SURVEY OF BOTTOM FISH RESOURCE IN THE NORTHWESTERN HAWAIIAN ISLANDS

by

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INTRODUCTION

In 1969, the Governor's Task Force on Oceanography of the State of Hawaii recognized a need to explore, inventory, and develop new fishing areas to relieve the fishing pressure being exerted on the marine resources around the principal inhabited islands of Hawaii. The obvious place to explore was the Northwestern Hawaiian Islands (NWHI), a part of the Hawaiian Archipelago extending 3,200 km in a southeast-northwest direction.

Compounding the need for an investigation of the NWHI resources was the enactment of the U.S. Fishery Conservation and Management Act (FCMA) of 1976 (Public Law 94-265), which extended U.S. jurisdiction over fishery resources 200 nmi from our nation's coastline. As management plans were being considered for various species of fish and shellfish in the Fishery Conservation Zone (FCZ) around Hawaii, it became abundantly clear that there was little information of the operational aspects of the fisheries and that, in some cases, nothing was known about the resources in the NWHI.

Realizing that the scope of the NWHI investigation was beyond the capabilities of the staff and facilities of any single research agency in Hawaii, the Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service proposed a cooperative research effort with the State of Hawaii's Division of Fish and Game (HDFG) and the U.S. Fish and Wildlife Service (USFWS). The result was the signing of a Tripartite Cooperative Agreement, which provided for a survey and assessment of the nearshore fishery resources by the HDFG, biological studies and inventory of land-associated seabirds by the USFWS, and quantitative fishery

assessment and survey of the benthic slope and pelagic resources by the Honolulu Laboratory

BACKGROUND

The marine fauna in the Hawaiian Archipelago is an offshoot of that great marine geographic region centered on the East Indies. In Hawaii, the species complex is not as diverse as that in the western Pacific and the neritic shelf zone, unlike that of the world's great fishing areas is narrow and poorly developed. As a result, of the approximately 682 species of fish found in Hawaii, only about 60, mostly occurring on the reefs and benthic slopes, are commercially exploited.

The bottom fish resource in Hawaii includes a wide variety of fish. Those of high commercial value, mainly members of the snapper-grouper complex, include pink snappers, Pristipomoides filamentosus and P. sieboldii, Brigham's snapper, P. zonatus, red snappers, Etelis carbunculus and E. marshi, sea bass, Epinephelus quernus, gray snapper, Aprion virescens, members of the family Carangidae including amberjack, Seriola dumerilii, blue crevally, Caranx melampygus, white crevally, C. ignobilis, and thick-lipped crevally, C. cheilio, and members of the goatfish family, Mullidae.

SAMPLING PROCEDURES AND EFFORT

Between October 1976 and June 1979, 13 cruises were completed in the waters around the NWHI, including 11 by the NOAA ship Townsend Cromwell and 2 by a chartered fishing vessel. During these cruises, we occupied 91 bottom trawling stations, 125 handline fishing stations, and 97 fish trapping stations.

In addition to the data collected on the Cromwell and on chartered vessels, the Honolulu Laboratory established a commercial vessel observer program to collect field data from commercial vessels fishing in the NWHI. Detailed records of catch by species, fishing effort, and sizes are recorded on standard log forms by Honolulu Laboratory observers on board the vessels. Data collected by these observers are essential for stock assessment.

AREA AND SEASONAL COVERAGE

To analyze the distribution of fishing effort and catches of bottom fish, the area around the NWHI was divided into squares, each square measuring 6 min to a side of latitude and longitude. The squares were identified by their latitude and longitude at the lower right corner.

Although it was highly desirable to systematically survey as many of these squares as practical and to repeat the surveys to obtain good seasonal coverage, it was impractical to do so mainly because of time limitations. However, during the 3 yr just completed, we believe that adequate coverage has been given to the major islands such as Necker Island and Maro Reef where commercial quantities of spiny lobsters, Panulirus marginatus, have been discovered.

In terms of areal coverage, it has been estimated that the FCZ around the NWHI consists of an area roughly 1.8×10^6 km^2. Of this total about 20,900 km^2 or about 1% lies within the 366-m (200-fathom) contour where most of our bottom fish research is carried out.

