An Overview of Guam's Inshore Fisheries

REBECCA A. HENSLEY and TIMOTHY S. SHERWOOD

Introduction

Background

Since long before the first contact of westerners with native Guamanians (or Chamorus[1]) in 1521, fish has been the primary source of protein for the islanders. Little is known about traditional management of Guam's fisheries, but fishing was and has remained an important part of life and culture. In the past, subsistence fishing provided Guam's residents with an ample supply of fish. Most of the fish caught were consumed by fishermen's families or shared with the community and were harvested from three main areas of the sea: The coral or nearshore shallow adjacent areas, nearshore slopes to about 100 fathoms and the surface ocean waters. Much of the traditional use of fish for social obligations in the form of fiestas (large gatherings for funerals, weddings, christenings) is still practiced.

Guam is a U.S. territory located in the western Pacific (Fig. 1). It is the southernmost and largest island in the Mariana Island Archipelago with over 130,000 people on about 550 km^2. Much of the change in Guam's fisheries, from traditional subsistence fisheries to the more modern subsistence, commercial, and recreational fisheries has occurred since World War II. Johannes (1978) maintained that the decline of the Pacific island fisheries was due mostly to change in the economic system of the Pacific Islands to a more western one which has eroded the ancient marine tenure laws and tra-

[1]Chamoru, previously Chamorro, is the currently accepted spelling of the indigenous people of Guam.

The authors are with the Division of Aquatic and Wildlife Resources, Government of Guam, P.O. Box 2950, Agana, Guam 96910. Correspondence to them may be addressed as follows: R. A. Hensley, Texas Parks and Wildlife Department, 1231 Agnes St., Corpus Christi, TX 78401; and T. S. Sherwood, 3245 Austin Dr., Colorado Springs, CO 80909. Views of opinions expressed or implied are those of the authors and do not necessarily represent the position of the National Marine Fisheries Service, NOAA.

ABSTRACT—Guam's nearshore reef fishery is a multi-gear, multispecies fishery that has undergone major changes through the years. Methods have evolved and become more modern. This, along with the changing economic status of Guam, has severely stressed the fishery. Top targeted species are being overexploited and "growth overharvesting" is occurring; the more serious form of "recruitment overharvesting," is happening to some of the key species. Major management concerns are discussed with respect to overfishing and habitat destruction. Management recommendations for this fishery include gear restrictions, size restrictions, and the establishment of marine conservation areas.

