

Guam's Small-Boat-based Fisheries

ROBERT F. MYERS

Introduction

Nearly 900 finfish species and a similar number of macroinvertebrate species inhabit the waters surrounding Guam. Approximately one-third of the species of finfishes and a smaller contingent of the invertebrates are utilized in the subsistence or commercial fisheries. Guam's exploited fisheries resources can be divided into the following five major groups based on biology and harvest method: Marine invertebrates, reef fishes, bottomfishes, pelagic fishes, and bigeye scad. Marine invertebrates include crustaceans, shelled mollusks, cephalopods, and

Robert F. Myers is with the Division of Aquatic and Wildlife Resources, Department of Agriculture, Government of Guam, P.O. Box 2950, Agaña, Guam 96910.

ABSTRACT—Recent trends in Guam's small-boat fisheries and current knowledge of their biology, management, and economics are summarized. Annual estimates of participation, effort, and harvest are given for the pelagic and bottomfish fisheries for 1980–91 and for the spearfishing and atulai fisheries for 1985. The pelagic fishery is the largest, with annual landings ranging from 168 to 364 metric tons (t), followed by the bottomfish fishery (14–43 t), spearfishing fishery (5–17 t), and bigeye scad fishery (3–20 t). All of the pelagic species are highly migratory and require regional management. They are heavily exploited by Guam-based domestic purse-seine and foreign longline fisheries, but region-wide catch and effort as well as the status of the stocks are largely unknown. Bottomfish and reef-fish stocks are shared to an unknown extent with those of the northern Marianas and are locally manageable. Certain vulnerable species of bottomfishes and reef fishes are overfished. Bottomfish and speared fish landings are dominated by small species with high turnover rates.

echinoderms (Amesbury et al., 1986).

Echinoderms are generally harvested by reef gleaners and rarely with the aid of boats. Other invertebrates are harvested by hand or spear and with or without the use of boats. Reef fishes include all finfishes associated with coral reefs and adjacent sand flats and seagrass beds, as well as a small number of primarily estuarine species and are taken primarily by nets, spear, and hook and line with or without the use of boats.

Bottomfishes include reef fishes that occur beyond the seaward margin of the reef as well as deep-dwelling coastal fishes occurring to depths of approximately about 300 m that are taken by hook and line from boats. Pelagic fishes include migratory open-ocean species as well as a few coastal pelagic and reef species taken by lines trolled from a moving boat, longline, or ikashibi. The latter two methods have been rarely employed and are not currently in use. Nearly all pelagic landings consist of the following five species: Mahimahi, *Coryphaena hippurus*; wahoo, *Acanthocybium solandri*; skipjack tuna, *Katsuwonus pelamis*; yellowfin tuna, *Thunnus albacares*; and blue marlin, *Makaira mazara*. The bigeye scad, *Selar crumenophthalmus*, locally known as atulai, is a coastal pelagic species that undergoes seasonal migrations and is taken by a variety of methods from shore as well as from boats. Boats are used in coordination with a large number of shore-based snorkelers or scuba divers to set large nets around shallow inshore aggregations. The only offshore boat-based method used for this species is jigging at night with the aid of lights.

The original Chamoru inhabitants were expert fishermen and seafarers.

Accounts by the early Spanish visitors indicate that they fished on the high seas for such formidable species as marlin and used numerous methods to catch reef and bottomfish from boats as well as from the shoreline (Amesbury et al., 1986). Throughout the Spanish period, the Chamorus were persecuted and an attempt was made to confine them to the island of Guam. Most of the male population was killed, and subsequent generations were of mixed blood. By the 1860's, there were only 24 outrigger canoes on Guam, all of which were used only for fishing inside the reef.

By the beginning of the American period in 1898, the indigenous inhabitants had lost many of their seafaring and fishing skills as well as the native names of many of the offshore species. Small outboard and inboard powered boats did not become commonplace until after World War II. Fishing remained the primary motivation for boating, and the methods in use today were well established by the mid-1960's. Unlike many U.S. areas, the concept of fishing for sport is relatively new, and the use of "recreational-type" boating and fishing equipment and techniques for subsistence and commercial purposes is well established.

Trolling is the most popular and important fishing method and was employed on 85% of the boat trips during fiscal year 1991. Bottomfishing with hook and line using poles, handlines, or electric reels from either an anchored or a drifting boat was the second most important method. Spearfishing and jigging under a nightlight for bigeye scad followed in importance. Other rarely used methods include spin-casting, longline, and ikashibi.

Procedures

As presently designed, the offshore fisheries survey is a combined fixed-point and roving survey. For the fixed-point portion, personnel from Guam's Division of Aquatic and Wildlife Resources (DAWR) are stationed at one or more major boat landings during a given time-frame for a given number of days each month. All returning fishing parties are interviewed and, when possible, their catch is examined and samples measured or weighed. A log of all departing and returning fishing parties is also kept. The roving survey consists of a twice-a-day circuit in which all empty trailers attached to vehicles and the time of day are noted at each location. Information derived from the site log and the roving survey are used to calculate proportionality values based on the proportion of island-wide fishing activity occurring at the sampled site and the proportion of 24-hour fishing activity actually sampled at the sampled site. The proportionality values used to expand for site totals are method-specific, but those used to expand for island-wide totals are not, since the roving survey does not have the capability of obtaining information on methods. A set of standardized mathematical formulas is used by the Guam Offshore Expansion System (GOES), and its algorithms are used to expand sample-day totals into estimates of monthly, quarterly, and annual totals and their standard errors (SE) and confidence limits (CL). The GOES was prepared by CIC Research, Inc.¹ (San Diego, Calif.) for the National Marine Fisheries Service (NMFS) and is available from the NMFS Honolulu Laboratory as Administrative Report H-83-21C. The inherent flexibility of GOES allows changes in sample periods, sites, and methods of determining proportionality constants in response to manpower or budgetary constraints as well as changes in the fisheries. The accuracy of the expansions is limited by the accuracy of the assumption that the sampled time-frames and sites are

¹Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

representative of the entire 24-hour period for the island as a whole. The precision of the expanded estimates is dependent on the sample size.

Prior to the implementation of the GOES, less reliable methods were used to estimate fishing activity from nonsampled sites. The original expansions assumed that activity from the sampled launch site, the Agana Boat Basin, was 50% of the island wide total. This was based on limited counts of boats using other launch sites during 1977-78. The expansions for 1977-82 were subsequently revised by using a set of proportionality figures based on observations made after implementation of the GOES. Surveys were initially limited to the hours of 0600 to 2100 or some portion within that time period. Fishing methods that occurred at night were frequently undersampled. Therefore, in 1985 the survey period was divided into two shifts with the late shift extending as late as 2400 hours, and in 1986 it was further extended with the morning shift as early as 0500 hours. With implementation of a boating activity log, it became easier to track boats that could not be intercepted, allowing greater flexibility in the survey shift hours without compromising the comparability of results between years. Specific changes in methods, hours, or sites are detailed in annual reports produced by the DAWR.

