loss due to catching brown shrimp too small to use when they would ordinarily be experiencing a rapid growth phase. A part of the shrimp fleet in all probability would catch most of the available white shrimp in less than a week. Then that part of the fleet would be confronted with waiting 2 to 3 weeks until 50% or more of the brown shrimp reached a useful size.

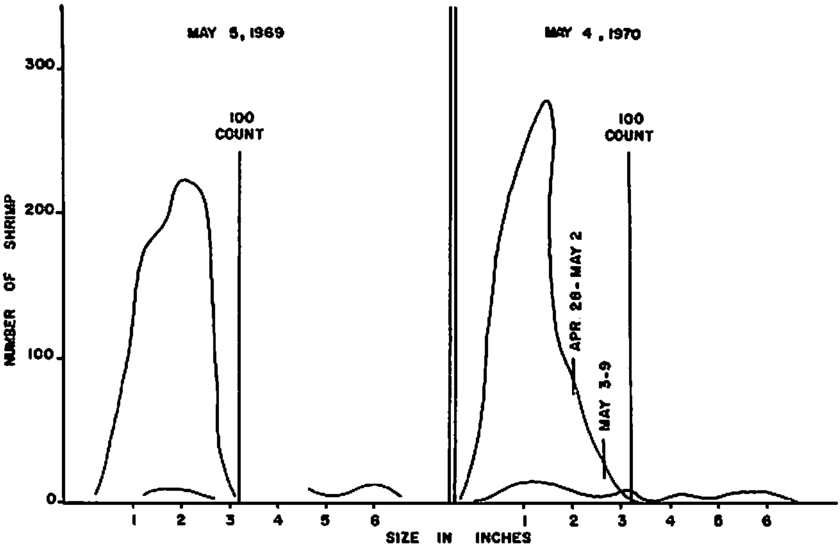

Fig. 13. Barataria Bay shrimp population.

Data presented in Figure 13 for the Barataria Bay area in early May of 1969 and 1970 is probably representative of this problem and typical for the several areas where it arises periodically in Louisiana. The large peaked curve represents the brown shrimp while the small flat curve represents the white shrimp. On May 5, 1969, some 17% of the available crop were white shrimp ranging in size from about 119 to 165 mm, this group being discreetly separated from the smaller brown shrimp. Accordingly, it appeared as though it would be feasible from the management viewpoint to harvest them. However, it could not be accomplished without the losses or risks stated above. To the contrary, the curves for May 4, 1970, show some 10% of the crop being white shrimp with less than 6% being larger than 100-count in size and these not being discreetly separated as in 1969. During the interim period in 1969 and at the urging of representatives of the industry, the Louisiana Legislature amended the law to provide a more lenient framework to the Commission for managing the spring shrimp crop. Generally, most shrimp fishermen and others in the industry have come to understand and accept these data and our interpretations; a comparatively small minority rejects them with little, if any, apparent basis. Because of this general acceptance throughout coastal Louisiana, the above mentioned statutory change was accomplished without the usual severe difficulties associate with much fish and wildlife legislation. The application of this statutory change in Breton Sound permitted the continued harvest of brown shrimp without jeopardizing the developing crop of white shrimp in more inshore waters.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to the technical and nontechnical staff of the Division of Oysters, Water Bottoms and Seafoods for their helpful and extensive efforts in the sampling and compilation of the data. Also, we express our gratitude to Mr. George W. Snow, Regional Supervisor, Statistics and Market News, National Marine Fisheries Service, and his staff for their continuing cooperative assistance in providing catch statistics.

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DISCUSSION

Shrimp Session

Discussion Leader: R. A. Wade
Discussion Panel: L. Demarest, S. Dobkin, E. M. Rome

Some Economic Aspects of Pink Shrimp Farming in Florida

L. G. Anderson

Q. Provenzano: What is the feeding ratio in pounds of food to pounds of shrimp?

A. Anderson: Twenty pounds of food per day for 180 days produced 1,000 pounds of food shrimp, or a conversion ratio of 3.6 to 1. I realize the biological significance of such conversion ratios but as an economist I must point out that there are many other things necessary to carry out this conversion. It's the high cost of these other items: (land, labor, and capital) that make the gloomy predictions of this paper necessary.

Q. Feddern: Why did you discontinue your economic analysis after fifteen years?

A. Anderson: The economic rational for such a step is that we are uncertain as to what will really be happening even next year (i.e. prices, costs, and even the social and legal situation may change). It is not wise to count your profits too far in the future. Also when it is considered that profits in the future have to be discounted by the interest rate to compare them with money today, it is realized that the discounted value of profits 15 years from now is quite small. For example the present value of $40,990, the net cash flow of the 1,000 acre food shrimp farm 16 years from now is $19,100 when the interest rate is 5% and $2,200 when it is 20%. It can be seen then that you really don't add much to the present value of a project, and hence to its internal discount rate, by extending the project for long periods. For this reason it was decided to cut off the project after 15 years.

Refining Shrimp Culture Methods: The Effect of Temperature on Early Stages of the Commercial Pink Shrimp

A. Thorhaug

Q. Dobkin: Your results showed survival time for various temperatures for each shrimp larval stage. Were other physical conditions also investigated?

A. Thorhaug: We attempted to use optimum conditions for all the other variables so that we only varied temperature. However, we know that the combined effect of two nearly lethal factors is greater than either single factor acting alone. For instance, a shrimp stressed for both temperature and salinity will die more readily than one stressed for salinity alone. This same type of experiment should be carried out varying salinity, food, oxygen, light, and other important factors to determine the optimum combinations for rearing shrimp as well as the danger points. The shrimp seemed to require 31 ‰ salinity and vigorous air bubbling in our conditions. These have been previously discussed by Idyll *et al.* 1970.

Q. Rome: Did you conduct experiments with other species of shrimp?

A. Thorhaug: Yes. We were fortunate to receive some larvae of *Penaeus californiaensis* several months ago. Although we do not have results comparable to the ones I just showed, they appeared slightly less tolerant of high temperatures in the later larval stages. There has been work on the temperature tolerance of the white shrimp by workers at the National Marine Fisheries Service Galveston biological laboratory, as previously mentioned.

Q. Demarest: Has there been experimentation with deeper tanks to increase larval survival?

A. Thorhaug: We have not personally experimented with different tank depths. It is obvious that the heat capacity and thus the fluctuations in temperature will partly depend on the depth of water in the tank. At Turkey Point three types of holding facilities are used: large indoor, temperature controlled tanks for the first naupliar stage; then out-of-doors, covered deep concrete tanks with running saltwater for stages up to post-larval; at this point shrimp are put into uncovered, relative shallow, large ponds.

The Distribution of Sediment Properties and Shrimp Catch on Two Shrimping Grounds on the Continental Shelf of the Gulf of Mexico

John R. Grady

Q. Dobkin: Is the organic content of the sediments high on the Tortugas grounds because of the presence of shrimp there rather than the reverse?

A. Grady: Shrimp would add to the total organic matter on the grounds although I have not computed how much this could be. Organic matter, when present in any amount, generally is held in higher concentrations by the finer particle sizes. Sediments just north of Rebecca Shoal and the Dry Tortugas have a slightly finer median diameter compared to the sediments outside the grounds, therefore, on the basis of the sediments alone, one could expect a slightly higher content there unless organic production was much lower than the other areas.

Management Guidelines for Predicting Brown Shrimp, *Penaeus aztecus*, Production in Louisiana

T. B. Ford

Q. Demarest: Do you need wider latitude and more time to control the brown shrimp season?

A. Ford: We do need more time. The revised law provides more leeway now. We are involved in a mixup, i.e., which group within the shrimp industry gets the first opportunity to catch the shrimp. We feel that we have good indications as to how it can be handled. The question is one of people management – will the industry accept and abide by good management.

Q. Rome: Is there an overlap with brown shrimp and white shrimp cognizant with the season?

A. Ford: Yes, at times. During the past several years, we could have had a one week open season in certain areas for white shrimp prior to the brown shrimp season.

Q. Dobkin: Can you do this predicting by areas?

A. Ford: Generally we feel that this approach by itself is poor because it would concentrate the fishermen in one area. It is regretful to us that the opening date for each area cannot be satisfied now. We could not change it 3 or 4 weeks. Previously, it had to be May 1st to the 15th.

Q. Good: Does there appear to be any deterioration in the area?

A. Ford: In general, at the present time, some 3 or 4 areas are deteriorating rapidly. There is a possibility of retardation of this by the use of the river water and its sediments to re-create land. We think that there are management opportunities for such a land-building process; however, it will cause numerous people management problems.

Q. Good: Do you have other factual information relative to it?

A. Ford: We have no specific information about regulating the flow of water on the upper tributaries of the Mississippi River but strongly suspect that it is practiced for flood control and navigation.

Q. Idyll: I am interested in the people management thought. All regulation is not people management. Among the fishing industry in Louisiana, the boats could do certain things relative to harvest.

A. Ford: The fisheries there are as we represent them. We hope we can gradually set aside these nursery grounds by a good management program. The first review of shrimp data was made with representatives of the shrimp industry in 1962. There has been good appreciation of these data. Nevertheless, we have a long way to go.

Q. Feddern: Have you done anything with pesticides?

A. Ford: We have not done anything relative to pesticides, such as bio-assays, at our marine laboratory. We hope to get into that. One of our difficulties has been time and competently trained personnel to handle this. All we know is that if crude oil is highly toxic, it is difficult to explain the high level of shrimp production in view of the substantial amount of oil offshore and inshore that occurs periodically. We found no evidence of damage in inside waters from the Chevron wild wells off Main Pass in 1970.

Q. Whiteleather: Why are you having difficulties obtaining pond stock?

A. Ford: One of the limiting factors in shrimp mariculture is postlarval shrimp for stocking ponds. The first culture efforts were made some time ago and considerable progress has been made, however, interest developed too rapidly without permitting time for solving the basic problems. I think we are about to see a reverse. Many are alert to the progress that is occurring and are watchfully waiting for a major breakthrough on the culture of brown and white shrimps. Another problem is ownership of wild shrimp entering private marsh ponds.

THURSDAY—NOVEMBER 12, 1970

Chairman - C. E. Larson, *U.S. Atomic Energy Commission, Washington, D. C.*

United Nations Development Program Food and Agriculture Organization of the United Nations Fishery Development Projects in the Caribbean

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New York, New York

Abstract

This paper gives a general resume of the objectives, the activities, and the results of several fisheries programs which the UNDP supports in the Caribbean. It reviews the development and results of five projects located in the Caribbean and Gulf of Mexico and presents a brief summary for each project. An over-all view is given of the orientation similarities and differences of the several programs, and an assessment is made of their contribution to the countries and the region.

INTRODUCTION

The United Nations Development Program, including its parent agency, has been in existence for only a little more than a decade. Yet during this short period greater changes have been made in the fisheries of the world's developing countries than have taken place throughout their entire previous history. During this same decade great changes have also taken place in the fisheries industry of the world's developed nations.

As a word of explanation, the UNDP is an agency of the United Nations, established originally in 1958 as the UN Special Fund, with headquarters in New York. It is responsible for assisting the developing nations to raise their levels of food and industrial production and to increase their economic well-being. The projects it supports cover all sectors of modern technology, from agriculture, health, and labor to the most complex industrial and scientific problems. In our field (fisheries) its contribution has been significant. In many places, a developing nation's scene has changed from one of picturesque, pleasant and unproductive artisanal fishing to dynamic industrial complexes yielding modern products and high returns.

In 1964, when my predecessor, Dr. Hiroshi Kasahara, reported to the Gulf and Caribbean Fisheries Institute on the Programs for Assistance in Fishery Development, the UNDP then had ten fishery projects and only six were actually in operation.

In the ensuing years, the UNDP, through its executing agency, FAO, has completed eleven projects, is presently engaged in or preparing to operate forty-two projects, and is considering twenty-one others. Several hundred fisheries technicians are deployed around the world. Budgets for these programs have amounted to $125.0 million, of which about three-fifths was supplied by the co-operating governments. I realize that these figures may not be tangible to you insofar as they have meaning in their effect upon individual fisheries projects. They do, however, indicate the magnitude of the global effort that is taking place to upgrade the fisheries sector of the developing nations' economies.

The picture in detail is not all this simple, however, and not all activities undertaken can be immediately identifiable as successful. In many new countries the development process is a slow one, since all the elements required to support the growth of modern methods are not always present. In some cases, the project is simply the yeast that starts a trend, which then may require years to reach its full momentum. The Caribbean area is one example. There are five projects presently being supported by the United Nations Development Program in the Caribbean area: The Central America Fishery Development Project (REG 30), the Caribbean Fishery Research and Development (REG 189), the Colombia Marine Fisheries Development Project (COL 22), the Venezuela Fishery Research and Development Project (VEN 14) and the Mexico Fisheries Research Project (MEX 15). We will look at each of these to see how they compare, what their objectives are, and what have been some of the results to date.

CENTRAL AMERICA FISHERY DEVELOPMENT PROJECT (REG 30)

The Central America Fishery Development Project includes Costa Rica, Guatemala, Honduras, El Salvador, Nicaragua and Panama. The project was originally declared operational in November 1966 with a total budget of $5.7 million, funded in part by the countries and in part by the UNDP. The Central America's project objectives were to help the countries assess their marine resources, foster increased fishery products, stimulate marketing and develop the fisheries economy. The project got off to a slow start, because there was a delay in delivery of the four project vessels. Once the vessels were delivered and the project became operational, the situation changed and it is now under full steam and producing results of considerable value to the participating countries.

Deep-water shrimp resources recently found by the project's exploratory activities off the Pacific Coast of Central America will probably lead to additional investment in vessels and equipment as the tempo of this new-found resource speeds up.

Lobsters have been found in significant quantities off the coast of Honduras and Nicaragua, and fishery production has increased seven-fold in Nicaragua.

New fisheries products for both export and local consumption are being stimulated by the activities of the project in the countries. Advice on improving the processing technology throughout the region is being given. All this leads to the need for financing fish terminals, markets and shops. These activities may be underwritten by financing from the International Bank.