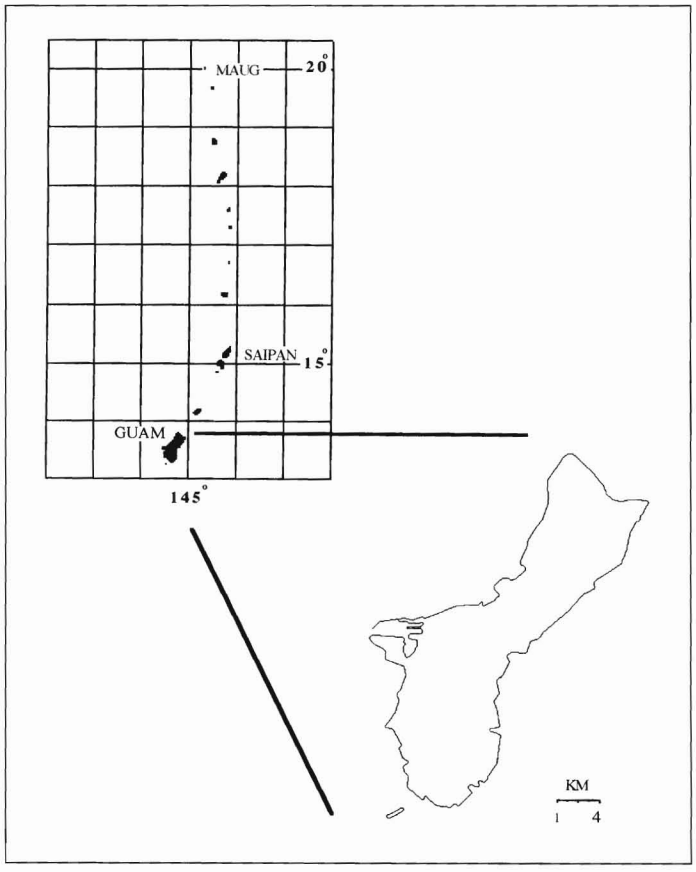

Figure 1.—Guam (13°30'N; 144°50'E) is the southernmost of the Mariana Archipelago.

ditional island conservation ethics. This, along with the introduction of more modern, manufactured fishing materials (monofilament nets, steel hooks, poles, reels, spearguns, scuba gear, etc.), has changed the complexion of Guam's inshore fishery and aided in the decline of the nearshore reef fishery. Ikehara et al. (1970) stated that Guam's shallow inner reefs appeared to be fully exploited and showed signs of overfishing. Katnik (1982) found that two heavily fished areas on Guam were overfished and stated that other accessible areas on Guam could be equally overexploited. What was once a well stocked, complex fishery with diverse fishing methods has changed to a fishery under serious fishing pressure.

Scope

Because of the increased efficiency of fishing techniques due to introduction of modern materials and because of the increase in fishermen and the island population, the Guam Division of Aquatic and Wildlife Resources (DAWR) recognized the need to protect the fishery from overharvesting. Initial monitoring of the resources began in the 1960's, and it had evolved by 1982 into the current creel survey methodology adapted from Malvestuto et al. (1978). Because of the different usage and the different areas of the sea utilized for the multispecies, multigear fisheries, Guam's fisheries monitoring was divided into two projects. These were the "inshore" (or nearshore reef) fisheries and the "offshore" (small boat) fisheries (Myers, 1993). The inshore fisheries discussed here will encompass the coral or nearshore shallow adjacent waters which consists mostly of fringe reefs.

This paper describes inshore fisheries, concentrating on data from 1982 through 1991. We discuss fishing techniques and data collection and compilation for landing and effort estimates of Guam's fishery. The harvest components (finfish, nonfinfish, and seasonal juveniles or traditional fishery) and current management practices are described with suggestions for conservation of the fishery.

Guam's Inshore Fisheries

Historic Fishing Methods

Detailed fishing techniques from prehistoric times have been described by Amesbury et al. (1986) and will be only briefly described here. Early fishing techniques (prior to the 1930–40 period) employed gear composed of natural materials. Today, inshore (or reef and lagoon) methods have incorporated modern equipment and have been modified in some manner from the traditional form of fishing. Some form of hook and line fishing, usually handline, has been done since the arrival of the Chamorus on Guam around 1500 BC (Amesbury et al., 1986). Net fishing has included forms of dip netting, bag seining, throw netting, surround netting, drag netting, and gill netting (a more recent form of net fishing). Fishing with traps and spears has occurred throughout the history of Guam. Women historically harvested the seagrass parrotfish (Scaridae) and some wrasses (Labridae) by hand. All social classes of Chamorus harvested eels with iron spears and crabs with multipronged spears. Gleaning for invertebrates has always occurred, especially for mollusks and algae for use as either bait or food. The Spaniards gleaned for sea cucumbers.

Several types of fishing no longer occur. Two of these are the opelu or hachuman fishing (for *Decapterus* sp.) and the decoy method of fishing (Amesbury et al., 1986). Turtles were harvested until 1976 when it was prohibited. Other currently prohibited methods include fish weirs, fish poisoning from root extract (*Barringtonia asiatica* tree), chlorine bleaching, and dynamiting. These are still practiced illegally on a small scale.