The annual estimates of participation, effort, catch, and economics presented here were compiled from a combination of sources. The DAWR and NMFS each generate GOES output from the same data base on different, incompatible computer systems and have different reporting requirements. DAWR expands by gear and fiscal year (FY). NMFS expands by calendar year and by fishery, based on the species caught being categorized as either pelagic or bottomfish, and includes all methods for each of these respective species groups. Personnel, time, and hardware constraints made it impossible to generate standardized output for all parameters and methods. Annual estimates based on the sum of monthly expansions differ slightly from

those based on a single period expansion. Annual CL and SE are known only for period expansions and are not presented herein. Whenever possible, information is presented in metric units by calendar year and method based on a period expansion. For some years and methods annual estimates are based on the sum of monthly expansions. All economic information is from annual summaries of commercial receipts compiled by NMFS. All annual estimates for trolling and bottomfishing are based on 362-day expansions (363 days in leap years) with landings from the annual 3-day Guam International Fishing Derby (GIFD) added in. Fishing by nonderby participants during the 3-day event is considered negligible. Annual estimates for spearfishing and night-lighting for atulai exclude the GIFD and are based on full monthly or annual expansions.

Summary data for the pelagic fishery are based entirely on NMFS output. In 1982 and 1985, only 1.7% and 0.2% of pelagic landings were by longline or ikashibi. An even smaller portion of the annual landings consists of sharks caught by other methods. Therefore, the pelagic fishery is considered synonymous with trolling since 98% or more of all annual landings are taken by this method.

Summaries of participation, effort, and catch data for the bottomfish fishery are based on DAWR expansions only and include all species caught by that method. Species composition is based on FY80-91 expansions. Economic summaries are based on NMFS data which exclude sharks and a small number of nonbottomfish species, but include bottomfish species caught by other methods. These differences are not considered large enough to affect the conclusions. Species composition for all other methods are based on fiscal year period expansions from October 1985 through September 1991.

The Fisheries

Pelagic Fishery

Guam's pelagic fishing fleet consists primarily of small recreational trolling boats that are either towed to

launch sites or berthed in marinas. Presently most of vessels are <10 m long and are typically owner-operated by persons who earn a living outside of fishing. However, almost everyone sells a portion of their catch at one time or another, and it is impossible to make a distinction between recreational, subsistence, or commercial fishermen. A small but rapidly growing segment of the fleet are marina-berthed charter vessels that tend to be larger than the owner-operated vessels, ranging in length from 8 to >15 m. A small number of similar boats are operator or corporation-owned and are used for a variety of other recreational purposes as well as fishing.

The Catch

Estimated overall pelagic landings have varied widely from year to year, ranging from a low of 168 metric tons (t) in 1987 to 364 t in 1991 (Fig. 1). A long-term trend is not detectable, but there does seem to be a slight general increase since 1987. Annual catches consist nearly entirely of five major species: Mahimahi, wahoo, skipjack tuna, yellowfin tuna, and Pacific blue marlin. Minor components include rainbow runner, *Elagatis bipinnulatus*; great barracuda, *Sphyrna barracuda*; kawakawa, *Euthynnus affinis*; dogtooth tuna, *Gymnosarda unicolor*; sailfish, *Istiophorus platypterus*; and shortbill spearfish, *Tetrapturus angustirostris*.

Approximately a dozen additional species are landed incidentally each year.

Mahimahi landings exceeded those of all other species during 7 of the last 12 years, making it the single most important species of the pelagic fishery (Fig. 1). Annual landings ranged from 13 to 182 t, with no detectable trend or cycle. Mahimahi are seasonal, occurring during the winter and spring with a peak in March, although a few may be found throughout the year. More than any other species, the success of the mahimahi run determines whether it is a good or bad fishing year. No attempt has been made to compare catches from different western Pacific locations in a systematic manner. It remains unknown whether a good Guam run is the result of a healthy western Pacific year class or is due to vagaries of oceanographic conditions that concentrate the run near Guam.

Annual landings of wahoo ranged from 15 to 72 t. There is considerable variability from one year to the next with no apparent trends, and in only one year, 1985, did wahoo landings exceed those of all other species. Wahoo are caught throughout the year, but November is typically the best month. At that time, small wahoo of 2–4 kg are common. Most wahoo are immature, but mature fish in the 14–22 kg range are occasionally caught throughout the year. Wahoo are often caught relatively close to shore, and

catches may increase during periods of high effort for mahimahi which may be in closer to shore during times of great abundance.

Skipjack tuna is the second most important species with annual landings exceeding those of all others during 4 of the last 12 years. Landings are highly variable, ranging from 27 to 113 t (Fig. 1). Skipjack tuna occur in surface feeding schools throughout the year and are often the most easily caught fish, particularly when other species are scarce. However, the relatively low marketability of skipjack tuna makes them less desirable, so many boats do not target them and catches are probably poor indicators of relative abundance. The skipjack tuna caught by trolling near Guam are typically in the 2–6 kg range, but occasional fish weigh up to 9 kg. Skipjack tuna are heavily exploited by a large fleet of domestic purse seiners operating out of Guam. The effects of this exploitation on the stocks and the state of the stocks are unknown.

Annual yellowfin tuna landings were consistently lower than those of skipjack tuna, ranging from 16 to 62 t. Yellowfin tuna are highly valued, and relatively low catches are a reflection of low availability to surface trollers. Yellowfin tuna reach a large size (>160 kg), but most caught by local trollers are in the 2–20 kg range. Occasionally larger fish up to 70 kg are caught. Yellowfin tuna form the basis of the Guam-based foreign longline fishery and are of great importance to the domestic purse seine fishery. The effects of these fisheries on the availability of fish to the troll fishery as well as on the stocks themselves are unknown. Even if the yellowfin tuna stock is not overfished, interception of Guam-bound fish by the more efficient longliners and purse seiners could reduce their availability to the local trollers.

Annual blue marlin landings have increased significantly over the last 12 years, ranging from 15 t in 1980 to 62 t in 1990 (Fig. 1; $r^2 = 0.831$, $P < 0.001$). In 1990, blue marlin landings exceeded those of all other species. The most rapid growth in landings occurred from 1988 to 1990. This is attributable to

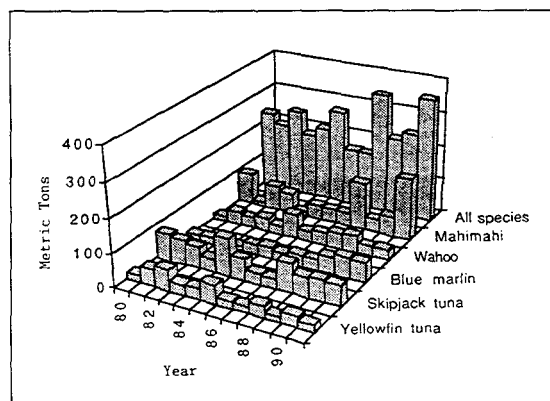


Figure 1.—Estimated annual landings of all pelagic fishes, mahimahi, wahoo, blue marlin, skipjack tuna, and yellowfin tuna by the Guam small-boat pelagic fishery during 1980–91.

rapid growth of the charter fleet which tends to target blue marlin more often than the noncharter segment of the fleet. Blue marlin are seasonal; the best catches occur during the warmest months from June to September. Most of the troll-caught fish are small, <70 kg, and are males. Occasional blue marlin are caught throughout the year, including large females of 140–400 kg.