Interest developed by the project has already brought an investment of $10 million to construct a fishing port in Panama City. Part of the Panamanian shrimp and purse-seine fleet is being modernized at a cost of $3.7 million. There is also the possibility that international funds may be available to finance trawling vessels in the Nicaraguan fishery.

This project terminates at the end of 1971. Several new local industries will have been developed as a result of its work. While we cannot assess the total investment the project has attracted, we do know that it is already several times greater than the project's total cost.

THE CARIBBEAN FISHERY DEVELOPMENT PROJECT (REG 189)

The Caribbean fishery development project began in August 1965. The project has gone through its first phase and is now in its second one. Original funding was $2.2 million, of which approximately $1.5 million was supported by the UNDP. This project was a co-operative venture of nineteen governments: Barbados, Antigua, Monserrat, St. Lucia and Antilles, Grenada, St. Vincent, Dominica, French Republic, Republic of Haiti, Jamaica, Surinam, Trinidad and Tobago, Guadalupe, Guyana, Puerto Rico, St. Kitts and Nevis-Anguilla.

Its objectives were to conduct exploratory fishing, to carry out market studies and demonstrations, and to train fishermen, officers and fishery officials. Three vessels were supplied for the exploratory work; two of 82 feet and one of 56 feet.

A 2-year continuation of the project began this year in June, with a budget of $1.8 million, of which $1.2 million was furnished by the UNDP. Although the project is still under way, it has already piled up a significant amount of investment in its area.

The three research vessels have found valuable fish resources in the region, particularly along the Guiana shelf. Capture of skip-jack and other pelagic fish like mackerel, wahoo, etc.; long-line fishing; shark fishing; and pargo fishing can be increased if not significantly improved. One benefit from the marketing and demonstrations is the increase in the consumption of fish taken by local fishermen. Today Caribbean nations must import about three-fourths of their fish needs. As consumption of local fishery products increases, these countries by 1975 may be saving nearly $30.0 million a year in foreign exchange for fish products that must now be imported.

The exploratory fishing and marketing operations of the project have demonstrated that there are good investment possibilities in the trawl fisheries off the coast of the Guianas.

In its training and demonstration operations, the project is training trawl crews, captains, fishery officials, developing fish-processing facilities, setting up distribution net works and market schemes, and providing investment consultant services. Private investment and some public investment will be generated from this activity. Unfortunately, in most places in the Caribbean, the infrastructure for the developing fisheries is inadequate or lacking, so that fish landing as well as processing and marketing facilities throughout the area will require public investment. The project has presented plans for fisheries terminals in Jamaica and Trinidad. Financing for these is likely to be forthcoming shortly.

It is difficult to obtain precise information on investments in so many countries, even though some of them are small. Information also is difficult to obtain from companies who wish to keep their investment programs confidential. Several large companies have invested in the region, but as yet we cannot estimate just how great their investment in the Caribbean region is. For those that have released their investment figures, we can say that they total more than $17.0 million in fishing vessels, shore facilities and marketing structures. The pay-off in investments in fisheries has more than justified the original cost of the project - approximately $4.5 million.

COLOMBIA MARINE FISHERIES DEVELOPMENT (COL 22)

The Colombia fisheries project became operational in January 1968. It is a country project with an original budget of $1.95 million, of which the UNDP contributed almost $1.0 million. Its objectives were to conduct resource surveys along the Pacific and the Caribbean coasts of Colombia.

Its work along the Pacific has demonstrated that shrimp resources must be managed to maintain production and to ensure adequate financial returns from vessel operations. The Caribbean activities have been devoted mainly to the survey of shrimp resources. To date, they have shown considerable quantities of shrimp from Barranquilla and to the eastward. Colombia's fisheries export about 1,700 tons of shrimp per year with a value of about $5 million. Fin-fish are also caught with the shrimp. In a country lacking adequate sources of protein, the potential value of these fin-fish resources to the industry looms high.

One interesting development of the project has been the assessment of the oyster resources of Cienaga Grande. They presently produce almost $2.0 million worth of oysters annually. The oyster industry can be expanded if the fresh waters of the rivers flowing into Cienaga Grande can be adequately controlled. The project is stimulating action on this control, since it would increase oyster revenues four-fold, to about $6 million. If the full potential of this resource is developed, as much as $8 to $10 million of oysters can be harvested each year.

While it is too early to determine the present level of investment generated by the project, it is already assured that the fisheries of Colombia will continue to become a greater part of the nation's economy.

VENEZUELA FISHERY RESEARCH AND DEVELOPMENT (VEN 14)

The Venezuela fishery research and development project became operational in December 1967. Like Colombia's project, it serves a single country. Total funding is almost $5.5 million, with $1.2 million contributed by the UNDP. Its objective is to determine the pelagic fish stocks available, evaluate the marine resources to determine their economic potential, and supply exploratory and experimental fishing and consultant services in processing, technology and marketing.

The research program of the project on what stocks are available has generated an increased interest by the private and public sectors in the fisheries. Project monitoring of the stocks of thread herring have shown that a 10-fold increase in the production from 500 to 5,000 tons is within the safe limits of the resource. Two or three other species are lying fallow and under stimulus may be expanded in like magnitude. As a result, the investment tempo has increased during the past few years. The demersal studies have found a promising new shrimp fishery in eastern Venezuela. It too is being pursued.

An unmeasurable but nevertheless important contribution of this project is the technical advice given both by direct contact and by demonstration to local industry and fishermen. The technical assistance given to the industry is starting to bear fruit, or should I say, fish. Industrial techniques are being up-graded as modest local investments are fed into the industry. For example, facilities for utilizing stick water are being installed in some local plants. Prospects are encouraging enough to anticipate that the expanding fish industry will seek out other pelagic fish resources. Local fleets are being modernized. Project personnel are supervising new construction of 11-meter vessels valued at approximately $5,000 each, and plant improvements are being made to specifications furnished by the project's technical staff.

The upgrading of the industrial processes, the improvement of production, and the increase of productivity and profitability are all real benefits whose numeric value cannot be estimated.

The project has prepared a fisheries development plan which will lay the groundwork for reorganizing the fisheries administration and apply incentives for fisheries development, assist in standardizing the quality of processed products, stimulate consumption of fish in the country and expand and modernize the fishing fleet. The plan is under review for adoption by the State Planning Organization.

The program, if implemented, will generate about $30.0 million in new investment when put into effect.

MEXICO - FISHERIES RESEARCH (MEX 15)

The objective of this project, which was declared operational on 27 October 1969 for $1,670,900, is to determine the magnitude of the pelagic and demersal fisheries resources in Mexican waters. As this project has just recently started, it is too early to assess its contribution to the Mexican economy. However, even though the technical details of the resources are not yet available, investment schemes are already under discussion with one of the international banks on funding, training, ship-maintenance procedures, sport-fishery development, and culture of fish in brackish water. The schemes in these areas can be implemented even while the project goes on about its major tasks. The Mexican Government is considering the adoption of similar projects that will be compatible with the development tempo and the policies of the country.

While the several projects in the Caribbean area require from one to several years before completion, worthwhile investment and development results have been forthcoming from each of them. Their influence upon the economy of the region will have an ever-expanding effect for a long time to come.

An Improved Field Method for Quality Evaluation of Shrimp Held in Refrigerated Brine and Ice

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Abstract

The pH of shrimp drip was used as an index to determine freshness. The investigation was directed towards finding an easier and quicker method to measure pH under in-plant and field conditions. Three color indicators were used to impregnate paper strips. The first was Merck's special indicator paper (9557) of pH range 6.5 to 8.0, the second was a mixture of bromothymol blue and cresol red, and the third was phenol red. A shrimp fishing cruise was conducted on board the research vessel *Choco*, to estimate shrimp quality from the time they are caught until marketed as fresh or frozen product. Results indicate: (a) paper strips impregnated with any of the three indicators used are quite suitable for measuring the pH of iced shrimp drip and therefore give a very accurate estimation of iced shrimp quality; (b) none of the three indicators used to impregnate paper strips is of value to determine freshness of shrimp held in refrigerated brine.

INTRODUCTION

The Colombian fishing industry is at present using odor and visual observation as criteria for evaluating shrimp quality. However, industry experience shows that this method does not ensure reliable results. In a previous paper, Rojas (1970) reported results obtained in relation to quality evaluation of shrimp held in refrigerated brine and ice and emphasized the need of finding an objective method for shrimp quality evaluation that could be used under in-plant and field conditions. In the laboratory tests, paper strips impregnated with phenol red were used to assess shrimp freshness (Iyengar et al., 1960). Nevertheless, the color scale for the color indicator used was not very discriminating due to the red tone prevailing in the pH range 6.8-8.2. Also the results were variable. This situation paved the way for experiments reported in this paper. Thus, two color indicators and a commercially made indicator paper were used. The first was phenol red (pH range 6.8-8.4), the second was a mixture of bromothymol blue and cresol red (pH range 6.8-8.8) and the third was Merck's special indicator paper 9557 (pH range 6.5-8.0). For the measurement of the pH of shrimp, the method developed by Bethea and Ambrose (1961) was used, but a modification of the original method which consisted in obtaining the drip from the peeled shrimp and not from the unpeeled shrimp was developed.

EXPERIMENTS

Shrimp of two commercial varieties, namely "Blanco" *(Penaeus schmitti)* and "Rosado" *(Penaeus duorarum)* were used in the experiments reported in this paper. A technological cruise on board the research vessel *Choco*, provided the shrimp for this study. Fishing operations were conducted on a commercial fishing ground south of Cartagena on the Atlantic coast of Colombia. After the net was emptied on deck the shrimp were separated from the remainder of the catch. They were then headed, counted, weighed and washed with sea water. A 60-pound mixed lot of shrimp was divided into four sublots: (1) Shrimp quality test I. Fifteen pounds of shrimp–which gave a count of 16-20 per pound– were packed between layers of crushed ice in an insulated container and placed in a room at 60.8F (16C). (2) Shrimp quality test II. Fifteen pounds of shrimp—which gave a count of 16-20 per pound– were dipped in a 2000 ppm sodium bisulfite solution for 30 seconds, then they were allowed to drain and placed in refrigerated brine (3% NaCl). (3) Shrimp quality test III. Fifteen pounds of shrimp–which gave a count of 16-20 per pound– were placed in refrigerated brine (3% NaCl) containing 1000 ppm of sodium bisulfite. (4) Shrimp quality test IV. Fifteen pounds of shrimp–which gave a count of 16-20 per pound– were placed in refrigerated brine (3% NaCl).

The purpose of measuring the pH of shrimp in sublots II, III, IV was to correlate the influence of the medium in which shrimp are stored on the determination of pH.

The theoretically expected temperature of the 3% brine employed in tests II, III, IV was 29.7F (-1.3C), but actual thermometer readings showed temperatures ranging from 28.4F to 28.76F (-2.0 to -1.8C).

In all shrimp quality tests, insulated containers (polystyrene foam) were used to keep both the shrimp and the refrigerated media. During storage the iced shrimp were re-iced as required, and the temperature of the shrimp held in refrigerated brine was controlled by intermittent exposure to freezing temperatures.

The experiments were carried out on board during the first 5 days. After this time, all the work was conducted in our technological laboratory in Cartagena. On board and laboratory pH measurements were performed with a Metrohm E 488 portable transistorized pH meter equipped with a combined glass electrode assembly with conical joint and insulating sleeve which needs no more than 1 ml of test solution for accurate pH readings.

Samples of 100 gm were removed daily from each of the insulated containers, rated organoleptically and analyzed by means of the impregnated test papers and the pH meter.

Preparation of test papers impregnated with phenol red — Number 1 filter papers were dipped in 0.1% phenol red (pH range 6.8-8.4) alcoholic solution (90 to 95% ethyl alcohol previously adjusted to a pH slightly lower than 7.0), and then dried in an oven at about 176F (80C) as described by Iyengar et al. (1960).

Preparation of test papers impregnated with a mixture of bromothymol blue and cresol red — 75 mg of bromothymol blue were added to 25 mg of cresol red; then, the mixture was dissolved in enough alcohol (70% ethyl alcohol) to complete 100 ml of indicator solution. Number 1 filter papers were immersed in this solution for a few seconds and then dried in an oven at about 176F (80C). The circular sheets were then cut into suitable strips. They were of deep lemon-yellow color.

Use of commercial indicator paper — Merck's special indicator paper 9557 (pH range 6.5-8.0) was used in an attempt to avoid preparation of test papers by unskilled industry personnel.

Method of measuring the pH of shrimp — The 100 gm samples of shrimp were deshelled, and placed on filter paper to remove adhering water, then wrapped in aluminum foil and frozen at -10F (-23.33C). After the shrimp were hard frozen, they were allowed to thaw at a temperature of 35.6F (2C). Two hours later the pH of the drip collected was measured by means of the potentiometer, and the impregnated paper strips.

Organoleptic procedures — Each of the thawed samples of shrimp were added to 3 ounces of boiling water containing 2 teaspoons of salt, allowed to simmer for 2 minutes, removed, and allowed to cool before being served. A taste panel composed of five members was asked to judge the shrimp as "high", "good", "fair", "borderline" or "inedible" (Kurtzman and Snyder, 1960). Numerical values of 5, 4, 3, 2 and 1, respectively, were assigned arbitrarily to the classifications for the purpose of treating the data quantitatively. Shrimp with a mean score of 4.2 or more were arbitrarily considered "high", those with a mean score of 4.1 to 3.4 were considered "good", those with a mean score of 3.3 to 2.6 were considered "fair", those with a mean score of 2.5 to 1.8 were considered "borderline", and those with a mean score of 1.7 and lower were considered "inedible".

RESULTS AND DISCUSSION

Shrimp quality test I — The pH of the iced shrimp (Fig. 1) increased progressively from 6.7 at the moment of catch to 7.30 in the first 7 days. It remained almost stationary or fluctuated between 7.20 and 7.30 during days 7 to 12. After this period the pH increased again from 7.30 to 7.65 on day 14. On day 16 the pH had reached 8.20, and from this day on the pH continued to increase.