Traditional fishing practices are still observed routinely on Guam. One practice is the fishing for seasonal juveniles recruiting to the reef flats (discussed below), while the other practice involves sharing the catch. The catch from the surround net or chenchulu (when used for catching seasonal mackerel or *Selar crumenopthalmus*) is still divided up into thirds with the portions going to the owner of the net, the village where the fish were caught, and those who helped harvest the catch.

Contemporary Fishing Methods

Many of the currently used methods are very efficient because the technology and materials used are readily available at a minimal cost. Contemporary methods include hook and line, net fishing (cast, gill, drag, and surround net), spear fishing (snorkel and scuba), hook and gaff, and "other" methods (a miscellaneous category that includes mostly gleaning for invertebrates). These methods, modified through time, are described below and account for the harvest of over 100 species of finfish and 40 nonfinfish species (3 lobster, 9 crab, 24 mollusk, and 4 echinoderm)[2] (Amesbury et al., 1986, 1991).

Currently, the most popular fishing method on Guam is hook and line. This technique ranges from the use of handlines to rod and reel with lures or baited hooks. Recently, we have observed fly fishing in Guam's waters.

The majority of the fish harvested are taken by net fishing. All types of net fishing done today, except gill netting, have long histories on Guam. Net mesh sizes range from 1/4-inch stretch (for seasonal juveniles) to greater than 3-inch stretch. The cast net or throw net (talaya) is one of the few nets that are still hand woven (using monofilament) by the traditional talaya fishermen[3]. These nets vary in mesh size and number of pockets depending on the fish targeted.

Other than the modern equipment, drag netting has changed very little through time. It still is the simplest form of net fishing where the net is

[2]This identifies all information, unless otherwise cited, obtained by the authors from Guam Fisheries Investigations-Project FW-2R-26 Job Progress Reports (Jobs: F-F1–2 Inshore Fisheries Survey; F-F1–3 Fisheries Data Processing; F-F1–8 Studies of Recreationally Important Reef Fish). Information can be obtained from the Division of Aquatic & Wildlife Resources (DAWR), Dept. of Agriculture, P.O. Box 2950, Agana, Guam 96910.

[3]D. Narcissi, Talaya fisherman, Guam Environmental Protection Agency, Harmon, Guam 96912. Personal commun.

pulled through the water as the fish are driven into the net. Today, this method is most often, but not always, used at night.

The use of the surround net or chenchulu has occurred for many years. Today, two types of surround netting occurs. In the first type, two people transport the net through the water on two large inner tubes. The fishermen begin setting the net in a 'U' shape and close the net into a circle as a second group of people drive the fish into the net. Once the net is set, the fishermen dive into the enclosure and harvest the fish by spear and/or hand. The second form of the surround net, also called the atulai gill net (Amesbury et al., 1986), is one that is used to harvest seasonal mackerel or atulai. This net is most commonly used in the harbors, channels, or bays. When a school of atulai is sighted, a boat surrounds the fish with the net and the school can be harvested over a period of days.

Gill net fishing is the most recent form of net fishing on Guam. This method is very popular (usually ranking in the top three of all methods used). This popularity is due to the availability of the gill nets, the comparative low cost, and the effectiveness of the modern monofilament materials. The net is used at any time of the day or night, but it is most successful on an ebb tide where fish escaping the shallows are gilled in the net.

Spearfishing has undergone a vast change with the advent of modern equipment, evolving from handmade spears and freediving to spearfishing with scuba gear. Spearfishing with snorkel and spearfishing with scuba target different fishes and are considered separate techniques. Because of the highly selective nature of both of these methods, spearfishing harvest consists of fish of larger species (i.e., humphead parrotfish, *Bolbometopon muricatum*) than other fishing techniques.

The remaining two methods are primarily used for harvesting nonfinfish. The use of hooks and gaffs targets octopus, although some mantis shrimp and miscellaneous fish are also caught. The last method, a catch-all category appropriately called "other," generally includes gleaning for nonfinfish. New or little-used techniques like dip netting and mantis shrimp traps fall into this miscellaneous category.