Participation and Effort

The exact number of boats or people participating in the troll fishery are unknown. The GOES enumerates boat-trips and person-trips. Therefore, a “threshold” C/E model is used by NMFS to estimate the annual number of boats participating in the fishery. The estimated number of boats increased more than twofold, from 115 to 282 between 1980 and 1989. The number has dropped somewhat since then, but more recent figures are considered low since the survey does not include boats that fish exclusively from unsampled sites which include a new marina that opened in early 1991. The increase in the number of boats over the 12-year period is significant ($r^2 = 0.637$, $P < 0.01$)

The estimated annual number of boat trips ranged from 6,287 in 1981 to 12,523 in 1991; most of the increase occurred after 1987 (Fig. 2). The number of boat hours spent trolling also increased significantly during the past 12 years ($r^2 = 0.555$, $P < 0.01$), reaching a peak of nearly 59,000 in 1988. However, the number of hours per trip has decreased in recent years because of the increasing proportion of charter trips ($r^2 = 0.775$, $P < 0.001$). Charter vessels typically carry more people but engage in shorter fishing trips than noncharter vessels.

Catch Rates

Catch rates as catch per unit of effort (CPUE) are calculated by dividing the total annual landings of each species by the total number of boat-hours spent fishing (gear in use). Since it is impossible to allocate species-specific effort, catch rates for a given species calculated in this manner may be in-

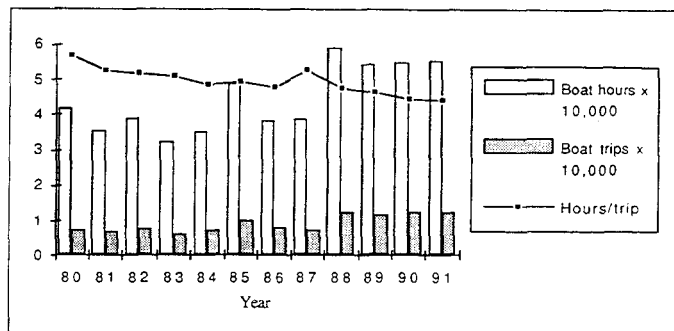


Figure 2.—Estimated annual number of boat trips, boat hours spent trolling, and hours spent trolling per boat trip around Guam during 1980–91.

fluenced by effort targeted towards other species. Catch rates for mahimahi and wahoo fluctuated widely over the past 12 years with no apparent trend (Fig. 3). Catch rates for skipjack tuna show a general decline with the exception of a sharp peak in 1984, and catch rates for yellowfin tuna declined significantly during the past 12 years ($r^2 = 0.408$, $P < 0.05$). Catch rates for blue marlin increased significantly over the past 12 years ($r^2 = 0.722$, $P < 0.001$). This is probably a result of the changing composition of the fleet toward more boats that are larger and better equipped to target and catch blue marlin. Recent low catch rates for skipjack tuna are likely due to economic reasons since that species is relatively un-

marketable and many boats do not target it. The decline in catch rates for yellowfin tuna cannot be attributed to economic reasons since that species is highly valued and often targeted. When other factors are considered such as declining average and winning sizes at an annual fishing derby, it seems plausible that the reasons for the decline are related to the species' availability. Lower availability of yellowfin tuna, particularly the larger size classes, could be a result of either changes in the stock or of interception by competing fisheries.

Economics

Guam's small-boat trolling fishery consists of recreational, subsistence,

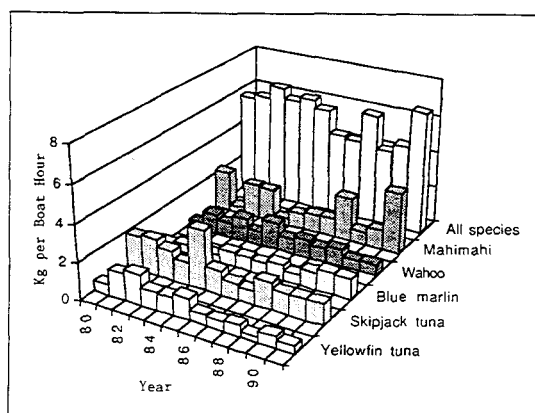


Figure 3.—Catch rates as kg per boat hour spent fishing for all pelagic fishes, mahimahi, wahoo, blue marlin, skipjack tuna, and yellowfin tuna by the Guam small-boat pelagic fishery during 1980–91.

and commercial fishermen, many of whom also engage in other methods of fishing. Most charter boat captains and crew are not employed elsewhere, but most other fishermen hold nonfishing jobs. Charter boat captains and crew generally supplement their pay with tips and proceeds from the sale of the day's catch. Many noncharter fishermen occasionally sell part of their catch, while a minority regularly sell all or most of their catch.

Over the past 12 years, an estimated 42% of the pelagic fish harvest was sold, generating inflation-adjusted annual revenues ranging from \$340,532 to \$635,006 (Fig. 4). The economics of Guam's trolling fishery is complex and has undergone numerous changes during the past 12 years. Inflation-adjusted revenue per trip has declined by 54% since 1983 (Fig. 5; $r^2 = 0.868$, $P < 0.001$). This is due to a number of factors including loss of markets, when there is inadequate availability, inability to efficiently process and freeze or export fish when there is a glut, and competition from other sources that either import inexpensive frozen fish or dump inexpensive rejected longline-caught fish on the local market. The Fisherman's Cooperative has never had widespread support among fishermen, and even members often do not support it by selling their fish elsewhere if offered a higher price. Continued disunity among the troll fishermen hinders them from gaining much political or public support. The charter segment of the fishery remains healthy since

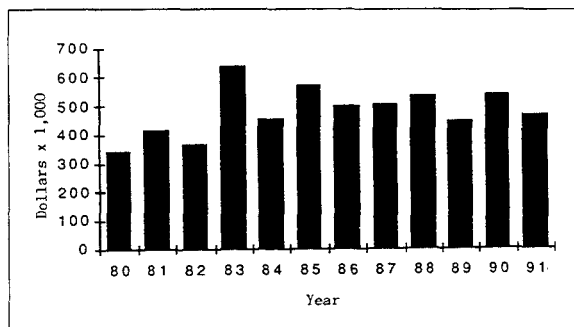


Figure 4.—Inflation adjusted annual revenues for troll-caught pelagic fishes during 1980–91.

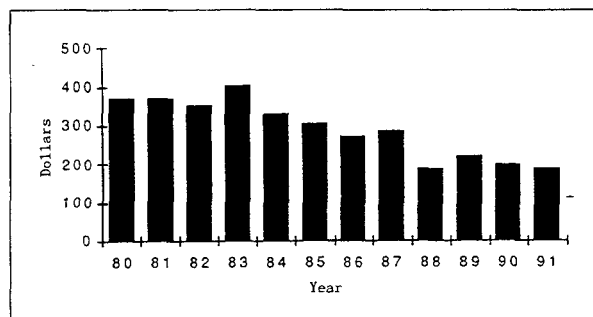


Figure 5.—Inflation adjusted revenue per trolling trip during 1980–91.

only a small portion of revenues are derived from the sale of catches.