BOTTOM TRAWLING

Our initial trawling effort was conducted with a high opening "Norwegian" fish trawl, which has a 20-m headrope, a 25-m footrope, and 36-cm diameter roller. On our more recent survey cruises, we have been using a larger "Noreastern" trawl, which has a 27-m headrope, a 32-m footrope, together with a pair of 1.8 × 2.7 m steel V-type doors. This trawl is used with a net sonde which permits us to monitor the depth of fishing and to avoid loss of the net over rough bottom. The "Noreastern" trawl has been particularly effective in sampling the seamount groundfish resource at Hancock Seamounts consisting mainly of armorhead, Pentaceros richardsoni, and alfonsin, Beryx splendens.

Trawl hauls varied from 15 to 30 min. Among the commercially valuable species caught in the trawl hauls were mackerel scad, Decapterus russellii, red bigeye, Priacanthus cruentatus and Cookeola boops, goatfishes, Parupeneus spp. and Mulloidichthys vanicolensis, pink snapper, Pristipomoides filamentosus, unicornfish, Naso unicornis, thick-lipped crevally, C. cheilio, amberjack, S. dumerilii, sea bass, E. quernus, spiny lobster, Panulirus marginatus, and slipper lobster, Scyllarides squammosus.

HANDLINE FISHING

When the NWHI survey was first begun in the fall of 1976, commercial handline gear similar to that used in the Hawaiian fishery was used. The mainline consists of braided dark-brown nylon line varying in strength from 65 to 120 kg. The mainline is joined to a monofilament drop line (90 kg test) to which are attached 4-5 monofilament hook lines (45 kg test)

spaced about 1.8 m apart; a 1.4 kg weight is attached to the end of the drop line. The hook line is about 1 m long. Hooks, which vary in size from No. 18 to No. 32, are Hawaiian-type recurved "oio" hooks.

To reduce the labor-intensive hand method of line hauling, hydraulic-powered reels or gurdies were used. The power reels, which proved to be extremely versatile and useful for bottom fishing, includes a davit with block, a rotating base, and brake and clutch assembly to control descent and ascent. We also experimented with electric reels, but these were abandoned after a few cruises because of the limited spool capacity.

Handline fishing stations are occupied day or night and usually lasts from 1 to 4 h. At each station, about four lines are fished although occasionally, as many as six lines have been fished at one time. During fishing, the vessel usually is allowed to drift from shallow to deeper waters or vice versa. A drift course parallel to a particular depth contour is desirable but rarely attainable.

FISH TRAPPING

Although several different types of fish traps were used in preliminary surveys in the NWHI, we eventually selected the rectangular, single compartment "Hawaiian-type" traps, which were made of 1.3-cm reinforcing steel frame measuring 152.4 cm long, 91.4 cm wide, and about 60.9 cm high. The trap was covered with 2.5-cm square galvanized wire mesh. This trap was modified by the addition of an off-center panel of wire mesh 50.8 cm from one end of the trap to create two compartments. The chamber, the shorter of the two compartments, has an entrance on both sides. Each entrance is

conical and has an outer diameter of 30.0 cm and an inner diameter of 16.5 cm. From the chamber, the parlor or the larger of the two compartments, which has the bait box, is entered through a third conical entrance of the same dimensions as those used to enter the chamber from the outside.

Smaller fish traps, which were lighter and easier to handle on the deck of the vessel, were constructed for cruises in 1979. These traps, essentially a scaled-down version of our original traps and with identical funnel openings, measured 108.0 cm long, 77.5 cm wide, and 46.3 cm high. The traps were covered with 2.5 cm × 1.2 cm hardware cloth.

Because fish traps were used in combination with lobster pots, most of them were set in the evening at about 1800 h, soaked overnight for about 14 h, and hauled the following morning after 0800 h.

PRELIMINARY RESULTS OF BOTTOM FISH RESEARCH

Among the ongoing research on the bottom fish resources in the NWHI are studies on distribution and relative abundance, fecundity, spawning season, age and growth, ciguatera, food and feeding habits, morphometric comparison, and population dynamics.

Relative Abundance

Preliminary results based on five cruises indicated that Pearl and Hermes Reef, located about 1,931 km northwest of Honolulu, is highly productive with an overall catch rate of about 2.8 fish/line-h. Other areas that showed relatively high productivity included Nihoa Island (2.3 fish/line-h), French Frigate Shoals (1.8 fish/line-h), Midway and Maro Reef (about 1.6 fish/line-h), and Necker and Lisianski Islands (1.5 and

1.4 fish/line-h). Gardner Pinnacles, Laysan Island, Raita Bank, Kure Island, and Brooks Bank all had catch rates of 1.2 fish/line-h or less.