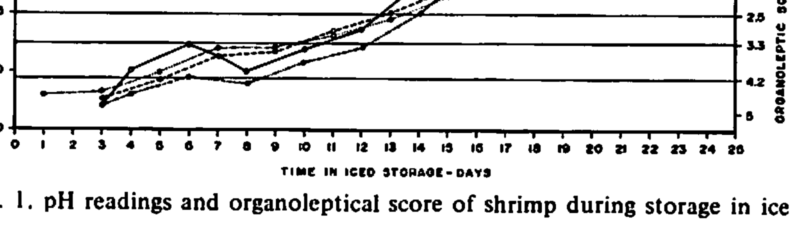

Fig. 1. pH readings and organoleptical score of shrimp during storage in ice.

Shrimp quality tests II, III and IV — The pH of the shrimp held in refrigerated brine with or without the addition of sodium bisulfite fluctuated between 7.0 and 7.7 during days 1 to 42. After this period the pH increased slightly, and on day 61 it had reached 8.0.

Figure 2 shows the pH readings of sublot 2 (Shrimp quality test II). The data obtained for Shrimp quality tests III and IV are similar to those of Shrimp quality test II and thus, they are not reported.

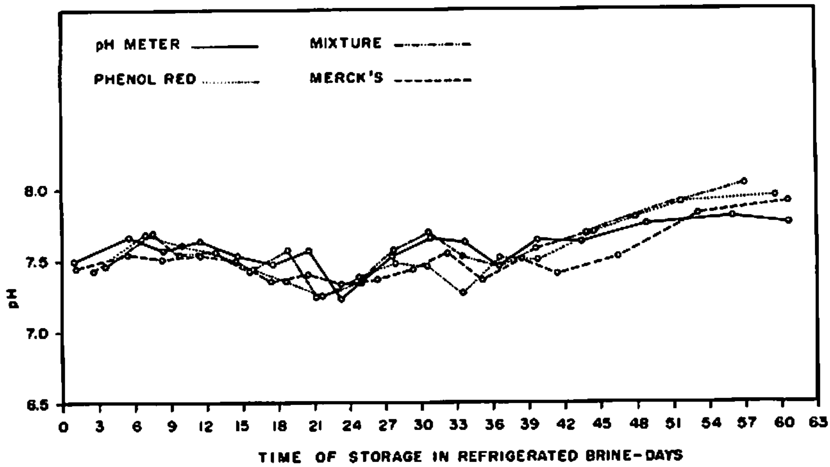

Fig. 2. pH readings of shrimp during storage in refrigerated brine (3% Na Cl).

Iced shrimp: Sensory test results— The taste panel considered the shrimp to be high quality from day 1 to 7. From day 8 to 11 the panel still rated the shrimp as good quality. On days 13 and 14, the panel rated the shrimp as fair quality, on days 15 and 16 as borderline quality, and on day 17 as inedible (Fig. 1).

Shrimp held in refrigerated brine: Sensory test results— The taste panel considered the shrimp to be high quality from day 1 to 10. From day 11 to 16 the panel still rated the shrimp as good quality. From day 17 to 25, the panel rated the shrimp as fair quality, from day 26 to 60, the panel rated the shrimp as borderline quality. Nevertheless, it is worthy to notice that shrimp 26 days and older had a very unpleasant odor, but texture and taste after cooking was still acceptable.

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine which of 3 color indicator impregnated paper strips would adequately serve as spoilage indices and provide for general characterization of shrimp held in refrigerated brine and ice. In addition, information was required on any differences which might arise between the quality evaluation of shrimp held in refrigerated brine with sodium bisulfite and the shrimp held in refrigerated brine without sodium bisulfite.

From the data obtained, any of the three impregnated paper strips would be suitable as an objective test to evaluate the quality of iced-stored shrimp. However, due to the highly differentiated color scale of the commercial indicator paper used, it was found to be the most suitable for the characterization of iced shrimp.

In relation to quality evaluation of shrimp held in refrigerated brine we concluded that none of the impregnated paper strips is of value to assess its quality.

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Status and Potential of the Fishery in the Caribbean

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INTRODUCTION

As is generally known, the Caribbean region is fairly complex ecologically, which understandably applies also to its fishery resources and their utilization. As can be surmised, the information available on these resources, especially the catch statistics, is more often than not unreliable. It is only recently, with the advent of several fishery development projects sponsored by the United Nations (FAO) Special Fund Development Program and those initiated by a few Caribbean countries, that more exacting catch statistics are available.

In relation to this, Table 1 shows the latest available total landings and estimates of the countries bordering the Caribbean. These are taken from the FAO *Yearbook of Fishery Statistics* (United Nations, 1969). The production figures for 1958 are also shown as a basis for comparison.

It can be readily seen from the foregoing table that four countries (Venezuela, Cuba, Colombia, and Jamaica) produce about 80% of the total. The main reasons for this are availability of richer fishing grounds, in the case of the first three, and greater fishing effort spent in harvesting by the latter.

So as to gain some familiarity with the Caribbean fishery resources a short description will follow of the three major zonal fishery classifications: (a) island arc and reefs, (b) continental shelf, and (c) pelagic. The last two conform with coastal and oceanic groups of the general description given previously. A suggested fourth classification, midwater, is not included owing to the present lack of information. These classifications are arbitrary and were only chosen for convenience rather than conventionality.

ISLAND ARC AND REEF RESOURCES

The island arc and reef fishery which amounts to about 35% of the regional production, or 100-metric tons, is essentially carried out, except for Cuba and Venezuela, from coastal fishing craft of simple design and construction, ranging in size and type from 14-foot row boats to 40-foot sloops. Over two-thirds of these are motorized, largely by outboard motors, and lack mechanical labor saving equipment and electro-acoustical aids. The most important fishing gear is the fish pot. However, a variety of other gear is also used, including the bottom trawl, haul (beach) seine, gill net, turtle net, cast net, set line and bottom and trolling lines. The overall production as well as the catch per unit of effort is low, probably one-fifth to one-tenth of the average taken by the more developed fishing nations.

TABLE I
Total Reported Fish Landings of the Caribbean for 1958 and 1968. Source: Food and Agricultural Organization Yearbook of Fishery Statistics 1968 (Weights in 1,000 Metric Tons)

South and Central America	1958	1968	Greater Antilles	1958	1968	Lesser Antilles	1958	1968
Brit. Honduras	.9	.5				Antigua	.8	.8
Costa Rica*	.3	1.0	Cuba	21.9	66.0	Barbados	4.5	3.5
Honduras	1.1	3.4	Dom. Rep.	2.0	3.1	Dominica	.4	.4
Nicaragua*	2.2	3.5	Haiti	1.5	2.5	Grenada	.7	1.3
Panama*	1.0	10.0	Puerto Rico	2.8	1.4	Guadeloupe	3.0	3.6
Venezuela	78.3	126.1	Jamaica	7.8	17.2	Martinique	3.7	4.6
Colombia*	6.1	23.0				Montserrate	.1	.1
Guatemala*	.1	.4				St. Kitts, Nieves		
						Anguila	.5	.8
						St. Lucia	.4	.4
						St. Vincent	.6	.4
						Trinidad, Tob.	4.2	13.0
						Virgin Is. UK	.4	1.2
						Virgin Is. US	.4	.8
						Bahama Is.	1.5	2.3
Totals	90.1	167.9		36.0	90.2		21.2	33.2
Grand Total:	147.2	291.3						

* Amounts shown are estimates of Caribbean landings only; total landings for countries bordering the Atlantic and Pacific for 1968 are: Costa Rica, 5.0; Nicaragua, 6.9; Panama, 71.6; Colombia, 93.0; Guatemala, 1.9.

The groups of fishes and shellfish most commonly taken, in relative order of importance include: Lutjanidae (snappers), Serranidae (groupers), Carangidae (jacks), Scombridae (mackerels), Labridae (labrids), Scaridae (parrot fishes), Mugilidae (mullets), Pomadasyidae (grunts), Clupeidae (sardines), Sphyraenidae (barracudas), Carcharhinidae and Lamnidae (sharks), *Panulirus* sp. (spiny lobster), molluscs, octopus (octopii), Loligo (squids), *Crassostrea* sp. (oysters) and *Strombus* sp. (conch).

Of these groups only the spiny lobster and to a limited extent the conch enter the export trade. In general most of the island group produce only half or less of the fishery products they consume.

CONTINENTAL SHELF RESOURCES

The second area, continental shelf, covers the northeast part of South America and Central America to the Yucatan Peninsula. The most productive areas of the Caribbean lie in the Guianas to Panama region, owing mostly to large river outflows, fairly wide shelf and in part, limited upwelling. This latter occurs in the Margarita Island area and off Barranquilla, Colombia. Except for the coastal section of Panama and Costa Rica, the marine environment and its species composition from Nicaragua to Yucatan resemble more the island arc type. At least 56% of the total Caribbean production is taken here, Venezuela producing the lion's share, followed by Colombia.

The predominant commercial species in the Guiana-Trinidad area are Sciaenidae (weakfish and croakers), Scombridae (mackerels), Clupeidae (sardines), Pomadasyidae (grunts), Ariidae (cat fishes), Ephippidae (spade fish) and Gerridae (mojarras). In the Trinidad to Panama region, the species listed above to a lesser degree plus Characins (fresh water fish), Lutjanidae (snappers), Pomacentridae (snooks), Carangidae (jacks), Mugilidae (mullets), Megalopidae (tarpon) and Engraulidae (anchovies).

From Nicaragua (and in part Costa Rica) to Yucatan the composition of the commercially important species is similar to that of the island arc. In the Guiana to Colombia region four species of penaeid shrimp are an important resource. Fisheries for these are centered in the Gulf of Venezuela-Lake Maracaibo and Guianas. Spiny lobster is important off the Central America shelf from Yucatan to Panama. Fishing methods vary widely, but the most common methods used in commercial harvest include trawling, beach seining, gillnetting, pound netting, cast netting, trolling, handlining, longlining, and pot fishing.

PELAGIC RESOURCES

The third and largest, the pelagic area, is the least productive, both in volume and number of species composition. The fisheries here are exploited by Cubans and Venezuelans, in addition to the Japanese, South Koreans and Taiwanese through the use of large vessels and modern equipment. Other countries participate to a limited degree during periods when migratory fish concentrations move within a day's round trip from home port. Less than 9% of the total Caribbean production is derived from the pelagic area. In order of importance the following group of fishes include the main commercial species: Scombridae (tuna, tuna-like and mackerels), Coriphaenidae (dolphin), Istiophoridae (marlins), Carcharinidae and Lamnidae (sharks) and Exocoetidae (flying fishes).

Three main fishing methods are employed to take pelagic species: (a) the longline method, which includes a main line and branch lines with hooks, suspended at a desired depth, used to great extent by Cubans, South Koreans, and Taiwanese, Japanese and Venezuelans to take large tunas and shark; (b) live bait fishing and trolling, used by the Cubans to capture skipjack and blackfin tunas; and (c) gillnetting for flying fish, which is practiced mainly in Barbados and to a lesser degree in the St. Vincent Island group.

As a further general guide to the distributional pattern of the Caribbean fishes I refer in part to Robins (1969). Studies of the island chain and reef fishes of the Caribbean show that, although most species enjoy a wide distribution, few are common to all segments of the region. Patterns of distribution can be defined geographically; such geographic divisions are not specifically defined by latitude, longitude or deep water barriers, but by ecologically similar environments.

Continental species require environments where changes are common and often drastic, such as changes due to seasonal shifts in climatic conditions, changes due to run off from large rivers, and changes due to turbidity caused by winds that stir silt rich bottom sediments. The continental species fall into two groups, northern and southern, with some species occurring in both areas. The northern species are distributed along the estuary-rich islands of Cuba, Hispaniola and in part Jamaica. Southern species are found along the coasts of the Guianas, Trinidad, Venezuela and pockets near river mouths from Colombia to Nicaragua.

Contrasting with the continental forms, the distinctive species-rich island arc and reef fauna exist in environments where water is clear, conditions buffered and sediments are largely composed of calcium carbonat‹ This group occurs from the Bahamas chain southward through the Greater and 'Lesser Antilles, and broad stretches of Central America where the continental shelf is not bathed by land run-off. As Robins (1969) further says, "not all shore-fish species may be thus categorized. Some are distributed through all the divisions". The commercially important species of the pelagic region are distributed evenly throughout the Caribbean with possible separation by vertical temperature gradients, as in the case of the tunas where albacore *(Thunnus alalunga)* as an example, is generally taken in deeper colder water.

Much of the following information on potential resources is taken from summary papers presented at the FAO-UNESCO sponsored Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR) and general comments derived from past exploratory fishing surveys (Bullis and Thompson, 1969). It was determined by consensus there that the living resources of present and/or potential commercial importance fall into the following general grouping: tunas and tuna-like (Scombroids), sardines, herring and anchovies (Clupeoids), demersal fishes (snappers, groupers, weakfishes and croakers and catfishes), crustaceans (lobster, shrimp, crabs), and miscellaneous resources (molluscs, cephalopods and sharks). The same sequence will be followed here owing to the probable "fit" this will have into the ongoing CICAR program.

TUNA AND TUNA-LIKE RESOURCES

Tuna and tuna-like fishes comprise about nine commercially important species in the Caribbean, the most important being yellowfin *(Thunnus albacares)*, big eye *(T. obesus)*, blackfin *(T. atlanticus)* and skipjack *(Katsuwonus pelamis)*. The first two are taken mostly by longline and are considered fully exploited. The latter two, skipjack and blackfin tuna, are harvested by the live bait method in Cuba and to a lesser extent by trolling and "drifting" in the Lesser Antilles. It is estimated that between 1,000 and 2,000 tons are taken yearly of these two species. Prospects for expansion of the fishery of this group are good, but will depend largely on the development of specialized surface fisheries in many areas of the Caribbean coastal waters. Recent surveys conducted by the Puerto Rican Government in the area with the use of tuna purse seiners showed that the most common surface occurring tunas in the Caribbean were skipjack and blackfin. However, their erratic behavior and limited concentrations precluded purse seining; nevertheless, other fishing methods would be feasible (Juhl, Bartlett and Maghan, 1970). Although supporting data is needed, it is estimated this resource could support a five or more fold increase (5 to 10 thousand tons).