Bottomfish Fishery

Bottomfishing is defined here as fishing from an anchored or drifting boat with hook and line without the aid of floodlights. Guam's bottomfish fishery is a small-scale commercial, subsistence, and recreational fishery that operates primarily from boats <25 feet in length. Nearly all fishing is done by Guam residents from owner-operated vessels, but occasionally tourists and residents fish from relatively large charter boats. Historically, the fishery has experienced considerable fluctuations in annual harvest primarily because of the high turnover rates of a few full-time highliners.

The fishery may be divided into two components based on depth and species. The shallow-water component (<150 m) is the larger of the two and usually targets the red-gilled emperor,

Lethrinus rubrioperculatus, as well as an assemblage of other emperors, snappers, and groupers. The deep-water component (150–250 m) targets the snapper, *Pristipomoides* spp., complex. A few species (most notably jobfish, *Aprion virescens*, and black jack, *Caranx lugubris*), equally abundant in both the shallow and deep zones, are grouped in the shallow fishery and excluded from the deep fishery for purposes of this paper. The larger size of the shallow-water component is the result of greater participation because of the lower expenditure and relative ease of fishing closer to shore. Small spincasting reels are often used for the shallowest bottomfishing, and electric reels, which may have multiple hooks per line, are used for deeper bottomfishing. Handlines are rarely used. Nearly all participants in the bottomfish fishery also troll for pelagic species, and most participate in both methods on the same trip. All the shallow bottomfish species are coral reef fishes, and they are subject to harvest by both offshore and inshore reef fishery methods. However, only small quantities of the most important bottomfishery species are harvested by these methods, and the most important reef fishery species form a negligible component of the bottomfish fishery.

The Catch

Since 1980 the annual estimated bottomfish catch has fluctuated between 14 and 43 t (Fig. 6). The fluctuations are due primarily to changes in the fishery rather than to changes in the stocks. However, decreasing catches

of some of the larger deepwater species are probably stock related. Catches for the past year may be slightly underestimated because of the opening of the Agat Marina which is not yet surveyed. It is believed that a larger proportion of the participation for bottomfish fishing occurs there than at the primary sampling location, the Agana Boat Basin.

Snappers and emperors are the most important bottomfish families, represent an estimated 38.5% and 29.5% of the weight of the harvest from FY1980–91 (Table 1), respectively. Only three other families represented more than 2% of the catch: Groupers (10.0%), jacks (9.4%), and requiem sharks (5.4%). Squirrelfishes, goatfishes, wrasses, dogtooth tuna, and triggerfishes each represented between 1 and 2% of the catch. At least 35 other families collectively represented the remaining 2.6% of the catch. Although sharks collectively represented 5.6% of the catch, they are not targeted and are often killed and discarded at sea. The landed catch is an unreliable indicator of stock size. An estimated 67.7% of the 1980–91 harvest consisted of shallow-water species, and 32.3% consisted of deep-water species.

The red-gilled emperor is the most important bottomfish species and represented 24.2% of the FY1980–91 estimated harvest, 82.1% of the emperor harvest, and 35.8% of the shallow-water harvest. Other important shallow-water species with percentage of total bottomfish catch indicated, were the jobfish (5.6%); the groupers (*Epinephelus fasciatus*, 3.4%; *Variola louti*, 2.8%; and *Cephalopholis sonerati*, 1.2%); the jacks (*Caranx lugubris*, 3.2%; *Carangoides orthogrammus*, 1.3%; *Caranx melampygus*, 1.2%; and *C. ignobilis*, 1.2%); and the snappers (*Lutjanus bohar*, 1.5%; and *L. kasmira*, 1.5%). The mean sizes of 5 shallow species (*Lethrinus rubrioperculatus*, *Cephalopholis urodeta*, *Epinephelus fasciatus*, *Variola louti*, and *Aprion virescens*) have remained essentially unchanged since 1980 (Davis²). The

²Davis, G.W. 1992. Territory of Guam 1991 bottomfish fisheries performance. In Bottomfish and seamount groundfish fisheries of the western

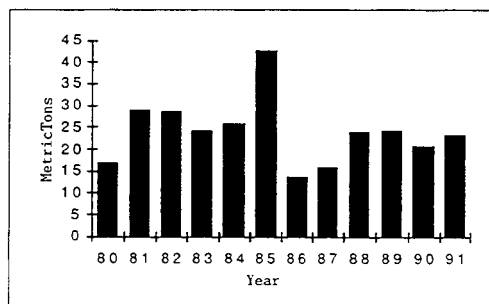


Figure 6.—Estimated annual bottomfish landings during 1980–91.

Table 1.—Species composition of Guam bottomfish landings during FY 1980–91.

	Total landings (kg)	Percent of		
		Total landings	Shallow portion	Deep portion
Sharks	14,996.5	5.4	8.0	
Holocentridae (Squirrelfishes)	4,259.4	1.5	2.3	
Serranidae (Groupers)	27,513.3	10.0	10.6	8.7
<i>Cephalopholis sonerati</i> (Tomato grouper)	3,384.5	1.2	1.8	
<i>Epinephelus fasciatus</i> (Black-tipped grouper)	9,239.4	3.4	5.0	
<i>E. octofasciatus</i> (Eightbar grouper)	7,696.7	2.8		8.7
<i>Variola</i> spp. (Lyretail groupers) ¹	7,567.9	2.8	4.1	
Carangidae (Trevallies)	25,824.7	9.4	12.2	3.5
<i>Caranx ignobilis</i> (Giant trevally)	3,435.5	1.2	1.8	
<i>C. lugubris</i> (Black trevally)	8,721.4	3.2	4.7	
<i>C. melampygus</i> (Bluefin trevally)	3,316.2	1.2	1.8	
<i>Carangoides orthogrammus</i> (Yellow-spotted trevally)	3,685.7	1.3	2.0	
<i>Seriola dumerilii</i> (Amberjack)	3,067.7	1.1		3.5
Lutjanidae (Snappers)	105,844.2	38.5		
Shallow snappers	26,630.1	9.7	14.3	
<i>Aprion virescens</i> (Jobfish)	15,294.1	5.6	8.2	
<i>Lutjanus bohar</i> (Red snapper)	4,174.5	1.5	2.2	
<i>L. kasmira</i> (Bluelined snapper)	4,099.2	1.5	2.2	
Deep snappers	77,716.9	28.2		87.5
<i>Aphareus rutilans</i> (Lehi)	10,824.7	3.9	12.2	
<i>Etelis carbunculus</i> (Ehu)	10,843.1	3.9	12.2	
<i>E. coruscans</i> (Onaga)	10,511.8	3.8	11.8	
<i>Pristipomoides auricilla</i> (Yellowtail kalekale)	17,065.5	6.2	19.2	
<i>P. filamentosus</i> (Pink opakapaka)	6,153.9	2.2	6.9	
<i>P. flavipinnis</i> (Yelloweye opakapaka)	10,043.7	3.6	11.3	
<i>P. zonatus</i> (Gindae)	9,712.1	3.5	10.9	
Lethrinidae (Emperors)	81,234.6	29.5	43.6	
<i>Lethrinus rubrioperculatus</i> (Redgill emperor)	66,722.0	24.2	35.8	
Mullidae (Goatfishes)	3,880.3	1.4	2.1	
Sphyraenidae (Barracudas)	909.3	0.3	0.5	
Labridae (Wrasses)	2,981.5	1.1	1.6	
Acanthuridae (Unicornfishes)	1,866.9	0.7	1.0	
Scombridae (Tunas)	3,208.7	1.2	1.7	
Balistidae (Triggerfishes)	3,433.5	1.3	1.8	
Total nonsnapper deep species	11,086.0	4.0		12.5
Total deep species	88,785.3	32.3		100.0 ²
Total shallow species	186,401.9	67.7	99.8 ²	
Total all bottomfish species	275,187.2	100.0		

¹ Primarily *V. louti* but also includes a small proportion of *V. albimarginata*.