Fecundity

Studies on fecundity were started in the past few months and have not advanced far enough to draw any conclusions; however, some of our preliminary findings indicate that ova development in the pink snapper, Pristipomoides filamentosus did not appear to be homogeneous throughout the ovary and that large ova showing the most advanced development appeared to be concentrated toward the center of the ovary. It was also determined that maturing ova in the pink snapper have a mean diameter of 0.51 mm whereas ripe ova have a mean diameter of 0.55 mm.

Food Habits

Concerning our efforts to study food and feeding habits of the fishes of the snapper-grouper complex, we have been having considerable difficulty collecting sufficient samples for analysis. Many of these fishes are taken from depths ranging between 90 and 275 m and when they are brought to the surface, expansion of the gas bladder forces the stomachs to evert and much of the stomach contents are lost.

Ciguatera

One of the major thrusts of our research on bottom fish for the past 3 yr has been a study of the occurrence and distribution of ciguatoxic fishes in NWHI waters. This study was initiated primarily because of the

concerns of the U.S. Navy, which administers Midway Islands, on ciguatera outbreaks among its naval and civilian personnel stationed at the base. As a result of these outbreaks, the U.S. Navy placed restrictions on catching and consuming fish that occurred in the lagoon waters.

Initially, our systematic sampling included the collection of tissue samples from all commercially valuable fish species caught in NWHI waters. From each fish, tissue samples were collected from the dorsal musculature, the ventral abdominal musculature, the gonads, and the liver. Subsequently, liver collection was discontinued and additional muscle tissues are being collected from near the anal region.

Each tissue sample is placed in a plastic vial, labeled, and frozen. Data collected on the fish include date, catch location, water depth, sex, length, and weight. The samples are processed at the University of Hawaii's John A. Burns School of Medicine, Pathology Department, where a practical, sensitive, and relatively specific radioimmunoassay (RIA) for the detection of ciguatoxin has been developed (Hokama et al. 1977). The toxicity levels of the fish tissues are determined from radioactive counts per minute per gram of tissue (c/m/g tissue), as follows: <350,000 c/m/g tissue - negative; 350,000-39,999 c/m/g tissue - borderline; and >400,000 c/m/g/ tissue - positive.[1]

From 1977 to 1978, the Honolulu Laboratory collected tissue samples from 751 fish and the HDFG collected additional tissue samples from 253 inshore fish (total, 1,004 fish) representing 80 different species. The

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[1]Hokama, Y. 1979. Development and testing of fishes for ciguatoxin. Final project report submitted to the State of Hawaii, Office of the Marine Affairs Coordinator, 9 p.

RIA tests showed that 150 fish of some 39 different species were either positive or borderline positive, indicating that the detected levels of ciguatoxin could be hazardous to humans (14.9%). There is, however, a possibility that some of the samples tested may have given a false positive reaction.

The rejection rate (in parenthesis) of some of the species where 10 of more fish were tested is as follows: C. cheilio (7.4%), C. ignobilis (12.3%), C. speciosus (7.1%), S. dumerilii (12.0%), Bodianus bilunulatus (38.5%), Cheilinus rhodochrous (68.8%), Lutjanus kasmira (17.4%), P. filamentosus (15.3%), Kuhlia sandvicensis (37.0%), Muraenidae (26.3%), Mugil cephalus (50.0%), and Polydactylus sexfilis (6.7%). Table 1 gives the results of other species tested.

Table 1

In the spring of 1979, following a sudden outbreak of ciguatera among the local populace, the Honolulu Laboratory also began a project of routinely sampling and pretesting amberjack destined for sale at Honolulu's fresh fish auction market. By mid-April 1979, information supplied by various government agencies and fish retailers indicated that about 30-35 recent outbreaks could be documented and that perhaps another 50-100 individuals were affected but had not reported it to the health authorities. Whereas several finfish were implicated in ciguatera attacks in past years, a high percentage of the 1979 outbreaks appeared to be traceable to amberjack.

The previously developed RIA test for ciguatoxin was again used to analyze the amberjack tissues. In addition, an experimental enzyme-linked immunosorbent assay (ELISA) for detecting ciguatoxin is in progress in hopes of simplifying the test for future use by the commercial fishing industry.