CLUPEOID RESOURCES

The Caribbean harbors a variety of commercially important species of the Clupeoids and related sardine-like fishes. The largest concentrations are understandably found along the continental coastal waters. Important genera include *Sardinella, Harengula, Opisthonema, Cetengraulis* and *Anchoa*. Venezuela with a total catch of about 40,000 tons per year is by far the greatest producer. The existence of important clupeoid resources off the coast of Surinam particularly and other specific places throughout the region suggest that substantial increases in the utilization of this resource can be expected. At the CICAR meetings it was emphasized that the real abundance of these species (clupeoids) has not been correctly assessed because observational techniques have not been adequate; in fact, previous attempts to estimate the volume of these resources in specific reef areas of the Gulf of Mexico and Caribbean have produced discouraging estimates. Conversely, test-fishing by night-light and fish pump methods have yielded significant quantities of sardine-like fish. It was recommended that full advantage must be taken of newly developed sounding equipment and remote sensing apparatus to obtain reliable quantitative estimates of these resources (Bullis and Roithmayr, 1969). This being the case with many of the clupeoids and related schooling resources of the Caribbean, it would be presumptuous to make a valid estimate of its potential at this time.

DEMERSAL RESOURCES

On the demersal fish groups, we again refer to the CICAR meetings. These resources are divided into the continental and insular fauna. The latter is extremely diverse and the fishery is adopted to the capture of a wide variety of species. Island fisheries, operating mainly with pots and hook and line, obviously have limited prospects and, as mentioned earlier, would only continue to supply local markets. Several papers presented at the CICAR meetings reflected the large amount of work carried out in exploratory fishing with various types of gear over extended period of years. These papers indicate that a large snapper, grouper and grunt (Pomadasyds) potential exists in the insular environment. The United States Bureau of Commercial Fisheries estimates this resource potential at 40,000 metric tons (Carpenter and Nelson, 1969). This is at least twice the present commercial production. Consequently, there seems to be ample margin for expansion. Already the U.S. snapper fleet and other foreign nations are increasing their fishing efforts. The fish taken at present by the U.S. fleet is unloaded in home ports located in the Gulf of Mexico.

CONTINENTAL AREA RESOURCES

The continental fauna group seems to hold, at present, the greatest potential for expansion. This group is typified by the Sciaenids (sea-trout and croakers) (Rathjen, Yesaki and Hsu, 1968). The area within the continental faunal zone to which specific reference is made covers from Trinidad to French Guiana. It is outside the Caribbean, but included with it because of its close biotic relationship. Rathjen et al summarized the results of more than ten independent fishing investigations conducted in the last 25 years, the most significant ones being the M/V *Coquette* explorations sponsored by Surinam and the M/V *Calamar* work under the United Nations Development Program/FAO Caribbean Fishery Development Project. The Guiana-Trinidad area is strongly influenced by the fresh water run-off from the Amazon-Orinoco and a dozen lesser, but significant rivers. Out to 15-20 fathoms the bottom is composed of soft sticky mud and beyond this it changes to a mixture of sand and mud and finally to pure sand off-shore. It is inside the 15-20 fathom line that holds the greatest potential. The marketable species, in order of importance, include sea trout *(Cynoscion sp.)*, croaker*(Micropogon)*, Surinam butter fish *(Nebris)*, silver perch *(Larimus)*, whiting *(Macrodon)*, moonshine *(Selene)*, bumper *(Chloroscombrus)*, mojarra *(Gerres)* and harvestfish *(Peprilus)*. Results of the fishing tests mentioned by Rathjen et al show that the first two species make up from 70% to 75% of the total catches in this area. It would be apparent then that these sea trout and croaker species would enter the export trade, should thyindustry develop. At present about 7,000 tons of these fishes are landed annually within the Trinidad-Guiana area. It is estimated that this area could support a 200,000 ton per year fishery, which would allow for a substantial export margin. Through the efforts of the United States Bureau of Commercial Fisheries and United Nations Development Program, FAO Caribbean Fishery Development Project (Millerd and Vidaeus, 1969) it is anticipated that industry will soon capitalize on these resources. It must be emphasized that the foregoing applies to resources of known existence and known market value. Further analysis of existing information and expanded investigations may uncover additional utilizable resources, not just in the Trinidad-Guiana area, but elsewhere in the Caribbean.

CRUSTACEAN RESOURCES

Crustaceans, our next subject, are richly represented in the Caribbean, especially in penaeid shrimp and spiny lobster. The Gulf of Venezuela and the shelf of the Guianas support some of the important shrimp fisheries in the world; however, concentrated fishing efforts being expended there at present place a question on further expansion until the dynamics of the stocks are fully understood. The papers presented at the CICAR meetings on this indicated that significant fluctuations in abundance without known reasons indicated the need for concerted studies in order to formulate effective management measures.

The spiny lobster *(Panulirus argus)* is widely distributed in the Caribbean, especially in the island arc and continental shoal areas of similar environmental characteristics, such as the Nicaragua-Yucatan area. As pointed out by Idyll (1969), the exploitation of the spiny lobster is not well developed except in a few particular cases. Catches are largest in Cuba, British Honduras, Nicaragua, Puerto Rico, Jamaica and Mexico. Idyll contended that although catch statistics for the area are available, these are not considered reliable. It may be possible, he believes, to expand a few lobster fisheries especially in the southern edge of the Caribbean Sea, which would include the Grenadine-St. Vincent Is. group; however, most lobster stocks are fully exploited. Although several fishing methods are used, such as diving, bull net and night-lighting, the most common is the use of traps. As reported by Windley (1968) approximately 12,000 metric tons of lobster are produced in the Caribbean. Other species of minimal importance include the sand lobster *(Scyllarus)* and related species of the spiny lobster such as *P. guttatus, Paninustus,* and *Justitia.* Deep water forms have appeared often in exploratory fishing catches, but except for the deep water prawn (Pleasiopenaeus) very little is known of their potential.

MOLLUSCAN RESOURCES

In the CICAR meetings, reviews were presented of resources which at present are relatively unimportant generally, but of considerable importance locally, and of great potential value if developed. These are the mangrove oyster *(Crassostrea mangle)* and mussel *(Perna perna).* The introduction of effective cultivation methods and the adoption of measures against pollution and destruction of mangrove stands could lead to a substantial industry and consequent export trade. This would apply specifically, at this time, to the extensive estuarine coastal areas of the continent and the islands of Cuba and Hispaniola.

A comprehensive review of the cephalopod fishing industry given at the CICAR meeting by Voss (1969) demonstrated the great importance of this group in the world fisheries and its relative present unimportance in the

Caribbean. Voss informed that although the region contained many species of cephalopods only six of squid and four of octopus were being harvested to a limited degree in selected areas.

Based on what Voss considers unreliable figures, the total cephalopod catch recorded for the Caribbean, including Mexican (Gulf) landings in 1967, was approximately 2,500 metric tons valued at about $500,000. This is believed to be insignificant in relation to the potential of the area. The species of squid of commercial importance include *Loligo, Doryteuthis, Lolliguncula, Sepioteuthis, Illex* and *Ommastrephes.* Four species of the genera *Octopus* are also considered important, *O. vulgaris, O. briareus, O. macropus* and *O. maya.*

The potential of this resource is best explained by a quotation from Voss' paper, "The potential of the fishery itself is difficult to determine. Observers repeatedly report large concentrations of squid throughout the Caribbean, and several fisheries officers with whom I have corresponded have considered that the stocks were sufficient to consider an export oriented fishery. The loliginid squids in particular are found almost throughout the entire region and in areas school in large quantities. Unfortunately, at the present time reliable figures as to distribution, numbers, places of concentration and abundance are almost completely lacking."

Recommended methods for catching squid are by trawling with nets, night lighting and dip net, and jigging. Octopus can be taken by trotline in which the branch line holds a clay "jug" or other type of container.

It can be gleaned from the foregoing that this cephalopod resource, especially squid, will undoubtedly become an important fishery product, for local use and export as well, as soon after more knowledge is gained and fishing technology applied.

SHARK RESOURCES

Shark resources are found in varying concentrations in all the Caribbean, however, known commercially significant numbers are found only in the Guiana-Panama continental shelf area. A small fishery exists in Venezuela, Surinam and Cuba. The total annual production is estimated to be about 7,000 tons. At present the UNDP/FAO Caribbean Fisheries Development Project has undertaken a study of the resource and its development. Preliminary results are encouraging with indications that the shark resources could support a substantial fishery (United Nations, 1970).

At least twenty species of shark were taken by the UNDP/FAO exploratory vessel M/V *Calamar;* however, three species predominated, black tip, bull and silky shark. *(Carcharhinus limbatus, C. leucas* and *C. falciformis* respectively.) The harvesting gear for taking shark is relatively simple, either multi-hook set lines or individual hand lines. Existing fishing vessels can easily be adapted to shark fishing, consequently, it is probably that the resource will receive greater attention soon. Once adequate processing and marketing procedures are introduced, shark is expected to enter the export trade, probably sooner than the previously described cephalopods, owing to existing consumer acceptance.

In summary, the following table is a compilation of the (additional) potential resources of the Caribbean described in this paper.

Resource	Estimated Potential 1000 metric tons
Tuna and tuna like group	10
Clupeoids	50+
Demersal	
Snapper and grouper	40
Seatrout group	200
Crustaceans (lobster)	4+
Molluscs (cephalopods)	50+
Sharks	10+
Total	364

+These are considered "uneducated guesses" and are included only for the sake of reference.

As you may recall from the statistics shown earlier, the total production of the Caribbean countries was 291.3 thousand metric tons. Based on this total the additional potential harvestable tonnage of the groups shown above, which by no means represent all the existing commercially significant species, is appreciably greater than the current production. It must be reiterated, however, that much more knowledge about these resources must be gained before more reliable assumptions can be drawn.

As a whole the people of the Caribbean are substantial fish eaters, nontheless, as a rule half or more of the fish is imported, especially in the Antillean Islands. This has been well documented by Millerd and Vidaeus (1969). It is apparent then that the demand for a large amount of fish exists, consequently as the Caribbean fisheries develop it is expected that any rise in production at present will be absorbed locally, especially in the island chain. The export trade in fishery products can gain importance in the higher resource potential areas as the local demand is satisfied and the production and marketing requirements are modernized. We believe that these requirements will be met in step with continuous overall development of the Caribbean area.

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Dynamic Factors Affecting the Performance of the Antillean Fish Trap

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INTRODUCTION

Traps constructed of sticks and galvanized wire mesh are used throughout the islands of the Caribbean, particularly in the Greater Antilles. In Jamaica (Munro, 1969), Puerto Rico (Oswald, 1962) and the Virgin Islands (Swingle et al., 1970) they are the main items of fishing gear and contribute the greatest part of the catch. They are also extensively used in Cuba (Buesa Mas, 1962) and in most of the other Caribbean Islands, but their relative contributions to the catches are unknown. They are prohibited in Florida. Their use appears to date from around 1920, when wire mesh became readily available at fairly low prices, but traps of the same basic design constructed of rattan or cane have probably been used in the Antilles for several centuries.

In this paper, the term "Antillean fish trap" is used in a generic sense, and refers to any trap constructed of galvanized wire mesh. Specific types of traps include the arrowhead or chevron trap of Puerto Rico and the Virgin Islands (Fig. 1a), the double arrowhead or Z-trap of Jamaica (Fig. 1b), and the S-shaped trap described by Buesa Mas (1962) in Cuba (Fig. 1c). The Z- and S-traps have two entrance funnels, the arrowhead has only one funnel. Simple rectangular traps are also used in some areas. The UNDP/FAO Caribbean Fisheries Development Project has recently experimented with other designs of wire-meshed traps which may in due course come into common usage.

Mesh sizes are usually of 3.17 - 4.13 cm (1 1/4" - 1 5/8") maximum diameter in Jamaica. Swingle et al. (1970) report a range from 1.90 - 5.08 cm (3/4" - 2") in the Virgin Islands. In Jamaica and Cuba the funnels are constructed in the "horse neck" style; that is, with a downward turn at the inner end so that the fishes enter the traps by swimming downwards through a horizontal plane. The inner aperture of the entrance funnel is usually pear-shaped, with a length of about 30 cm and a circumference of about 72 cm. The overall dimensions of the Jamaican traps average around 180 - 230 cm long (70 - 90 ins.), 100 cm wide (40 ins.) and 61 cm (24 ins.) deep.

In most areas the traps have been used most extensively in the near-shore reef areas in depths down to about 50 m. They are also used in deeper waters but losses of traps fished in deep water are often fairly high owing to currents drawing the buoys under water or washing the traps into very deep water, or to ships cutting the buoy lines with their propellers. In Jamaica, the most heavily fished area is the zone of *Acropora cervicornis* corals which extends from depths of 1 m to around 15 m, depending upon the clarity of the water.