² Excludes incidental taxa not tabulated.

red-gilled emperor, above-listed groupers, and most others in the fishery are small species with high turnover rates. This is indicative of a mature fishery in which the larger species are overfished.

Pacific region. 1991 Annu. Rep. West. Pac. Reg. Fish. Manage. Council., Honolulu, Hawaii.

Among the deepwater species, 87.5% consisted of snappers of the *Pristipomoides* complex. The most important species with percentage of total bottomfish catch indicated, were yellowtail kalikali, *Pristipomoides auricilla*, 6.2%; ehu, *Etelis carbunculus*, 3.9%; lehi, *Aphareus rutilans*,

3.9%; onaga, *E. coruscans*, 3.8%; yelloweye opakapaka, *P. flavipinnis*, 3.6%; gindai, *P. zonatus*, 3.5%; and opakapaka, *P. filamentosus*, 2.2%. The most important nonsnapper deepwater species were the large eightbar grouper, *Epinephelus octofasciatus*, 2.8%, and the amberjack, *Seriola dumerili*, 1.1%. Grouper was rarely caught and did not even appear in the sampled catch during most years. Also, catches of onaga, another large and the most highly prized of the deepwater snappers, decreased considerably during the past 6 years. Sample sizes for both of these species were inadequate for year-to-year comparisons, and in some years they were not even encountered in the survey. However, the mean sizes of five important species (*Pristipomoides auricilla*, *P. flavipinnis*, *P. zonatus*, *Etelis carbunculus*, and *Aphareus rutilans*) have remained essentially unchanged since 1980 (Davis²).

Participation and Effort

The estimated number of vessels in the bottomfish fishery has increased significantly over the past 12 years from 24 to 173 boats in 1991 ($r^2 = 0.702$, $P < 0.001$). The current number could be higher since the Agat Marina, which opened in early 1991, is not sampled. However, long-term trends in overall effort as boat trips and boat hours are not apparent (Fig. 7). This apparent contradiction is due to the effects of a few commercial highliners that dropped out of the fishery in 1986. There has been a short-term trend toward increasing effort since then, and this is expected to continue.

Catch Rates

The annual catch rate for the bottomfish fishery has decreased significantly over the past 12 years (Fig. 8; $r^2 = 0.718$, $P < 0.001$). This may be a result of a few commercial highliners dropping out of the fishery after 1985. With the exception of 1983, catch rates were significantly higher (3.4–3.6 kg/boat-hour) for 1980–85 than all years since then (2.3–2.8 kg/boat-hour). However, the catch rate has remained steady since 1986, indicating that the fishery is stable.

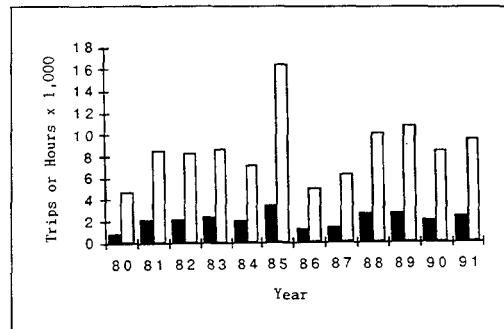


Figure 7.—Estimated annual number of boat trips and boat hours for the bottomfish fishery during 1980–91.

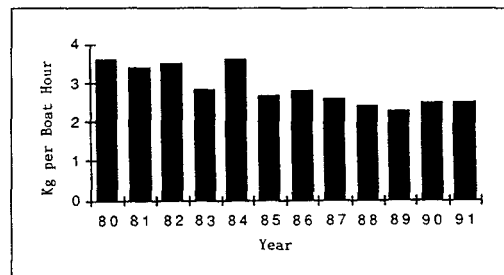


Figure 8.—Catch rates (kg/boat-hour) for the bottomfish fishery during 1980–91.

Economics

Nearly all of Guam's bottomfish fishermen hold jobs outside the fishery, and only a small minority sell their catch. However, high turnover rates among a few full-time highliners have greatly influenced annual catch and effort estimates, particularly prior to 1986. Over the past 12 years, an estimated 31% of the bottomfish catch entered the commercial market with annual inflation-adjusted revenues ranging from \$22,994 to \$114,176 (Davis²; Fig. 9). After a 1983 peak, revenue per trip declined sharply and has remained between \$103 and \$159. Inflation-adjusted average price of bottomfish has remained between \$5.64 and \$7.67/kg during the past 12 years. The trend has been a slow and steady decline offset by a sharp rise between 1988 and 1989. Although the supply for fresh local bottomfish has never

met the demand, competition from inexpensive imports from the neighboring islands has kept the price depressed and is expected to continue to do so.

Reef-fish Fishery

Guam's reef-fish fishery is composed of several fisheries based on method and logistics. The bulk of the fishery is shore-based (Hensley and Sherwood, 1993) and not considered here. The boat-based portion consists primarily of spearfishing and, to a minor extent, of other methods also used in the shore-based fishery. The minor methods include the use of various nets, spin-casting, and gleaning. Since these methods are infrequently encountered, not expanded separately, and collectively represent less than 1% of the annual estimated boat-based harvest, they are not considered here.

Nearly all spearfishing activity with boats occurs from owner-operated

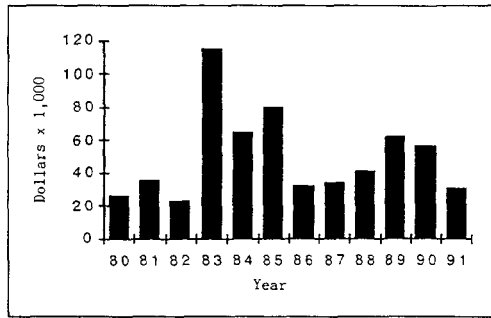


Figure 9.—Inflation adjusted annual revenues for the bottomfish fishery during 1980–91.

rather than chartered boats. The fishery is highly seasonal and the highest mean monthly participation, effort, and landings occur in June, the lowest in March. This seasonality is due to weather and sea conditions which render northwestern exposures inaccessible because of high seas and surf. The fishery consists of two components based on whether or not scuba equipment is used. The range of species targeted is quite broad and includes nearly all coral reef-dwelling finfishes ≥ 12 cm, crustaceans, and mollusks, the latter picked up by hand incidentally. There is considerable overlap among species targeted by the shore-based spearfishing fishery and shallow bottomfish fishery. Estimates of participation, effort, and catch are crude since it is difficult to get statistically useful sample sizes. Spearfishing is an infrequently encountered method that often occurs outside the surveyed time-frame, and tends to occur more frequently from under- or unsampled launch sites. Considerable spearfishing activity occurs at night and parties return between 2100 and 2400 hours. Since this component of the fishery was not monitored until FY 1985, only information beginning with that year is considered here. Estimates of catch and effort are given for calendar years, but species composition is available only for fiscal years.