From April 17 to August 14, 1979, 534 amberjacks were sampled at the auction market and the tests indicated that 35 were positive and 59 were borderline in toxicity, or a total of 94 (17.6%) had detectable levels of ciguatoxin.

Whereas the percentage of toxic fish in the samples was relatively high in May immediately after sampling began, it decreased in subsequent months and the percentage of rejection in August was about 5%, down from about 20% when the project was initiated. Preliminary results also indicate that very little, if any, correlation exists between fish size and RIA values, and between RIA and ELISA values. Research to improve the ELISA test is currently underway at the University of Hawaii.

Age and Growth

Another important study being conducted on members of the snapper-grouper complex is that dealing with age and growth. Pioneering research conducted in Puerto Rico by Pannella (1974) on the use of otoliths to age tropical fish was followed by several studies in the central Pacific, particularly in Hawaiian waters (Struhsaker and Uchiyama 1976; Ralston 1978; Moffitt[2]; Uchiyama and Struhsaker[3]).

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[2]Moffitt, R. B. 1979. Age, growth and reproduction of the kumu, Parupeneus porphyreus Jenkins. Unpubl. rep. Dept. Zoology, Univ. Hawaii, Honolulu.

[3]Uchiyama, J. H., and P. J. Struhsaker. Age and growth of skipjack tuna, Katsuwonus pelamis, and yellowfin tuna, Thunnus albacares, as indicated by daily growth increments of sagittae. Manuscr. in prep. Southwest Fisheries Center Honolulu Laboratory, National Marine Fisheries Service, NOAA, Honolulu, HI 96812.

Otoliths are extracted at sea or in the laboratory from frozen specimens brought back from our field surveys. Data collected with the otoliths include species, date of capture, catch locality, length, weight, and sex.

Whole-mounted or sectioned otoliths are read under a compound microscope at magnifications varying from 300X to 800X. Although we have made counts on several species, we have yet to demonstrate that a 1:1 relationship exists between age in days and the number of growth rings; however, on the basis of evidence from previous studies on other tropical species in Hawaiian waters, we are working under the assumption that each growth increment counted in the otolith represents 1 day. Attempts to corroborate this assumption will be made in the near future by tetracycline injections of live fish.

Much of the results of our age and growth project, therefore, are preliminary. A von Bertalanffy growth curve has been fitted to daily ring counts obtained for the amberjack (Figure 1). This growth is based on data from only six fish and a more realistic estimate will become possible only after data are obtained from additional specimens. Also, the validity of the 1:1 relationship for amberjack will have to be justified.

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Aging of other species is also underway. The study on the pink snapper, Pristipomoides filamentosus, is complicated by what appears to be differential growth due to sex. Males appear to grow slightly faster than females. Other species that are being studied are the sea bass, E. quernus, pink snapper, P. sieboldii, red snappers, Etelis carbunculus and E. marshi, and thick-lipped crevally, Caranx cheilio.

SUMMARY

The Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service, in cooperation with the Hawaii Division of Fish and Game, the U.S. Fish and Wildlife Service, and the University of Hawaii Sea Grant Program, has embarked on an extensive investigation of the living marine and terrestrial resources of the NWHI. Among the bottom fish resources under investigation are such species as snappers, groupers, carangids, goatfishes, armorhead, and alfonsin. Sampling is conducted primarily from the NOAA ship Townsend Cromwell using bottom trawls, handline gear, and traps.

Results of bottom fish research to date indicate that Pearl and Hermes Reef is highly productive with overall catch rates of 2.8 fish/line-h. Catch rates from other localities in the NWHI varied from 2.3 to less than 1.2 fish/line-h.

Research on distribution and occurrence of ciguatoxic fishes in the NWHI has been accelerated considerably by the development of a practical sensitive, simple, and relatively specific RIA test. Of 1,004 fish representing 80 different species tested from 1977 to 1978, 150 fish, representing 39 species showed relatively high levels of ciguatoxin. A possibility exists that some of the samples produced false positives.

Amberjack landed at the Honolulu fish auction market also came under scrutiny after several outbreaks of ciguatera were reported to local health authorities. In April-August 1979, 94 out of 534 amberjack tested (17.6%) showed either a positive or borderline level of toxicity, necessitating rejection of the fish for human consumption.