Despite the fact that the Antillean fish trap is the main item of fishing gear in many areas, little work appears to have been done on the factors affecting its

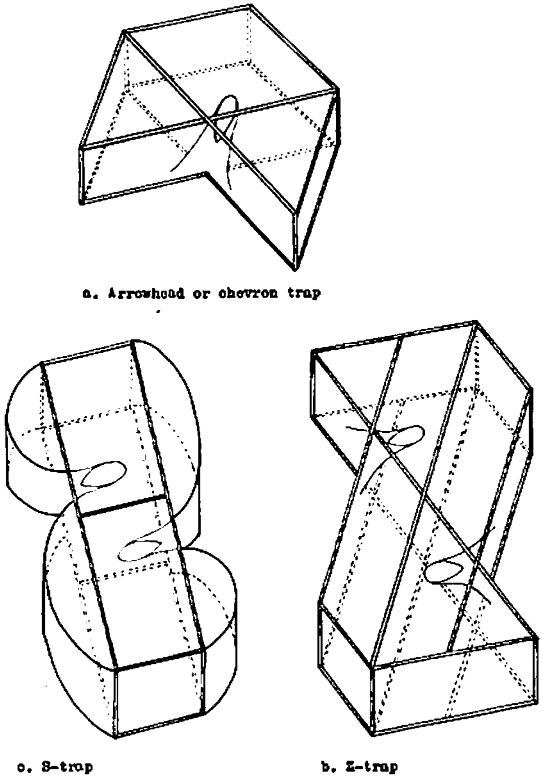

Fig. 1. Antillean fish traps constructed of wooden poles and galvanized wire mesh. (a) Arrowhead or chevron trap (Puerto Rico & Virgin Islands); (b) Z-trap (Jamaica); (c) S-trap (Cuba).

performance or upon the effects of these small-meshed traps upon the fish communities. In Jamaica, where the intensity of fishing on the near-shore reefs appears to be higher than in any other island in the Caribbean, the abundance of fishes on the reefs is remarkably low. We are working on the hypothesis that the low density of fishes is a direct consequence of exploitation with small-meshed traps; that is, that the largest reef fishes and thus usually those which mature at a relatively large size are subjected to severe biological overfishing, while the smaller reef fishes which mature before recruitment to the traps are subjected to intense exploitation with a correspondingly low stock density, but are not biologically overfished. Radical changes in the composition of the fish communities might result from such a situation and we have undertaken an investigation of the composition of communities of fishes in the Port Royal reef system and of the factors affecting the performance of the traps as a preliminary step to a more extensive investigation.

Methods of investigation

Most of the information reported here has been obtained by SCUBA observations of the composition of trap catches. Traps are placed in depths of 20 - 45 feet (7.1 m - 13.7 m) in the *A. cervicornis* zone of the inner reefs of the Port Royal reef system, and the accumulated contents of the traps are counted as frequently as possible. The traps are emptied and reset at each new moon or full moon, and are subjected to the minimum of disturbance in the interim.

In addition, trap fishing is conducted on all reefs in the Port Royal area to provide fishes for routine biological analysis. Traps are set and retrieved by SCUBA divers, partly in order to avoid having to buoy the traps and the resultant thefts, and also to ensure that traps are set at precisely the desired depths.

Expression of results

Regular SCUBA observations and counts of the contents of a trap yield a set of data which can be expressed in a number of ways; either as total cumulative ingress into the traps, or mean daily ingress, or as total cumulative "catch" or mean daily "catch". The "catch" refers to the number of live fishes which would have been captured if the trap had been hauled at the time of observation. In contrast, the term ingress refers to the number of fishes or invertebrates *known* to have entered the trap and ignores losses due to deaths of fishes in the trap (including predation) and losses due to escapement. As such, "total ingress" is a minimum estimate and cannot account for fishes which enter the traps and then die and are eaten, or escape, in the interval between observations. Nor can those fishes be accounted for which enter the traps, are counted and then escape or die and are then replaced by another of the same species. The "soak" is the period between the setting and hauling of a trap.

Results of ordinary trap fishing are expressed as total catch or as catch per day soaked.

Composition of the catches

Within the near-shore *A. cervicornis* reefs there appear to be few species of fishes or invertebrates which will not enter traps. In the Port Royal reef system, on the south coast of Jamaica, we have captured 95 species of fishes and invertebrates by means of routine fishing with traps covered with 4.13 cm (1 5/8 inch) diameter wire mesh. Details of the composition of these catches are given in Table 1. Parrot fishes, surgeon fishes and grunts predominate in the catch and *Haemulon plumieri* (8.1%) and *Acanthurus chirurgus* (7.6%) are the most abundant species in terms of weight. Nevertheless, diversity is very high and while the ten commonest species comprise about 50% of the catch, the remaining 50% is comprised of 85 species.

"Lunar" periodicity

Initial data on trap fishing and the experience of local fishermen indicated that catches were affected by moon phase or by the corresponding tidal rhythms. Sets of traps used in the observation dives were therefore set and emptied on successive new and full moons and thus subjected to a 14 - 16 day soak between hauls.

TABLE 1

Composition by Weight of Antillean Z-Trap Catches from the *Acropora cervicornis* Zone (5 - 15 m) of the Port Royal Reefs, Jamaica. Mean Soak, 12 Days; Maximum Diameter of Mesh, 4.13 cm (November 1969 - September 1970)

Scaridae	16.4%	*Sparisoma chrysopterum*	4.5%
		Sp. viride	3.3%
		Sp. aurofrenatum	2.7%
		Scarus croicensis	2.0%
		Other scarids (6 spp.)	3.9%
Acanthuridae	15.2%	*Acanthurus chirurgus*	7.6%
		A. coeruleus	4.9%
		A. bahianus	2.6%
Pomadasyidae	11.6%	*Haemulon plumieri*	8.1%
		Other pomadasyids (9 spp.)	3.5%
Palinuridae	8.1%	*Panulirus argus*	7.0%
		P. guttatus	1.1%
Serranidae (excluding hamlets)	7.9%	*Epinephelus guttatus*	2.7%
		Petrometopon cruentatum	2.0%
		E. striatus	1.8%
		Other groupers (3 spp.)	1.5%
Chaetodontidae (excluding *Chaetodon* spp.)	7.8%	*Pomacanthus arcuatus*	4.4%
		Holacanthus ciliaris	2.3%
		Other angel fishes (2 spp.)	1.1%
Majidae	4.3%	*Mithrax spinosissimus*	4.3%
Lutjanidae	4.0%	*Lutjanus apodus*	1.5%
		Other lutjanids (6 spp.)	2.5%
Carangidae	3.5%	*Caranx ruber*	2.9%
		Other carangids (3 spp.)	0.6%
All other families	21.2%	All other species (48 spp.)	21.2%
	100 %	Total species = 95	100 %

Figure 2a shows fluctuations in the catch rates of all species of fishes in traps which have been set and hauled at random intervals during the course of the lunar month. Figure 2b shows a similar pattern and is derived from analysis of observed rates of ingress into traps which have been regularly set and hauled at successive new and full moons. Both graphs show pronounced depressions in catch rates shortly after the quarter-moons; that is, at moon ages 10 and 24 in the case of the data derived from trap fishing and at moon ages 8 and 23 - 24 in the case of the data derived from SCUBA observations. Figure 2a shows a peak in catch rates at the new moon and peaks at 15 and 21 days after new moon, while Figure 2b shows a pronounced peak in the rate of ingress 4 days after new moon and a broad peak, which may be bimodal, extending from 12-20 days after new moon; that is, around the time of the full moon. Figure 2b also shows examples of intra-monthly variations in rates of ingress of some of the characteristic reef fishes, *Haemulon plumieri, Sparisoma aurofrenatum* and *Acanthurus coeruleus.* The patterns of intra-monthly variations in catch rates are largely dissimilar but all agree in having decreased rates on ingress shortly after

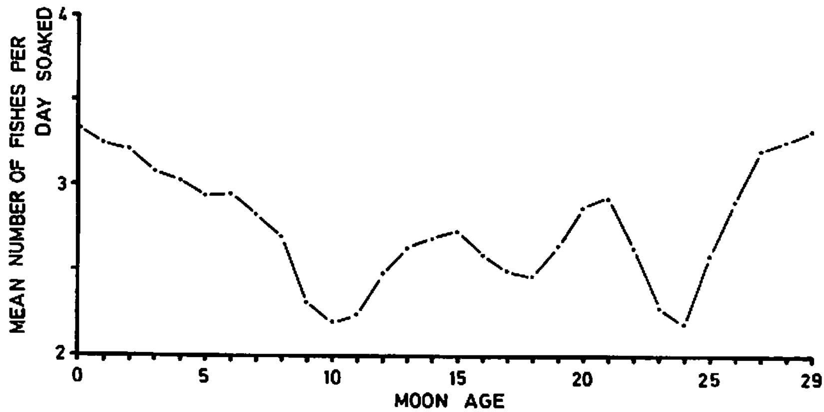

Fig. 2a. Intra-monthly fluctuations in catch per day soaked of Antillean Z-traps at the Port Royal reefs, Jamaica (February-September 1970). Soaks exceeding 8 days are excluded from the analysis. Number of traps hauled = 425; Number of fishes = 6,345.

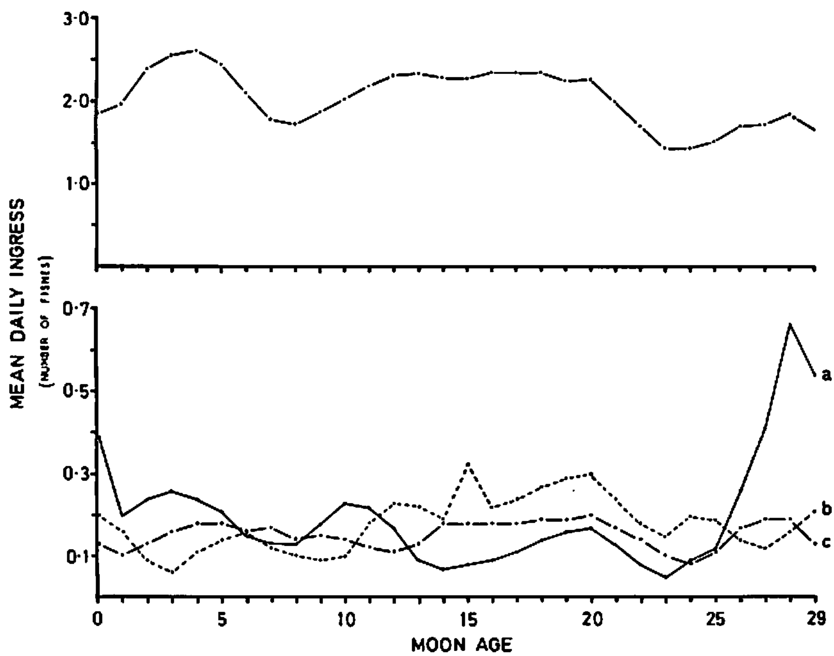

Fig. 2b. Intra-monthly fluctuations in the mean daily rate of ingress into Antillean Z-traps at the Port Royal reefs, Jamaica (February-July 1970). Number of traps observed = 471; Number of fishes observed = 2,500. (i) All species. (ii) (a) *Acanthurus coeruleus* (Acanthuridae) (b) *Sparisoma aurofrenatum* (Scaridae) (c) *Haemulon plumieri* (Pomadasyidae).

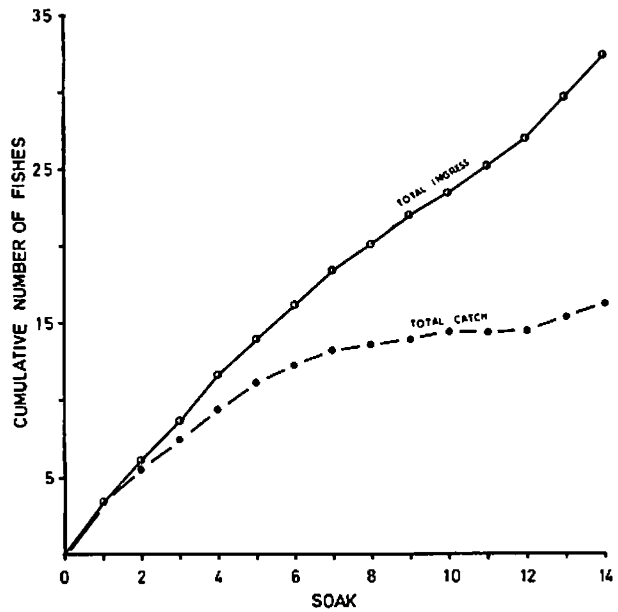

Fig. 3. The relationships between total cumulative ingress, total cumulative catch and duration of soak of Antillean Z-traps at the Port Royal reefs, Jamaica (February-July 1970). All traps are hauled and reset at successive new and full moons. Soak, 14-16 days.

the quarter moon, usually at moon ages 8 - 9 and 23. Moon ages of 8 - 9 and 23 correspond almost exactly with the times of the neap tides at Port Royal and we have therefore concluded that the very real variations in the profitability of catches within the lunar month are a result of a general *depression* in catch rates which is related, perhaps for complex ecological reasons, to the periods at which tidal currents reach their minimum velocity.

Catch per day soaked

We have studied the relationship between the catch and the length of time that a trap is left immersed in the water (the "soak").

Owing to the wide variations in catch that occur, even when traps are set adjacent to each other, it was not possible for us to define the relationship between catch and soak by means of routine trap fishing. However, by using SCUBA techniques, we have been able to follow the build-up of catches in individual traps, each of which are hauled and reset on successive new and full moons. This procedure eliminates a major source of variability in the data, and we have obtained relatively smooth curves showing the relationships between cumulative ingress, cumulative catch and duration of soak (Fig. 3). All of the observed traps were set and hauled on successive new and full moons and as a result of the lunar or tidal phenomena which depress the catch at the neap tides, the curves showing cumulative ingress and catch are slightly sigmoid in shape.

The fraction of the ingress which is lost from the traps increases steadily with increasing soak, and reaches 50% after 14 days. This suggests that given sufficient time a very large proportion of the fishes which enter the traps may escape; even if the escape be the result of random movements in the trap. We have seen relatively few dead fishes in our traps and the corpses of those seen have often remained in the trap for several days before disappearing thus suggesting that losses caused by predators are relatively small. Also, substantial numbers of fishes have been observed to disappear from traps which contain no predators at all.

If escapement is the major factor accounting for the differences between observed ingress and observed catch, then very substantial increases in productivity could be achieved by including in the design of the entrance funnels a device which will prevent the fishes from swimming out of the funnels.

Figure 3 shows that the curve indicating cumulative catch may tend towards an asymptote, taking a form similar to that of the adult phase of a growth curve. This raises the possibility that it may be feasible to treat such data in terms similar to those used for describing growth rates of organisms, i.e., in terms of the asymptotic level beyond which the catch will not increase, and in terms of the rate at which this level is approached. We intend to explore this possibility, particularly in relation to the different economic returns which may be expected as a result of varying the duration of the soak.