The Catch

Annual catch estimates since 1985 have varied widely from 5 to 17 t with

a trend toward increased landings (Fig. 10). Prior to 1989 the bulk of the catch was caught by snorkelers, but for the past 3 years 50% or more of the landings have been caught by scuba divers. A broad range of species is targeted including nearly all coral reef dwelling finfishes ≥ 12 cm as well as incidental crustaceans and mollusks. Over 100 species have been observed in a given survey year, and probably another 50 species are landed but not encountered by the survey.

Since FY1985, 36% of the catch has consisted of parrotfishes (Scaridae), followed by surgeonfishes (Acanthuridae, 19%), and wrasses (Labridae, 7%) (Table 2). Other important finfish families include the groupers (6%), rudderfishes (5%), snappers (3%), jacks (3%), and squirrelfishes (2%). The

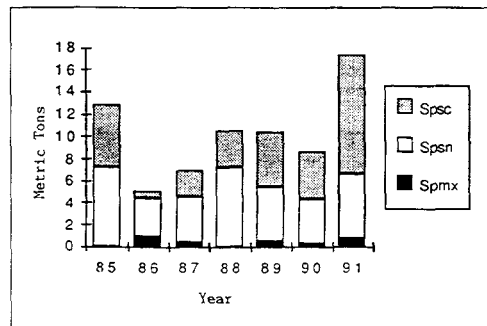


Figure 10.—Estimated annual spearfishing landings utilizing small boats during 1985–91. Spsc = landings exclusively by scuba diving; Spsn = landings exclusively by snorkeling; Spmx = landings by a combination of scuba diving and snorkeling.

most important invertebrates are spiny lobsters (4%), primarily *Panulirus penicillatus* which are speared, and topshell (2%) which are picked up by hand. Higher proportions of wrasses, groupers, rabbitfishes, parrotfishes, goatfishes, sweetlips, and spiny lobsters are caught by scuba divers than by snorkelers (Table 2). Greater differences occur at the species level since many species typically inhabit depths beyond the reach of most snorkelers. There are also distinct differences between day and night catches, but separate day and night expansions have not been run.

Participation and Effort

The estimated annual number of boat trips and person trips has fluctuated widely since 1985, ranging from 279 to 1,057 and from 748 to 3,330, respectively. The estimated annual number of boat hours and person hours has also fluctuated widely, ranging from 894 to 2,151 and from 2,293 to 7,119, respectively (Fig. 11).

Catch Rates

Overall catch rates as kg/boat-hour and kg/person-hour have ranged from 5.2 to 9.4 and from 1.5 to 3.1 since 1985, respectively (Fig. 12). The catch rate for the scuba segment has risen sharply over the last 2 years. This is not believed to be indicative of a healthy fishery for nonbiological reasons that are not apparent from the

Table 2.—Species composition of Guam landings taken by divers during FY 1985–91. All fishes were taken by spear, and invertebrates were taken by hand as well as spear. Taxa comprising less than 1% of total landings are not shown.

Taxon	Snorkel only		Scuba only		Unknown or both		All methods	
	kg	%	kg	%	kg	%	kg	%
Fishes								
Carriacanthidae (Reticular sharks)	502.3	1.4	189.2	0.6	0.0	0.0	691.5	1.0
Holo-centridae								
(Squirtfishes)	744.2	2.1	585.7	1.8	89.5	3.4	1,419.4	2.0
Serranidae (Groupers)	1,390.1	3.8	2,714.0	8.4	78.2	2.9	4,182.3	5.9
Carangidae (Jacks)	1,545.0	4.3	210.8	0.7	25.5	1.0	1,781.3	2.5
Lutjanidae (Snappers)	910.8	2.5	978.9	3.0	58.6	2.2	1,948.3	2.7
Haemulidae (Sweetlips)	314.1	0.9	909.2	2.8	18.5	0.7	141.8	1.7
Lethrinidae (Emperors)	643.3	1.8	435.8	1.3	58.1	2.2	1,137.2	1.6
Mullidae (Goatfishes)	408.3	1.1	518.7	1.6	56.5	2.1	983.5	1.4
Kyphosidae (Rudderfishes)	3,241.1	8.9	311.3	1.0	48.9	1.8	3,601.2	5.1
Mugilidae (Mulletts)	755.7	2.1	0.0	0.0	0.0	0.0	755.7	1.1
Labridae (Wrasses)	1,524.1	4.2	3,175.6	9.8	477.1	17.9	5,176.8	7.3
Scaridae (Parrotfishes)	12,238.9	33.7	13,152.9	40.7	394.5	14.8	25,786.3	36.2
Acanthuridae								
(Surgeonfishes)	7,215.8	19.9	5,987.2	18.5	341.3	12.8	13,544.3	19.0
Other fishes	868.4	2.4	923.4	2.9	79.1	3.0	1,870.7	2.6
Total	32,301.9	89.0	30,092.7	93.1	1,725.8	64.9	64,120.1	90.0
Invertebrates								
<i>Trochus niloticus</i> (Topshell)	807.7	2.2	197.9	0.6	604.7	22.7	1,610.3	2.3
<i>Tridacna maxima</i> (Giant clam)	1,194.1	3.3	6.7	0.0	0.0	0.0	1,200.8	1.7
<i>Octopus</i> spp. (Octopus)	441.9	1.2	208.6	0.6	104.8	3.9	755.3	1.1
<i>Parulirus</i> spp. (Spiny lobsters)	1,214.0	3.3	1,635.5	5.1	130.8	4.9	2,980.3	4.2
Other invertebrates	326.4	0.9	194.6	0.6	92.9	3.5	613.9	0.9
Total invertebrates	3,984.1	11.0	2,243.3	6.9	933.2	35.1	7,160.6	10.0
Method totals	36,286.0	100.0	32,366.0	100.0	2,659.0	100.0	71,280.4	100.0
Percent of total catch		50.9		45.4		3.7		100.0

summary statistics. These include greater success at intercepting scuba diving spearfishing parties, particularly those returning late at night, and a shift in effort to deeper water (30–42 m) by parties that consider shallow areas “fished out.”

Economics

Spearfishermen often sell their catch, but no economic information is available. Catch disposition is recorded but has never been analyzed. Competition from inexpensive imports probably inhibits growth, which slows the potential for overfishing.