Age and growth studies based on counts of growth increments in otoliths have concentrated on commercially valuable fish of the snapper-grouper complex. A 1:1 relationship between age in days and number of growth rings has yet to be demonstrated for the species under consideration. Preliminary estimates indicate that amberjack attain a length of 35 cm in 12 mo and 56 cm in 18 mo. For pink snapper, Pristipomoides filamentosus, males appear to grow slightly faster than females.

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Table 1.--Number and percentage of fish, by species, caught in waters of the Northwestern Hawaiian Islands and found by radioimmunoassay to have toxic and borderline levels of ciguatoxin, 1977-78.

Species	Nontoxic	Borderline	Toxic	Total fish	Total borderline and toxic	Percent borderline and toxic
Acanthuridae						
Acanthurus leucopareius	1	0	0	1	0	0.0
A. nigroris	5	1	2	8	3	37.5
A. triostegus	11	1	1	13	2	15.4
A. xanthopterus	1	0	0	1	0	0.0
Ctenochaetus strigosus	8	0	0	8	0	0.0
Holocentridae						
Adioryx lacteoguttatus	2	0	0	2	0	0.0
A. sammara	1	0	1	2	1	50.0
A. spinifer	2	0	0	2	0	0.0
A. xantherythrus	1	0	0	1	0	0.0
Myripristis amaenus	7	0	1	8	1	12.5
M. murdjan	7	0	0	7	0	0.0
Carangidae						
Carangoides ferdau	7	1	0	8	1	12.5
Caranx sp.	1	0	0	1	0	0.0
C. cheilio	88	5	2	95	7	7.4

Table 1.--Continued.

Species	Nontoxic	Borderline	Toxic	Total fish	Total borderline and toxic	Percent borderline and toxic
C. ignobilis	57	4	4	65	8	12.3
C. lugubris	2	1	3	6	4	66.7
C. melampygus	4	1	3	8	4	50.0
C. speciosus	13	0	1	14	1	7.1
Decapterus pinnulatus	3	1	0	4	1	25.0
Elagatis bipinnulatus	1	0	0	1	0	0.0
Seriola dumerilii	73	3	7	83	10	12.0
Trachurops crumenophthalmus	3	0	2	5	2	40.0
Serranidae						
Epinephelus quernus	87	6	7	100	13	13.0
Labridae						
Anampses cuvieri	1	0	1	2	1	50.0
Bodianus bilunulatus	8	0	5	13	5	38.5
B. oxycephalus	2	0	0	2	0	0.0
Cheilinus rhodochrous	5	1	10	16	11	68.8
Coris venusta	1	0	0	1	0	0.0
Epibulus insidiator	1	0	0	1	0	0.0
Macropharyngodon sp.	1	0	0	1	0	0.0

Table 1.--Continued.

Species	Nontoxic	Borderline	Toxic	Total fish	Total borderline and toxic	Percent borderline and toxic
Stethojulis sp.	1	0	0	1	0	0.0
Thalassoma ballieui	3	1	0	4	1	25.0
T. duperreyi	1	0	1	2	1	50.0
T. purpureum	8	0	0	8	0	0.0
T. umbrostigma	1	0	0	1	0	0.0
Lutjanidae						
Aprion virescens	1	1	0	2	1	50.0
Etelis carbunculus	4	0	1	5	1	20.0
E. marshi	51	0	0	51	0	0.0
Lutjanus kasmira	57	6	6	69	12	17.4
Pristipomoides filamentosus	116	13	8	137	21	15.3
P. sieboldii	12	0	0	12	0	0.0
P. zonatus	20	0	0	20	0	0.0
Kuhliidae						
Kuhlia sandvicensis	34	6	14	54	20	37.0
Muraenidae	14	1	4	19	5	26.3

Table 1.--Continued.

Species	Nontoxic	Borderline	Toxic	Total fish	Total borderline and toxic	Percent borderline and toxic
Mugilidae						
Mugil cephalus	6	2	4	12	6	50.0
Neomyxus leuciscus	2	0	0	2	0	0.0
Mullidae						
Mulloidichthys flaviolineatus	3	0	3	6	3	50.0
M. vanicolensis	1	1	0	2	1	50.0
Parupeneus bifasciatus	1	0	0	1	0	0.0
P. cyclostomus	2	0	1	3	1	33.3
P. multifasciatus	7	0	0	7	0	0.0
P. pleurostigma	2	0	0	2	0	0.0
P. porphyreus	4	1	0	5	1	20.0
Upeneus arge	1	0	0	1	0	0.0
Polynomidae						
Polydactylus sexfilis	14	0	1	15	1	6.7
Priacanthidae						
Priacanthus sp.	0	1	0	1	1	100.0
P. cruentatus	2	0	0	2	0	0.0
Scaridae						
Scarus spp.	4	1	2	7	3	42.8