Changes in the composition of the catch with increasing soak

Our SCUBA observations have shown that there is a succession of species captured in the traps. Figure 4 shows the relative percentage frequency of observations of specimens of sixteen of the most important species of fishes and crustaceans captured in traps. These species fall into three groups; those showing a progressive decline in frequency of occurrence with increasing duration of soak, those which show no significant changes in frequency of occurrence, and those which show a progressive increase in relative frequency of occurrence. The species included in the last group do not usually appear in traps until several days have elapsed.

In general, it is not possible to distinguish any features which characterize these groups of species other than to note that *Scarus croicensis* and *Sparisoma aurofrenatum*, both of which decline steadily in relative abundance, are the two species which are most often found dead in the traps, although the proportion of dead fishes is very small. *Panulirus argus*, the spiny lobster, increases steadily in relative abundance with increasing duration of soak and is perhaps attracted to dead fishes in the traps.

Conspecific attraction to captured fishes

Analyses have been conducted to verify observations that in many cases a trap appears to capture large numbers of individuals of the same species or genus with the result that traps set adjacent to each other in essentially identical environments may yield radically different catches.

The observation records were therefore scanned to determine whether or not the presence of fishes of a particular species in the trap resulted in increased catches of that species.

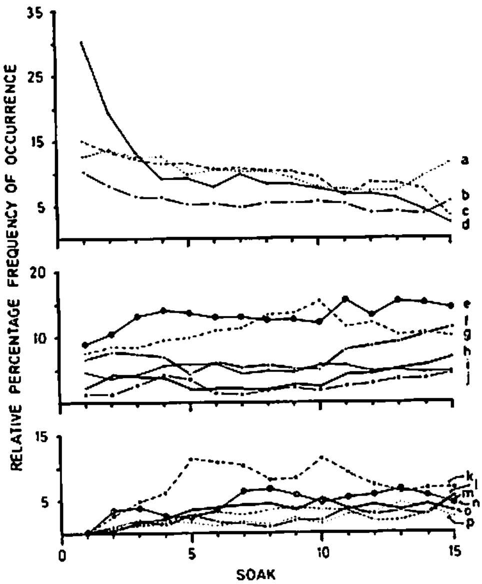

Fig. 4. Changes in the relative percentage frequency of occurrence of sixteen common species of fishes captured in Antillean Z-traps, in relation to the duration of the soak.

Key to symbols:

a)	*Acanthurus bahianus*	b)	*Petrometopon cruentatum*
c)	*Sparisoma aurofrenatum*	d)	*Scarus croicensis*
e)	*Haemulon plumieri*	f)	*Acanthurus chirurgus*
g)	*Acanthurus coeruleus*	h)	*Pomacanthus arcuatus*
i)	*Panulirus guttatus*	j)	*Lutjanus apodus*
k)	*Sparisoma viride*	l)	*Mithrax spinosissimus*
m)	*Holacanthus ciliaris*	n)	*Sparisoma chrysopterum*
o)	*Panulirus argus*	p)	*Caranx ruber*

Figure 5 shows that in the case of *Haemulon plumieri* this appeared to be substantially correct. When more than four *H. plumieri* were present in the trap the subsequent daily ingress of *H. plumieri* rose sharply. The various species of scarids and acanthurids yield similar, but less striking, results. Holocanthids, acanthurids, pomadasyids, scarids, and carangids have all been observed to be attracted to captured conspecifics. When this occurs the fishes tend to swim side by side on either side of the wire mesh. This often results in the fish which is at liberty being inadvertently led down the entrance funnel and retained in the trap.

Conspecific attraction may, therefore, to a large degree, account for the high between-trap variability in catches which is a feature of this fishery.

Effect of structure of traps

Extensive comparative work has been done using Cuban S-traps and Jamaican

Z-traps. The S-traps are easier and cheaper to construct, and are lighter and more easily handled, particularly under water. Z- and S-traps have been set in pairs, unbaited, and the catches compared. Comparison of 41 pairs of catches showed that catches of the S-traps were 29% greater by numbers and 25% greater by weight, but owing to the high variability encountered, the differences were only significant at the 80 - 90% level of probability and further comparisons need to be made before the differences are established.

A limited amount of fishing done with arrowhead traps indicated that they caught only about half as much as the Z-traps.

Traps shaded on the upper surfaces with interwoven palm fronds captured fewer scale fishes, but rather more spiny lobsters than unshaded traps, and shade is therefore not a factor inducing fishes to enter the traps.

We have therefore concluded that the continuous curves of the S-trap guide fishes to the entrances and that this probably accounts for the superior performance of these traps. Likewise, the number of entrance funnels is also important.

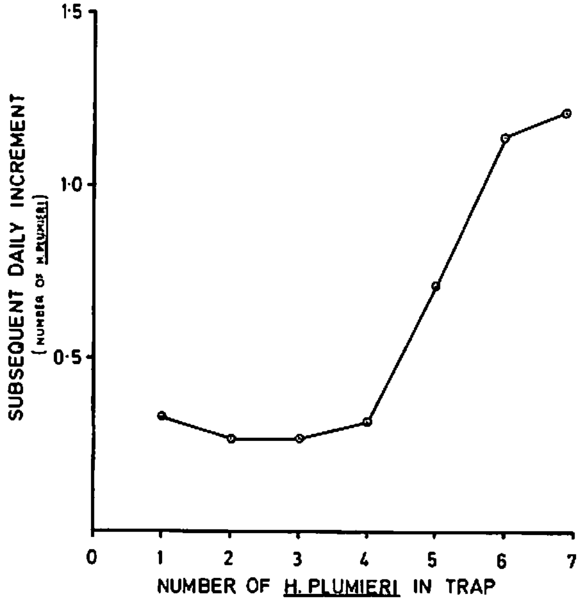

Fig. 5. The effect of conspecific attraction upon catches of *Haemulon plumieri*.

Effect of bait

Owing to the deaths of fishes in the traps, the traps are to a certain extent self-baiting. However, tests which were conducted to determine whether chopped fish bait was effective in increasing the catch and also in changing the composition of catches indicated that the catches in the Port Royal area were not improved by the addition of bait in the form of chopped fish. Indeed, a comparison of the catches of 27 pairs of baited and unbaited traps showed the unbaited traps to be 15% more effective in catching fishes! However, the baited traps captured fishes of slightly greater mean weight and a few more spiny lobsters than did the unbaited traps.

In Jamaica, a wide variety of fruits and vegetables are commonly used as bait. We have not been able to conduct definitive tests on these baits but the limited information that we have indicates that such items are also not very effective in attracting fishes or crustaceans to traps.

Pieces of broken porcelain are also often placed in traps or tied to the wire mesh. In some cases it is claimed that this attracts fishes, in others it is said to facilitate location and recovery of unbuoyed traps.

We have therefore concluded that at least at the low level of density of fishes encountered in the Port Royal reefs, that curiosity, inadvertent entrance and conspecific attraction are more important factors than bait in determining the magnitude of catches.

Fate of untended or lost traps

Traps which are lost or abandoned in the water have always been thought to constitute a management problem because they continue to fish and remove stock from the reefs. However, as indicated previously, a substantial portion (perhaps as much as 50%) of the fishes which enter the traps eventually escape. The individuals which do not escape live for a variable length of time depending upon physiological factors and upon their willingness to consume food in the trap - viz. dead fishes and algal growths. However, almost all fishes which have been confined in traps for periods approaching 2 weeks show obvious signs of physical deterioration including wounds from predators or abrasions from the wire mesh, often with secondary fungal infections.

The usual sequence of events is probably that increasing numbers of fishes accumulate in the traps for a period of time which probably seldom exceeds a month. The captured fishes are subjected to an increasing mortality rate, partly due to physical deterioration and starvation, but also due to predation by moray eels *(Gymnothorax moringa* and *G. funebris)* which may prey heavily on the catch and stabilize it. Finally, the traps which have accumulated large numbers of fishes may be attacked by large predators such as the nurse shark, *Gingylostoma cirratum*, and the trap may be ripped open and become inoperative.

CONCLUSIONS

(1) The rate of ingress of most species of fishes into traps is substantially depressed at or near the time of neap tides, and is about 50% greater at or around the spring tides.

(2) With increasing duration of soak, the accumulated catch in traps tends towards an asymptote indicating that soaks exceeding about 2 weeks are probably unprofitable.

(3) The decreased rate of retention of fishes in traps soaked for extended periods is probably a result of increasing rates of escapement from the traps. Increases in catch rates of up to 100% may be possible if a suitable non-return device can be fitted to the entrance funnels of the traps.

(4) Progressive changes occur in the relative composition of trap catches with

increasing soak but the causes of these changes are unknown.

(5) The presence of conspecifics in a trap results in increased ingress of that species. We believe that this accounts for much of the very high variability of catches which occurs even between adjacent traps.

(6) Antillean S-traps of Cuban design yielded catches which averaged 25% heavier than those obtained in traditional Jamaican Z-traps. We believe that the continuous curves of the S-trap serve to guide fishes into the entrance funnels more effectively than is the case with the angular Z-trap. Single-funneled arrowhead traps yielded substantially smaller catches.

(7) Within the rather impoverished fish community of the Port Royal reefs, chopped fish bait was ineffective in increasing trap catches and it is concluded that curiosity, inadvertent entrance and conspecific attraction are more important factors determining ingress into traps.

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Porpoise Fisheries in the Southern Caribbean — Present Utilizations and Future Potentials

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EARLY BEGINNINGS OF WEST INDIAN WHALING

Organized commercial whaling of some kind has existed in the southern Caribbean, and especially in the southern Lesser Antilles, for about two centuries.

History records that a whaleship from New England ran into trouble with the local authorities for not dipping its foresail to the King's colors as it put into Barbados in 1763, and that arrangements were being made to use that island's port facilities (and those at St. Eustatius) for whalers as early as 1775 (Stackpole, 1953: 23, 73). At that time the primary quarry of the whalemen was the sperm whale *(Physeter catodon)* and the humpback *(Megaptera nova-eangliae)*. In those earlier days, the whalemen who came to the southern Caribbean worked out of the now famous New England ports and only stopped at the islands for supplies and recruits for their crews. The West Indian whaling grounds (see Clark, 1887a, 1887b; True, 1904; Townsend, 1935) usually were only one of several whaling areas that these ships worked on their long voyages that sometimes lasted for 4 years or more. The practice of whaling in the region and calling at West Indian ports continued well into the present century when as late as 1912 a New England based whaler filled out its crew and departed from a West Indian port (Dominica in this case, after a non-whaling passage from Barbados) for limited whaling in local waters before going on to a more extensive cruise through the North and South Atlantic to return to Barbados (Murphy, 1947, 1967). As all whalers did, the New England ships from time to time took a few porpoises[1] and other small whales, including blackfish, for fresh meat and oil to be utilized aboard ship (Clark, 1887c). Consequently, the scene was set for today's whaling by the local people of the southern Caribbean as they readily learned both catching techniques and food habits from these early contacts.

LOCAL WHALING AND PRESENT UTILIZATIONS OF WEST INDIAN CETACEAN STOCKS

All of the formal whaling in the Lesser Antilles is patterned after the style of the New England whalemen (Morice, 1958; Rathjen and Sullivan, 1970). The

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[1] Although there is a technical basis for separating them, for the general purposes of this paper we use the term "porpoise" for all of the small cetaceans, including those which more correctly are mammalian "dolphins", which do not have a special and widely used common name such as blackfish or killer whale. The latter two also are really dolphins, but for collective purposes in this discussion would also be included as porpoises. In reality, no true porpoises in the technical sense are presently known from the region here under discussion.

style of the boats used, the techniques employed, and the uses of the whales and porpoises they kill are all very similar to the ancestral fisheries. The primary differences between the old and the present day whale fisheries are that the latter is a shore-based fishery and the prime objects of the chase are the smaller cetaceans. The forebears of the present whalemen learned their trade as crewmen on the New England whaleships which called in the West Indies and there was no need to change the basic fishing principles which had served the 18th and 19th century whalemen so well. Those modifications that have occurred have, for the most part, been introduced in the past 2½ decades.

Two basic kinds of organized whaling are still practiced in the Lesser Antilles. The older fishery still seeks the humpback whale, or an occasional sperm whale, and is now restricted to the island of Bequia in the St. Vincent Grenadines. The West Indian based humpback fishery was first developed at Bequia during the heyday of the New England whaling (Brown, 1945) and appears to be dying there today. At one time a certain amount of whaling of this kind spread to Grenada (Isle de Caille and St. George's), St. Lucia (Pigeon Island), Barbados (Speightstown and Holetown) and Trinidad (Monos Island), but these activities ceased for the most part at least a half century ago. For a brief time in the early 1920's a Norwegian whaling company established a shore station on Grenada (Brown, 1942, 1945), but it is remembered now chiefly for its introduction of shoulder bomb guns into the fishery. This type of gear still is used sometimes in the dying Bequia humpback fishery in conjunction with the old-style hand toggle harpoons of the kind handed down from the old New England style of whaling. On the average, only two or three humpbacks are taken annually in the Bequia fishery now and there have been years recently when none at all were captured. Sperm whales are taken even less frequently. Techniques used in this fishery were adequately described by Brown (1942, 1945) and Fenger (1958).

The second style of contemporary West Indian whaling is that used to hunt the blackfish or pilot whale *(Globicephala macrorhyncha)*. Like the Bequia fishery for humpbacks and sperms, the blackfish fishery is shore based, but unlike the former in which the whales sometimes are sighted from land, the blackfish catchers always set out on their own each fishing day to hunt and kill their quarry never with assistance from shore. The techniques used in this fishery in its older and purer form were described best by Brown (1945) and Hickling (1950). Since those descriptions were published, a small boat-mounted harpoon gun (actually a modified shotgun) has been introduced (in 1946, according to Jackson, 1967) and only as recently as early 1968 an inboard motor launch has been employed by one group of whalemen from St. Vincent. The motor launch permits the men a much greater cruising range and a greater maneuverability when they are going onto whales, and in addition gives them more freedom from the vagaries of the wind. It seems likely that more of these launches eventually will replace those sailing boats still used by the rest of the whalemen. At St. Vincent this one motor launch accounts for most of the porpoises (which generally are faster swimming than the blackfish) now taken, as well as a good percentage of the blackfish. Costs, both initial and operating, have been the primary deterrent to additional launches, but additional ones, both inboard and outboard, are planned. The first motor launch was built for use with engine power while the others planned so far are to be modified sailing boats.