Bigeye Scad Fishery

The bigeye scad, locally called atulai, is a small coastal pelagic species that is cosmopolitan in the tropics, but probably forms a distinct stock in the Marianas. It periodically occurs in large schools in coastal bays and channels as well as from near the surface to depths of >200 m near shore. It typically aggregates inshore during the day and migrates offshore at night. When

inshore, bigeye scad are taken by a variety of shore-based methods including teams of people using large barrier nets with the aid of boats and divers. When offshore, they are attracted to lights hung from small boats and jigged. Shore-based methods typically account for 70% or more of the annual landings (Hensley and Sherwood, 1993).

Jigging for bigeye scad by nightlight is done during moonless periods. Prior to 1985, too few returning fishermen were intercepted by the survey, so only the period 1985 through 1991 is presented here. The fishery is highly seasonal; the greatest effort and catches occurred during July and August and there is almost no activity or catches from December through April.

The Catch

Estimated annual landings since 1985 have ranged from 3.4–20.2 t with no apparent trend. Good and poor years coincide well with estimated annual landings by shore-based methods (Hensley and Sherwood, 1993), indicating that these results are real rather than the result of inadequate sample size. The largest estimated combined annual catch for Guam for all methods was 76.5 t in 1989. An upper bound of 200 to 440 t for an annual range of harvest for the entire Mariana Archipelago has been suggested (Polovina et al., 1985). This is based on the untested assumption that the abundance per mile of 200 m contour in the Marianas is the same as that in the Hawaiian Islands. For Guam and Galvez-Santa Rosa Banks, the equivalent upper yield would be 50–112 t. No figure is available for Rota Banks and 45° Banks.

Participation and Effort

The estimated annual number of boat trips and person trips has fluctuated

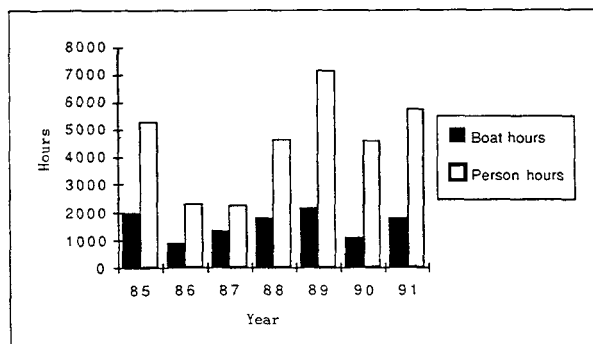


Figure 11.—Estimated annual number of boat hours and person hours spent spearfishing during 1985–91.

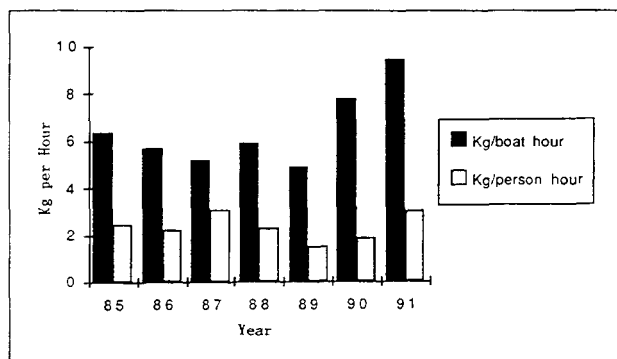


Figure 12.—Catch rates as kg per boat hour and kg per person per hour spent spear-fishing during FY 1985–91.

widely since 1985, ranging from 325 to 1,280 and from 911 to 3,475, respectively. The estimated annual number of boat hours and person hours has also fluctuated widely, ranging from 2,167 to 9,385 and from 5,312 to 26,088, respectively. No clear trends are apparent.

Catch Rates

Catch rates since 1985 have ranged from 1.0 to 3.8 kg/boat-hour and from 0.4 to 1.4 kg/person-hour, respectively, with no apparent trend or correlation with annual landings.

Economics

Bigeye scad are sold by subsistence and commercial fishermen along the roadside, in stores, or directly to restaurants. Bigeye scad and closely related species are also imported fresh from the Philippines. Neither the proportion of the annual harvest that is sold nor revenues have been estimated for this fishery although some sales information is available on the offshore survey data base. An assessment of the economics of this fishery is not possible at this time. Since bigeye scad are usually the single most important inshore species in terms of annual landings, their economic importance must be great.

Discussion

Pelagic Fishery

At present, trolling is the only method used by Guam's small-boat

fishery that targets pelagic species. The targeted species are all migratory, high-trophic-level predators. Fish caught in the vicinity of Guam are part of regional or possibly Pacific-wide stocks. Although some species may linger in the vicinity of Guam for a while, they are generally seasonal in occurrence, have very high fecundity, and grow fast. Pelagic species that spend at least the daylight hours >50 m (broadbill swordfish, *Xiphias gladius*; bigeye tuna, *Thunnus obesus*; and albacore, *Thunnus alalunga*) are not locally fished, although there is commercial interest in them.

Annual landings of Guam's troll-caught species are highly variable. There are no apparent trends in the catches of mahimahi, wahoo, skipjack tuna, or sailfish. Catches of blue marlin increased during the past 12 years, whereas catches of yellowfin tuna decreased. Catch rates for blue marlin have increased in recent years, whereas catch rates for skipjack and yellowfin tuna have declined. Increasing charter boat participation and interest in sportfishing rather than commercial fishing are likely causes of increasing catches and catch rates for blue marlin. The low marketability of skipjack tuna is the most likely cause for declining catch rates for that species, but declining catches and catch rates for yellowfin tuna may be stock related. These two tunas as well as bigeye tuna are the principal components of the Guam-based domestic purse seine and

foreign longline fisheries which operate primarily in more southern Federated States of Micronesia waters. The impact of these large-scale fisheries on stocks of these, as well as incidentally caught mahimahi, wahoo, blue marlin, and sailfish, are largely unknown, and the data necessary to assess this are not available to U.S. fisheries scientists. However, landings of longline-caught tuna transhipped through Guam are being collected by the Guam Department of Commerce; the South Pacific Commission is collecting data on the purse seine fishery and has a major tagging study of yellowfin tuna in progress. The most complete assessment of blue marlin to date (Skillman, 1989) indicates that it is growth overfished, but that the situation may be improving because of increased use of deep vs. shallow longline gear.

A major complaint by troll fishermen is that they must now travel farther to obtain the same catches they once enjoyed closer to Guam. To evaluate this apparent indicator of possible overfishing, a detailed analysis of catch rates by primary fishing area must be done. Although the necessary information is on the data base, outmoded computer equipment and a shortage of personnel have prevented such an analysis. With the possible exception of yellowfin tuna, there is no other indication of overfishing.

Management of the local pelagic fishery is meaningless because Guam's small trolling fleet does not have the potential to affect the stocks. However, certain beneficial measures have and could be taken. The deployment of FAD's probably helps to attract and hold migrating pelagics closer to Guam. The banning of longlining within 50 miles of the 100-fm contour of Guam and its satellite banks reduces the risk of gear conflicts and prevents the interception of pelagics once they are within the range of the trolling fleet. A similar ban on domestic purse seiners could also benefit the troll fishery, but this is highly unlikely on legal grounds.