Inshore Creel Survey

The primary objective of the inshore fisheries survey was to obtain the most accurate estimate of the total annual inshore fisheries harvest in order to monitor and manage the resource. Fishing activity has been monitored since the early 1960's when much of the early information was taken by DAWR conservation officers (law enforcement personnel). Monitoring changed over the years, as did fish identification. The early 1960's catch was identified by the Chamoru name of the fish. Problems with catch composition arose because one name could mean any wrasse species, parrotfish would be identified by color (blue, brown, white, and green), and rabbitfish would be identified by at least five names that described the fish by size. As taxonomic skill increased, the catch was reported in increasing detail.

Working closely with the U.S. National Marine Fisheries Service, the DAWR developed a program for analyzing the inshore fisheries. Since the installation, all the data collected has been analyzed by this program. In 1991, we modified and restructured our analysis to allow comparison of data from 1982 to the present. (Because of methodological changes, data prior to 1982 do not lend themselves to analyses.)

Survey Methodology

Because much of the shoreline is inaccessible to most fishermen (i.e., military bases, clifflines), not all of Guam is surveyed. Data collection for the inshore fisheries expansion is conducted in an area representing 85% of the total fishing participation (verified from shoreline usage seen during aerial surveys). A two-part roving creel survey, effort (or participation) and catch, is performed for both day and night (begun in 1985) to provide sufficient data to allow for 90% confidence limits for the inshore analysis. Detailed methodology and analyses are described in Amesbury et al. (1991).

During an effort survey, a surveyor records all active fishing participation (time of day, location, number of people, number of gear units, fishing methods, reef zone fished, weather conditions, and surf conditions). Counts are made of fishermen and gear and are used to estimate effort in terms of person-hours (p-hr) and gear-hours (g-hr). The catch survey is of the roving fisherman-intercept type and requires as many interviews for as many fishing methods as possible. The survey variables collected include fishing method, number of fishermen, bait type, number of gear, mesh size, interview time, trip length, species caught, numbers of catch species, and individual weights and lengths. Catch data is used to estimate overall landings (kg), CPUE, and species composition.

The majority of the species caught are represented with this methodology. Species that recruit en masse, like mañahak (rabbitfish) or atulai, cannot be adequately represented in the current creel survey. Catch estimates of these species are obtained when the recruiting runs occur and are added to the survey expansion catch values to obtain the yearly inshore harvest.

Finfish

Finfish are the primary harvest (usually >95%) of contemporary fishing methods. This harvest includes all sizes of reef fish, even the highly anticipated seasonal runs of juveniles. Deepwater and/or pelagic fish, normally harvested using offshore techniques, are occasionally caught using inshore methods. Over 100 species of finfish are harvested in the inshore fishery. The primary families include: Acanthuridae, Carangidae, Gerreidae, Holocentridae, Kyphosidae, Labridae, Lethrinidae, Lutjanidae, Mugilidae, Mullidae, Scaridae, and Siganidae. The top ten species caught in the inshore fishery, not including seasonal juveniles, are *Naso unicornis, Caranx melampygus, Siganus spinus, Mulloides flavolineatus, Lethrinus harak, Valamugil engeli, Kyphosus cinerascens, K. vaigiensis, Cheilinus fasciatus*, and *Gerres* sp. Ranking of these species changes as fishing pressure and gear use fluctuates.

The harvest of one of these key species, *Mulloides flavolineatus,* best describes what is occuring in the finfish fisheries. By 1991, the harvest declined by 90% over a 6-year period (from 33,896 to 3,417 kg). The 100–150 mm size class is targeted in the traditional fishery, which prevents many fish from reaching larger size classes and further impacts the reproductive potential of the population. The downward trend in overall harvest is characterized by the absence of larger females that represent the major portion of the spawning potential.