Before the advent of the mounted gun, the whales were harpooned with a typical New England toggle iron (harpoon) attached to a long and heavy wooden shaft. All of this was thrown by hand either directly at the whale or, more frequently, was skipped across the surface of the water into the side of the prey as it rose to blow. The same technique is used today with the gun except that the wooden shaft is shorter. The range and accuracy of each shot has improved to the point where the additional cost for the gun and ammunition to propel the harpoon is justified. Some harpoons are still thrown by hand, however, and as always in the past the animals on the line are killed by hand lancing over the side of the boat.

The sailing boats measure some 27 feet (8.2 meters) in length and carry a crew of six who row when necessary to increase the speed or when sailing is not practical due to unfavorable winds (Fig. 1). Of this crew of six, the harpooner is the nominal captain, another is steersman, and the remaining four do the rowing. All lend a hand when it comes time to haul in the catch and bring it over the side into the boat or secure it for towing alongside. In our experience the one launch carries a crew of only five, and the captain is a supervisor rather than the harpooneer. He and his helmsman station themselves astern, while the remainder of the crew, including the harpooneer, stand watch closer to the bow. This one launch is slightly longer in length and broader in beam than its companion sailing boats.

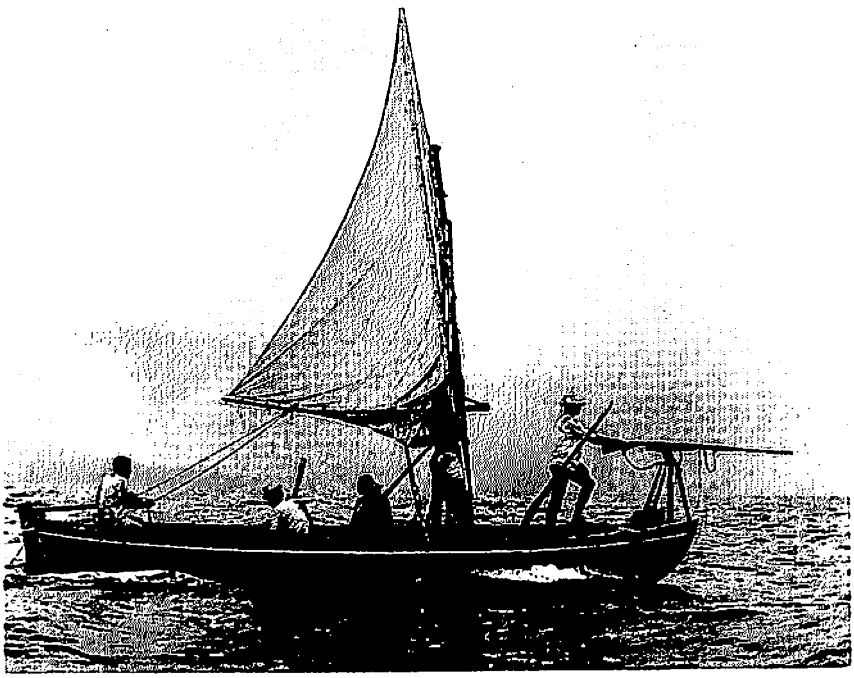

Fig. 1. Blackfish boat under sail while hunting off the leeward coast of the Lesser Antillean island of St. Vincent on 21 May 1968. (Photograph by William A. Huck)

The fishery for blackfish was started at Barrouallie, on the lee shore of St. Vincent, early in the first quarter of the present century (Morris, 1966; Jackson, 1967). An old Bequia whaling boat is said to have been bought and fitted out for the commercial capture of porpoises around St. Vincent. It is reported that on one of the earlier porpoise hunts a much larger animal resembling a porpoise was taken that proved to be a blackfish (truly a large species of porpoise). For a number of reasons, but primarily because of its larger size and supposedly preferable taste, this species soon became the primary quarry of the fishery. Before this commercial venture, a few porpoises were harpooned for personal use from existing small fishing boats (Griffith Arrindell, *pers. conversation*, 1970).

Fig. 2. Blackfish *(Globicephala macrorhyncha)* being butchered on the beach at Barrouallie, St. Vincent, on 21 May 1968. The heads are set aside for special handling to obtain the melon oil for export to the United States for use in lubrication of fine instruments. The ever-present dogs and chickens help clear the beach of unsanitary scraps from the cutting up which usually takes place the morning after the catch. (Photograph by William A. Huck).

Barrouallie is still the center of the fishery (Fig. 2) with some half dozen boats at a maximum landing an annual average of about 350 blackfish and an aggregate of perhaps as many porpoises and other assorted small to large cetaceans. If anything, this estimate for non-blackfish landings may be high. Humpback whales are seen off the lee shore of the island by men engaged in this fishery, but because of its size this species is not pursued by the Vincentians.

The men do take several small sperm whales each year (Fig. 3) and a few killer whales *(Orcinus orca)*, false killer whales *(Pseudorca crassidens)*, and Risso's dolphins *(Grampus griseus)*. A preliminary report on these and other, smaller, species taken in the St. Vincent fishery has been prepared (Caldwell, et al., In press). In all, 12 species of cetaceans presently are known from the Barrouallie fishery and at least six more are suspected on the basis of zoogeographic rational and from descriptions provided us by the whalemen.

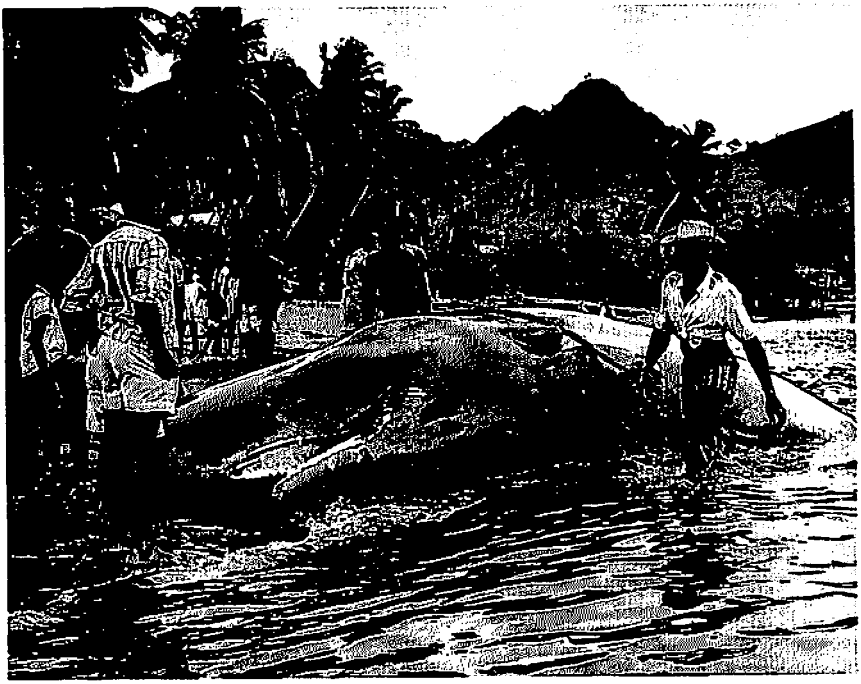

Fig. 3. Female sperm whale *(Physeter catodon)*, 7.8 m in length in a straight line from tip of snout to fluke notch, captured in the blackfish fishery off the island of St. Vincent and landed there, at Barrouallie, on 24 May 1968. (Photograph by William A. Huck)

At St. Vincent, in addition to Barrouallie some whaling has been done from the towns of Rose Bank (still active), Wallibou and Cumberland. From nearby St. Lucia, whaling boats leave from Vieux Fort and Port Castries, and from Dominica they depart from Pointe Michele. Morice (1958) inferred that blackfish are taken near Martinique, but we have no other evidence for a commercial blackfish fishery there. Blackfish are taken year-round, with peaks of production in late spring and in the fall. The Bequia humpback whaling is pretty much restricted to the months of February, March and April.

We are told by fisheries officers and other reliable observers that porpoises sometimes are taken by accident in beach seining operations for fin fish in waters around Trinidad, Tobago, and some of the Venezuelan islands (see Fig.4). Apparently if the fin fishing had not been good on the day the porpoises were taken, the latter would be utilized for food in the local markets for human consumption. Otherwise the porpoises are either abandoned if dead (released if alive) or used for food for dogs and sometimes swine. Reports of similar accidental captures in West Indian beach seining operations for fish go back at least as far as a century or more, for Gosse (1851:357) recorded them in the harbor of Kingston, Jamaica, with the comment that there the porpoises were considered a nuisance because they were of no value as marketable food. Our own long-time experience with Jamaican fishing and fish market operations has failed to produce such records during the past 15 years, nor have we heard of any such porpoise captures there. We have, in fact, heard of no commercial porpoise-catching operations in any of the Greater Antilles or northern Lesser Antilles. In the waters of Venezuela, at least, a few porpoises are also taken for food and oil by harpoon from boats not regularly engaged in such activity. Indications of such porpoise fishing around the island of Margarita are available (Anonymous, n.d.; Caldwell, Cervigon and Caldwell, MS) but the subject needs additional study. The taste for porpoise meat seems to be limited primarily to the southern West Indies and Caribbean.

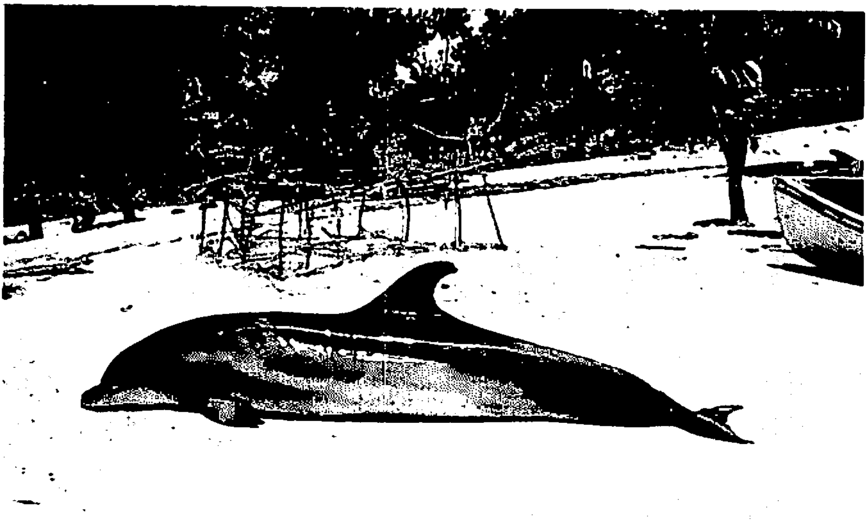

Fig. 4. Fresh-caught Atlantic bottlenosed dolphin *(Tursiops truncatus)* collected incidental to a fin-fish fishery at La Blanquilla Island off Venezuela during March, 1966. Length of carcass reportedly about 230 cm. Spotted belly suggests that the animal is an adult female. (Photograph courtesy Fernando Cervigon)

To sum up the present state of West Indian whaling then, porpoises and other small cetaceans, as well as a few individuals of the larger species of whales, are taken on a regular and organized basis in the southeastern Caribbean and West Indies. A few more, especially porpoises, are taken incidental to the fin-fish fisheries or from boats in passage engaged in such fisheries. While the annual production of West Indian whaling is small, the products of the fisheries often form a significant part of the local economy and the meat (utilized either fresh or salted and dried) and oil are included in the diet of the local people as important sources of protein and fats (Caldwell and Erdman, 1963). In this region such things are often in short supply despite the abundance in the sea. In short, the people of this area are educated toward the full utilization of porpoises and other small (and large) whales when that resource is available to them.

FUTURE POTENTIALS FOR WEST INDIAN WHALING

We already have noted that the humpback whaling industry is rapidly dying. The blackfish industry appears to be relatively stable in numbers of whales captured and the gradual reduction in numbers of whalemen seems to be compensated for by the increased efficiency of the remaining boats, and especially so with the advent of the motor launch concept. There is a hazy potential for yet another utilization of the West Indian porpoise stocks if projected tuna seining plans and hopes materialize.

The extensive purse seine fisheries for tuna in the eastern Pacific often produce large numbers of porpoises as these mammals often travel with the tuna schools and serve the fishermen (albeit unwillingly) as natural beacons for the tuna schools. The purse seine nets are set around the porpoises in the hope of catching unseen schools of tuna below, and most of the porpoises are encircled and captured as well. While every effort by the fishermen is made to release them alive, the mortality rate on the porpoises is so high that there is a real fear among cetologists that the schools will be depleted to the point where irreversible damage will occur. Consequently, a great effort is now being made to solve the problem of release of porpoises without release of tuna so that the former will continue to serve as future surface markers for other tuna schools. The relationship between porpoises and tunas in the eastern Pacific, the subsequent problems of porpoise mortality, and efforts to reduce it, have been discussed in some detail (Perrin, 1968, 1969, 1970a, 1970b; McNeely, 1961; Miller, 1970; Anonymous, 1968, 1970a, 1970b).

From time to time there have been proposals to conduct tuna purse seining operations in the Caribbean area. Some exploratory fishing operations of this nature have been carried on (Bartlett, 1969) and while tuna were sighted, the general results of the survey were not promising (Albert C. Jones, *pers. comm.*, 1970). Nevertheless, the possibilities for the development of such a fishery still exist. Because the same kinds of porpoises (or very closely related species) occur in the southern Caribbean as occur in the eastern Pacific, it seems logical to assume that if in the future a tuna purse seine fishery is developed there that porpoises will be utilized as surface markers as they are in the eastern Pacific. While the species involved have yet to be documented fully, in recent years we have been told (by Stewart Springer and Harvey R. Bullis, for example) that porpoises are indeed sometimes seen in association with tuna schools in the tropical and temperate western Atlantic. We presume from the general similarities between the marine faunas of the western Atlantic and eastern Pacific that the species associations of porpoises and tuna are also similar in the two regions. An ongoing survey (Anonymous, 1969) of porpoise-tuna associations in the tropical eastern Atlantic, which faunistically is also similar to the southern Lesser Antilles, should shed further light on the potential porpoise-tuna relationships in the latter region.