The charter and recreational components of the fishery are economically healthy, and continued growth is ex-

pected. However, the health of the commercial component is in decline because of a combination of competition from cheaper, more efficient sources including longline-caught fishes rejected for transshipment and the absence of a unified local marketing effort.

Bottomfish Fishery

The bottomfish fishery appears to be stable, but the dominance of small species with high turnover rates is indicative of a mature fishery in which the larger, long-lived species are overfished. Indeed, two of the most important, desirable, and largest of the deep-water species in "virgin" catches have nearly disappeared in recent years. The grouper *Epinephelus octofasciatus*, which represented 13% of the catch (90% of which were the deep-water component) in the late 1960's and was a prominent component of catches in the relatively unexploited Commonwealth of the Northern Mariana Islands in the early 1980's (Ikehara et al., 1970; Polovina et al., 1985), is now rarely caught and has not even appeared in the sampled catch for most years since 1980. Catches of onaga, *Etelis coruscans*, the single most important species in catches of the late 1960's (25%), have decreased considerably during the past 6 years. However, unchanging mean sizes of 10 important bottomfish species since 1980 (5 shallow and 5 deep) indicate that the fishery is stable.

Polovina and Ralston (1986) calculated an annual equilibrium yield for the 125–275 m depth band of 15.6 t for Guam and 7.8 t for the Galvez-Santa Rosa Banks region (23.4 t total, but this excludes the smaller Rota and 45° banks). The mean annual harvest for the 1980–91 period was about 24 t, 7 of which were deepwater species. The largest estimated annual deepwater harvest was 12.8 t (42.8 t in 1985 for all depths), well under the estimated equilibrium yield. For the fishery as a whole, there is no indication of overfishing.

Since it is impossible to target a given species reliably and the viability of released deep-water species is unlikely, species-specific management measures would not be practical. At

some point, a value judgement must be made whether or not to sacrifice the most vulnerable species in return for increased overall yields. Assuming that there is a single archipelagic stock, then as long as there are refuges in the form of lightly fished banks or islands sufficient to insure an adequate spawning stock biomass of key species, no specific management measures are necessary.

The economics of the fishery is complex and poorly understood. Although supply has never met the demand, several factors probably limit participation. These include competition from inexpensive imports of reef and bottomfishes and a booming economy that offers better opportunities elsewhere. No one depends on bottomfishing to earn a living. There have been no full-time commercial highliners since the mid-1980's, and increasing annual landings since then are attributable to an increase in the number of participants which are probably primarily recreational and subsistence fishermen.

More effective management of the fishery would be facilitated by a clear separation of deep- and shallow-water effort as well as catches and better consideration of the overlap and interaction of the shallow water component with other competing fisheries. Biological studies of key species are desirable.

Reef-Fish Fishery

Spearfishing is the only significant reef-fish fishery other than the shallow bottomfish fishery which uses small boats. The same stocks are also harvested by shore-based spearfishing as well as other methods. Catch rates have increased during the past 3 years primarily because of an increase in the use of scuba equipment and the tendency of certain "highliners" to shift to deeper water. The sample size is insufficient for statistically significant trends to be detected. To date, biological data on the species have not been examined, nor have there been any studies of the biology of key species. However, anecdotal information suggests that some species, if not the fishery as a whole, are overfished. There is universal agreement among long-time spearfishermen that catches are down

considerably from several years ago, and that one has to travel to the least accessible areas or to visit deeper water to obtain worthwhile catches. This author as well as other divers have noticed a decline in many of the larger species during the past 15 years. In comparison to other relatively unfished islands in the region, the community structure of Guam's reef fishes was noticeably different as long as 15 years ago and dominated not only by small species that mature rapidly but also by relatively small individuals of many species. There also seems to be a trend among divers in general, particularly the transient military and nonindigenous population, to take up nonconsumptive activities such as photography. Since this group consists primarily of those with relatively low spearfishing skills, the remaining skilled fishermen could cause the catch rate to increase until biological reasons impact it. However, no statistical significance can be attached to apparently increasing catch rates in recent years because of high variability and small sample sizes.

De facto refugia in the form of seasonal rough water as well as less accessible islands in the CNMI and offshore banks may prevent recruitment overfishing for many species. However, many lagoon and reef-flat species do not benefit from this and are under considerable fishing pressure at Rota and Saipan, the only other islands with these habitats.

New management measures are needed to prevent a decline in this fishery. A network of permanent preserves that encompass a diversity of habitats and that are large enough to ensure the protection of the more mobile and larger, more vulnerable species is needed. This would also reduce the potential for conflicts by satisfying the demands of nonconsumptive users. Species-specific management of the most vulnerable species is also desirable. Restriction of certain practices such as the commercial sale of speared fish or the use of scuba to spear fish, particularly at night, should be considered.

Although no economic information has been summarized, the supply has

never met the demand. However, competition from inexpensive imports keeps prices low and may reduce the pressure on the resource.

Bigeye Scad Fishery

Estimated annual landings since 1985 have fluctuated widely. Good and poor years coincide well with estimated annual landings by shore-based methods, indicating that these results are real rather than the result of inadequate sample size. There is no indication of overfishing. Since the largest estimated combined annual catch for Guam for all methods—84.3 t—falls midway between suggested upper equilibrium yields based on studies in the Hawaiian Islands, this fishery should be closely monitored.

Acknowledgments

This project was supported by the Guam Federal Aid in Fisheries Restoration Program funded by the U.S. Fish and Wildlife Service and the Western Pacific Fisheries Information Network funded by the National Marine Fisheries Service. I gratefully acknowledge the cooperation and assistance of the Guam Fishermen's Cooperative, the Marianas International Fishing Derby Committees, and the fishermen of Guam. David C. Hamm of the National Marine Fisheries Service's Honolulu Laboratory and his staff deserve special thanks for the many hours above and beyond the call of duty spent preparing many of the statistics used herein.

Literature Cited

- Amesbury, S. A., F. A. Cushing, and R. K. Sakamoto. 1986. Guide to the coastal resources of Guam: Vol. 3, Fishing on Guam. Univ. Guam Press, 110 p.
- Hensley, R. A., and T. S. Sherwood. 1993. An overview of Guam's inshore fisheries. *Mar. Fish. Rev.* 55(2):129-138.
- Ikehara, I. I., H. T. Kami, and R. K. Sakamoto. 1970. Exploratory fishing survey of the inshore fisheries resources of Guam. Proc. 2nd. CSK Symp., Tokyo, p. 425-437.
- Polovina, J. J., R. B. Moffitt, S. Ralston, P. M. Shiota, and H. A. Williams. 1985. Fisheries resource assessment of the Mariana Archipelago, 1982-85. *Mar. Fish. Rev.* 47(4):19-25.
- _____ and S. Ralston. 1986. An approach to yield assessment for unexploited resources with application to the deep slope fishes of the Marianas. *Fish. Bull.* 84(4):759-770.
- Skillman, R. A. 1989. Status of Pacific billfish stocks. In R. Stroud (Editor), Planning the future of billfishes, part 1: Fishery and stock synopses, data needs and management, p. 179-196. Natl. Coalition Mar. Conserv., Savannah, Ga.