Many of the once economically important larger species, like the humphead parrotfish, *Bolbometopon muricatum*; wrasse, *Cheilinus undulatus*; groupers over 25 kg, and snappers are rarely seen in Guam's waters, much less reported on the inshore survey catch reports. Interest in the harvest of aquarium fish is on the rise, while the actual harvest appears to be declining. These fish may be less susceptible to overfishing because of their high turnover rate, but problems are beginning to surface with respect to the use of chemicals for fish collecting, habitat destruction, and unmonitored or illegal catches.

The harvest of recruiting juvenile fishes (Table 1) makes up Guam's traditional finfish fishery. It historically has been and still remains an important part of the nearshore reef fisheries. Seasonal juvenile harvest can range from a minor component of <1% (in 1982–83) to over 50% of the overall harvest (in 1991).

Two major components of the juvenile harvest are mañahak and atulai (Fig. 2). The local residents anxiously await the recruitment of both species to the nearshore reef waters. Even though the yearly run of mañahak does not always occur, fishermen will gather at the shoreline during the first few days of the last quarter lunar phase of the expected recruitment period. The mañahak recruit onto the flat area of the reef in aggregations or "balls", as they undergo morphological development from planktivorous to herbivorous fish (Kami and Ikehara, 1976). The largest, as well as the most economically valuable, catch of mañahak is prior to the complete coloration and dietary change (the first 1–2 days on the reef). Harvesting of mañahak is conducted with all nets using a 1/4–1/2 inch stretch mesh size. Atulai usually begin their seasonal runs into inshore waters by the age of 4 months (Amesbury et al., 1986). The atulai are harvested with surround nets, cast nets, and by hook and line and usually represent the majority of the seasonal harvest.

The recruitment of other juveniles, like i'e' (jacks), ti'ao (goatfish), en masse and aguas (mullet), do not occur like the mañahak or atulai, but they are still heavily fished. The recruitment periods for these juvenile fishes often overlap and peak harvests are seen every 3–4 years. The harvest of these juveniles is primarily by net fishing

Table 1.—Seasonal juvenile fishes targeted in Guam's traditional finfish fishery. Chamoru names are after Kerr (1990).

(English Name) Chamoru name	Family and species targeted
Aguas (mullet)	Mugilidae
Atulai (bigeye scad, mackerel)	Carangidae; *Selar crumenopthalmus*
Achemsom[1] (fusilier)	Caesionidae
I'e' (jacks)	Carangidae; primarily *Caranx melampygus*
Mañahak (rabbitfish)	Siganidae; *Siganus spinus, S. argenteus*
Ti'ao (goatfish)	Mullidae; *Mulloides flavolineatus*

[1] Many local fishermen use this name to incorrectly identify juvenile fusiliers when they recruit en masse. Achemsom actually means small rainbow runner (Carangidae; primarily *Elegatis bipinnulatus*).