Unlike those tuna seiners operating in the eastern Pacific hundreds and even thousands of miles from their home ports in California, the seiners that might work in the Caribbean likely would be based closer to their fishing grounds. The recent development of modern fishing port facilities at Guiria in northeastern Venezuela (Beattie, 1970) lends credence to this assumption.

Porpoises accidently killed in the eastern Pacific tuna fishery are usually discarded because they take up valuable fish space in the freezers and because there is no market at all for them at home even if the holds were not full. If a porpoise carcass accidentally slips into the freezer hold it is returned to California, but again it is discarded on unloading unless it falls into the hands of some willing biologist waiting at dockside. We have ourselves obtained such solid-frozen carcasses in years past and found on necropsy that they were in edible condition had anyone wished to make such use of them. With a little care on board ship they could be made a very acceptable food product.

Inasmuch as Caribbean tuna seiners most likely would be working closer to home and making shorter cruises in which space in the hold might not be at such a premium, it would seem desireable that porpoises accidentally killed in the seining operations be retained and frozen. They could thus constitute a utilization of an otherwise wasted food resource already acceptable to and badly needed by many of the local people in that part of the Caribbean and West Indian region where a significant portion of such tuna seiners might be expected to land anyway.

The price of the resulting porpoise products should be high enough to pay the costs of handling and marketing these porpoises at a small profit. However, profits should not be so high that it might become more or even as profitable to catch porpoises outright than tuna. Nor should even this price be so high that the low income segment of the local population to whom the utilization of this resource would be directed would be unable to buy. It is our feeling that the utilization of this particular resource be for the benefit of the consumers, not the fishermen, but that the latter should make a small profit for their trouble and to encourage them not to waste the resource already in their hands. As in the present eastern Pacific tuna purse seine fisheries, the men in any Caribbean and West Indian fishery of this kind should be educated to the fact that the porpoise populations are subject to rapid decimation and that their loss would mean the loss of the whole fishery, or at least its curtailment in ease and success of operation.

We also want to emphasize that we do not propose an accelerated fishery directed at the porpoises, but only that it might well be practical in this *particular* geographical area to utilize an otherwise wasted resource. Each day we learn the hard way that our natural resources are not unlimited and certainly under no circumstances should they be wasted. Just because current human need and economics dictate that "secondary" resources be destroyed is no excuse for the wasting of such secondary resources. They are, in fact, secondary only to some other activity that is deemed "primary" for the moment. In reality they all are just as important in the ecological scheme and must not wantonly be destroyed. When there seems to be no other alternative to destruction, then these secondary resources should not be wasted, but instead should be utilized in some manner. This is what we suggest for any porpoises that might be killed by accident in a potential Caribbean and West Indian tuna purse seine operation. The combination of porpoises in association with the tuna, nearby landing facilities for the catch, and a local population educated to the utilization of porpoises may make this geographical region almost unique for the potential utilization of this otherwise wasted resource.

We suggest, therefore, that in the event a further effort is made to develop a tuna purse seine fishery in the Caribbean and West Indies that the utilization of this apparently inevitable but otherwise wasted resource be considered in any planning.

ACKNOWLEDGMENTS

We wish to thank Warren F. Rathjen of the U.S. National Marine Fisheries Service, Woods Hole, Massachusetts, for valued comments made during the preparation of this report, Dr. Albert C. Jones of that Service, in Miami, Florida, provided otherwise unavailable reports on West Indian exploratory fishing and also made valued comments. Support for certain phases of the work resulting in this report came from the American Philosophical Society (grant no. 962, Johnson Fund), the National Science Foundation (grant no. GF-241) and Marineland, Inc. For all of this assistance and for help from the St. Vincent whalemen (especially Griffith Arrindell and William O'Garro of Barrouallie), Conrad Francis of Barrouallie, John R. Sullivan then of the U.S. Peace Corps on St. Vincent, and J. H. Rapsey and C. S. Bauden of the St. Vincent Teachers College, we are most grateful.

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DISCUSSION

Caribbean Session

Discussion Leader: G. B. Gross
Discussion Panel: H. C. Girigorie, R. C. Griffiths, I. Kristensen, R. S. Wolf

United Nations Development Program

Food and Agriculture Organization of the United Nations

Fishery Development Projects in the Caribbean

W. E. Ripley

Q. Gross: The UNDP has been in operation for some years with fisheries projects all over the world, can you give us any information on the effectiveness of the UNDP program?

A. Ripley: The UNDP has had fisheries projects throughout the world and has been stimulating the development of fisheries since 1958. As an example of what has come about between 1958 and 1968, in 1958 the developing nations then shared 8.2 million tons of fish as their part of world production, but in 1968 their production was increased to 25.3 million tons. The developed countries in the meantime increased their production from 17 to 25 million tons. During the same period their rate of increase was not as rapid. These simple statistics do not imply that the UNDP programs are entirely responsible for the increase in the developing countries' share of the world fisheries production. They do, however, offer evidence that the stimulation given by fisheries projects has had an effect. The intangible effects of the technical assistance given in the fisheries projects that are executed by FAO for the UNDP certainly also have had an important contribution towards helping the developing countries obtain a large share of the fisheries of the world.

Q. Griffiths: Regional projects are a good deal more difficult than is ordinarily known by people who have not worked with them -- the problems related to different cultures, acceptance of different fisheries products, technical and economical problems related to contacts with other culture. Under these circumstances, are regional programs a wise thing?

A. Ripley: It is understood that regional programs have difficulties that are not inherent in an individual country program. However, the benefits often are quite extensive when a program is developed on a regional basis. There can be benefits of additional capital and market base for expansion of fisheries activities in the region and in the savings that occur, in pooling efforts in determining what resources are available for development. The UNDP has many regional programs and, in fact, 18 percent of the funds have been allotted for regional projects in the future.

Q. Girigorie: Are there any plans to follow up the Caribbean regional project?

A. Ripley: At this time there are discussions being held in planning for a new project. Although we do not know exactly what the final outcome will be, I believe there will be some kind of regional activity forthcoming as a follow up of the existing project. The resources work done by REG 189 has indicated good stocks of fish in the southernmost area of the region, and if the necessary capital and effort is brought to bear in this area, it should produce favorable results.

An Improved Field Method for Quality Evaluation of Shrimp Held in Refrigerated Brine and Ice

H. Rojas Garcia

Q. Kristensen: From other information available, the pH of shrimp gives inaccurate information of shrimp quality, could you explain the results that you obtain?

A. Rojas Garcia: The traditional method used in the determination of the pH of shrimp gives erroneous results, this might be in relation to the non-homogeneous extractive obtained by these methods.

If the shrimp lot to be examined is of unknown origin and thus including mixed qualities of shrimp, the "improved method" that I propose will not adequately serve as a freshness test, but, if the shrimp lot is of a known origin (in example, shrimp from a culturing pond) the method will be highly satisfactory.

Q. Griffiths: What is the practical importance of your findings in the use of color indicators?

A. Rojas Garcia: Reported results mainly from U.S. researchers show that "good" quality shrimp have a pH of 7.50 to 8.25, "acceptable" shrimp have a pH of 8.26 to 8.40. Our results indicate that the pH of "good" shrimp is of 6.7 to 7.30, "acceptable" shrimp have a pH of 7.20 to 7.30, and "borderline" shrimp have a pH of 7.65 to 8.20, these results as you can see are very different from other findings.

Strasburger (Comment) We have found in our work with canned marine products that the pH is extremely useful. In some cases the pH of the product has to be adjusted and stabilized. For other processes we did not find the pH to be a good indicator.

A. Rojas Garcia: I do not claim that the traditional method of pH measurement in shrimp is a good indicator of quality. What I found in my research work was that *the method that I described* is useful to measure the pH of shrimp of a known history.

Status and Potential of the Fishery in the Caribbean

R. Juhl

Q. Wolf: The UN/FAO Caribbean Fisheries Development Project recently completed a shark assessment survey. The results of the survey indicate availability of at least 10 to 12 thousand sharks per year in the Guianas coastal areas. Have you included this estimate in your figures on the potential of the Caribbean?

A. Juhl: Yes, the results of those fishing tests were included. It is well to note that the shark fishery potential is several times the present production and its full development is expected in the near future with the advent of the much needed processing technology.

Q. Wolf: Can you tell us the reason why these shark resources are not utilized to a greater extent commercially?

A. Juhl: At the present time only a few of the island people and to a greater extent those from the Guianas coast consume shark, owing in part to social custom and limited processing techniques. The latter will, no doubt, be overcome by UN/FAO project activities in marketing and technology.

Q. Kristensen: In many areas including Curacao, production of fish is low, except for seasonal over abundance which gluts the market and depresses the price. How have you managed to take care of these periods of over-abundance?

A. Juhl: In Puerto Rico the fluctuation in fish production is considerably less than in the continental shore areas. In cases when production is above normal the excess is handled through ample existing marketing outlets. It is imperative, in situations of overabundance, to make available a greater number of freezing facilities and processing techniques such as drying and smoking, so that full advantage can be gained during periods of abundance. This will not only help to stabilize the price but also provide fish during periods of scarcity.

Dynamic Factors Affecting the Performance of the Antillean Fish Trap

J. L. Munro

Q. Wolf: I realize that your fishing is mostly done with unbaited traps. Nevertheless, can you comment on the relationship between catches and the quantity of bait in the trap? What relation does this have to depth?

A. Munro: We could not provide you with any data on that. We have been fishing only in depths of 20-80 feet (6 m-26 m) with unbaited or lightly baited traps.

Q. Gross: Why do lobsters enter the Antillean fish traps?

A. Munro: I think that in a general case, the lobsters are looking for a refuge and, particularly at night, the trap appears to be an effective hiding place. They are also attracted to dead fishes in unbaited traps.

Q. Girigorie: A number of different types of traps have been tested by the UNDP Caribbean Fisheries Development Project, with good results in many cases. However, you report catches of only 2.2 fishes per day, or an average of less than a pound a day. Are the coastal waters in Jamaica fished out? Why do fishermen continue to fish?

A. Munro: In the Port Royal Reefs, our catches average about half-pound per day. Comparison with the results obtained by the Caribbean Fisheries Development Project is not really valid because they have been fishing in much deeper water. However, catch rates in the Virgin Islands, and on the Pedro Bank approach 10 pounds per day. This indicates that Jamaican near-shore reefs are seriously overfished, and fishing on these reefs is probably only practicable for part time fishermen.

Q. Kristensen: There are big fish available in some areas. Are the small fish used in Jamaica? Is it not possible to protect the small fishes?

A. Munro: Small fish are readily marketable in Jamaica and therefore, the average size of the fishes in the catch is not very important to the fishermen or to the consumer. However, our project is engaged in estimating the optimum mesh size for traps relative to the economic and biological status of the fishery. We believe that increasing the mesh size would dramatically improve the productivity of the fishery, because most species are captured when immature and well in advance of their optimum size.

Porpoise Fisheries in the Southern Caribbean — Present Utilizations and Future Potentials

D. Caldwell and M. Caldwell

Q. Girigorie: You indicated that in some years only two or three whales are caught. Did you also say that in other years none were taken?

A. Caldwell: That is correct. In the Bequia whale fishery near St. Vincent, usually one or two humpback whales are taken each year and one or two sperm whales over any given period of several years. The fishery is dying, however, and in some years no whales of any kind are taken. The fishery is not declining for lack of whales, we are told, but because no new whalemen are joining the fishery and the older men are gradually giving it up.

Q. Wolf: You indicated that demand for whale meat is high. Does this demand not encourage higher catch effort and consequently should not protection be increased in order to preserve the whales?

A. Caldwell: While the demand for whale meat is high, it is a local demand. None of the meat and blubber is exported from the islands where the whales are caught except that some of the Bequia whalemeat is taken to nearby St. Vincent. The numbers of whalemen appear to be stable or on the decline because only a few men are willing or able to undertake the rigors and expense of whaling. While possible future regulation of the fishery should of course be kept in mind during any studies, there is presently no indication that the whale and porpoise stocks are declining in the Lesser Antilles. Present indications are that instead it is more likely that the local fishing effort is on the decline more so than the local cetacean stocks. Subjectively, of course, the whalemen tell us that the local stocks appear to be the same as in years past, but that the fishing effort is much reduced. Consequently, under present conditions, the cetaceans appear to be in no special danger in the Lesser Antilles.

Q. Jensen: The walrus in Alaska is said to be heading toward extinction, yet many animals are wasted each year because they sink when shot and are lost before the fishermen can reach them. Do you have any thoughts on how many blackfish and porpoises are lost at St. Vincent in this manner?

A. Caldwell: Apparently essentially none. The nature of the fishery is such that the animals are harpooned and thus are attached to the catcher boat by a sturdy line that makes it simple for them to be recovered. Were they shot with rifles like the walrus most, undoubtedly, would be lost because the small toothed whales and porpoises all sink rapidly upon death.

Q. Good: Is there any support for research on the Lesser Antillean porpoises?

A. Caldwell: None of a fishery nature. We have a small amount of support from the American Philosophical Society for studies on cataloging the cetacean fauna of St. Vincent and the Fisheries Research Board of Canada has, on brief occasion, visited the region for similar reasons. To my knowledge no broad studies on the biology, and especially the stocks, of these cetaceans are being undertaken with or without direct support. Sightings are sometimes recorded by research vessels in the region for other purposes, but the findings are often limited to "whale" or "porpoise" without a positive identification of the species seen. We are attempting to incorporate such data into our own overall catalog of West Indian and Caribbean records.