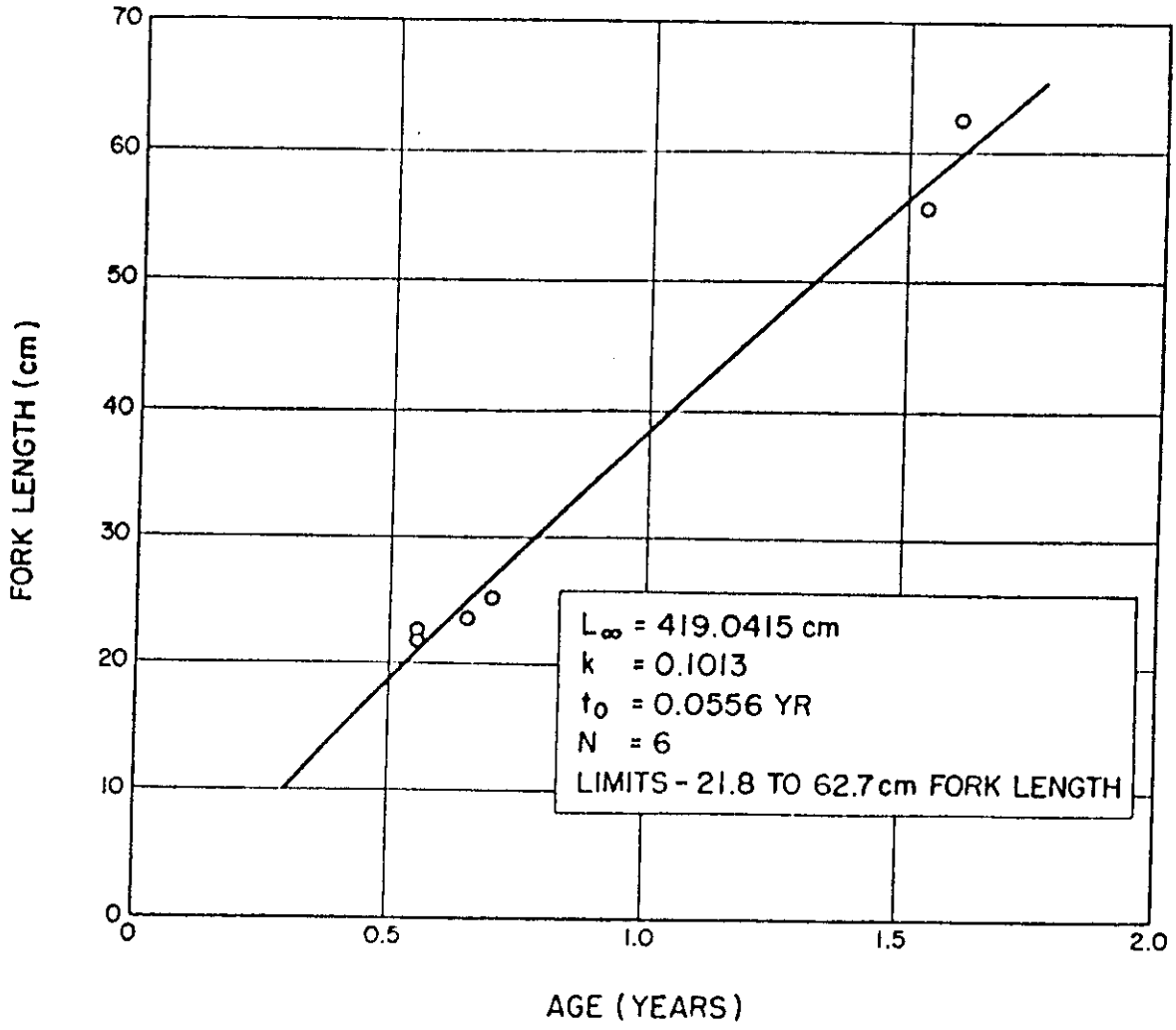

Figure 1.--Preliminary age and length relationship of amberjack, Seriola dumerilii, based on examination of growth increments in the otoliths.