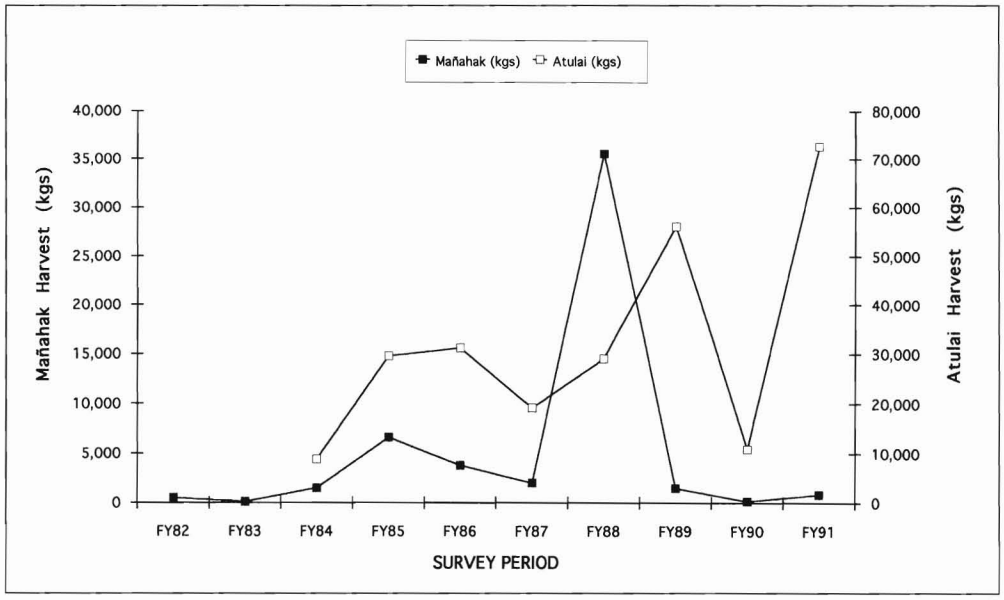

Figure 2.—Estimated harvest from 1982 through 1991 of two of Guam's seasonal juveniles (mañahak = young rabbitfish, primarily *Siganus spinus*; atulai = young mackerel, *Selar crumenopthalmus;* FY = 12-month fiscal year). Names are after Kerr (1990).

(using 1/4–1/2 inch stretch mesh size), except the i'e' which are often harvested by hook and line.

Nonfinfish

Until recently, the funding constrained the DAWR to work on finfishes only; therefore, information on nonfinfish is limited to catch statistics for methods that also target finfish. Since harvesting of invertebrates is one of the less frequent and easily missed activities (i.e., virtually all lobsters are taken by spearfishing), our nonfinfish harvest is probably underestimated. For a few of the species most often collected, the true annual catch is probably only a few metric tons at most.

The coral reef is Guam's single most valuable resource, and, over the years, coral has been harvested for ornamental and commercial use. The most common corals harvested commercially in the past included *Acropora*, *Antipathes*, *Fungia*, *Heliopora,* and *Tubipora* sp. (Hedlund, 1977). Coral (dead or live) is no longer legally collected without a permit (now issued for educational or research purposes only), and the regulation is strictly enforced.

Two species of green algae (*Caulerpa racemosa* and *Codium* sp.), two species of red algae (*Gracilaria edulis* and *Asperagopsis* sp.) and one species of brown algae (*Sargassum polycystum*) are commonly harvested (Hedlund, 1977). The green algae or seaweed is seasonal (usually January through May) and when collected, is often sold at local markets. Sargassum and *Enteromorpha* sp. are also collected as bait for rod and reel fishing for herbivores[4].

Many molluscan species have been and are still harvested on Guam. About 15 bivalve species (3 of which are tridacnid clams) have been harvested on Guam (Stojkovich and Smith, 1978). Other shelled mollusks collected include *Trochus* sp. (topshell or aliling), chitons, conchs, nerites, and strombids (Smith, 1986). A few of these mollusks (plus some not mentioned) are collected for ornamental use. The octopus is the most sought after unshelled mollusk; squid and cuttlefish form part of the incidental catch. Of all these, only *Trochus* has a fisheries potential and is currently regulated with size restrictions and is strictly monitored.

Crustaceans make up a major portion of the nonfinfish catch. About nine species of crab are hunted, including land and marine crabs. *Carpilus maculatus* (7–11 crab) and *Etisus splendens* are primarily targeted, whereas *Calappa hepatica* and rarely *C. calappa* (box crabs) are taken as incidental catch during net fishing, spearfishing, or gleaning. Two species of land crabs (*Cardisoma carnifex* and *Birgus latro*) are also highly prized, but are not monitored on the inshore fisheries surveys. Lobster catches are highly prized. The following species are identified in Guam's catches: Palinuridae (*Panulirus longipes*, *P. ornatus*, *P. pencillatus*, *P. versicolor*), Homaridae, and Scyllaridae. The spiny lobster, primarily *P. pencillatus* and the slipper lobster, *Scyllarides squamosus*, are the two main components of the inshore lobster catch and are harvested by spearfishing and "other" techniques (i.e., gleaning). Mantis shrimp, another crustacean, is often mistaken for lobster by some fishermen. It is harvested by hooks and gaffs, shrimp traps, and through incidental catches.

Smith (1986) stated that other invertebrates harvested have included two species of sea urchins (*Tripneustes gratilla* and *Echinometra mathaei*), two species of sea cucumbers (*Stichopus horrens* and *Holothuria atra*) and a freshwater shrimp (*Macrobrachium* sp.). The sea urchin *T. gratilla* has been harvested for ripe gonads. The harvest of sea cucumbers is sporadic (*H. atra* is the most common species harvested). Present harvest is less than that reported in the late 1800's, when catches of 2–3 tons were documented (Amesbury et al., 1986).

Five species of sea turtles have been identified in Guam's waters[5]. Harvest of sea turtles on Guam was prominent prior to World War II and occurred legally until 1976. Inshore catch reports for 1967–68 noted landings of over 80 turtles in 18 months, the largest individuals weighing an estimated 450 pounds. It is currently difficult to determine the extent of the actual catch because of the illegal nature of this activity. Examples of significant poaching activities were seen during a 2-week period in 1990–91, when an estimated 20 turtles (in two separate incidents) were poached.

Catch and Effort Estimates

Overall catch values for 1982–91 for all fish caught (finfish, nonfinfish, and seasonals) for both day and night are shown in Figure 3. In 1990, the participation declined to less than 50% (42,294 fishermen) of the 1984 high (107,391 fishermen). Similar trends for effort and catch are seen (Fig. 3) where the highs occurred in 1984, but lows occurred in 1989 and 1990. Effort and participation increased in 1991 and are attributed to an excellent year for seasonal juvenile harvest. If harvest estimates for atulai and mañahak (Fig. 2) were removed from the catch values, the overall harvest falls between 1989 and 1990 estimates. The 3–4 year pulse of other juveniles (i'e', aguas, and ti'ao) was also observed in 1991 and falsely elevated the survey estimates (number of participants, gear, catch, etc.). If the juvenile harvest values were removed from all years, the 1991 harvest estimate would still be smaller than any previous year.

Day Fishing Estimates

Day harvest and effort values for means for reef fisheries during 1982–91 are shown in Figure 4. A 60% decline in the number of fishermen occurred in 1990 (30,396) from a high in 1984 (97,603). Similar trends for inshore finfish are seen for both effort and catch (Fig. 4) where highs occurred in 1984. Catch follows effort until 1988 when harvest continues to drop while the effort increases. Nonfinfish effort declined over 90% by 1989 (2,759g-hr) from a high in 1982 (28,613 g-hr). Harvest of nonfinfish, though underestimated, declined from 29,499 kg in 1982 to 1,289 kg in 1990. Both

[4]R. A. Hensley, DAWR, P.O. Box 2950, Agana, Guam 96910. Personal observ.

[5]Hensley, R. A. The distribution and abundance of marine turtles from 1966 to 1992 in the waters of Guam. Texas Parks and Wildlife Department, 1231 Agnes St., Corpus Christi, TX 78401. Unpubl. manuscr.

finfish and nonfinfish show declines in effort and harvest estimates for 1988–91 as compared with the 1982-87 period.

Night Fishing Estimates

During the night surveys from 1985 through 1991, effort reached a high for finfish in 1987 (58,893 g-hr) and declined more than 50% to a low in 1990 (25,181 g-hr). Night harvest of finfish rose to a high of 23,538 kg in 1988 before declining to less than 50% in 1991 (10,285 kg). Nonfinfish showed little change in effort until the drop in 1989–90 (from >2,000 to 340 g-hr). The overall night harvest was composed of nonfinfish harvest that ranged from 3.2% (361 kg) in 1989 to 23% (4,684 kg) in 1986.

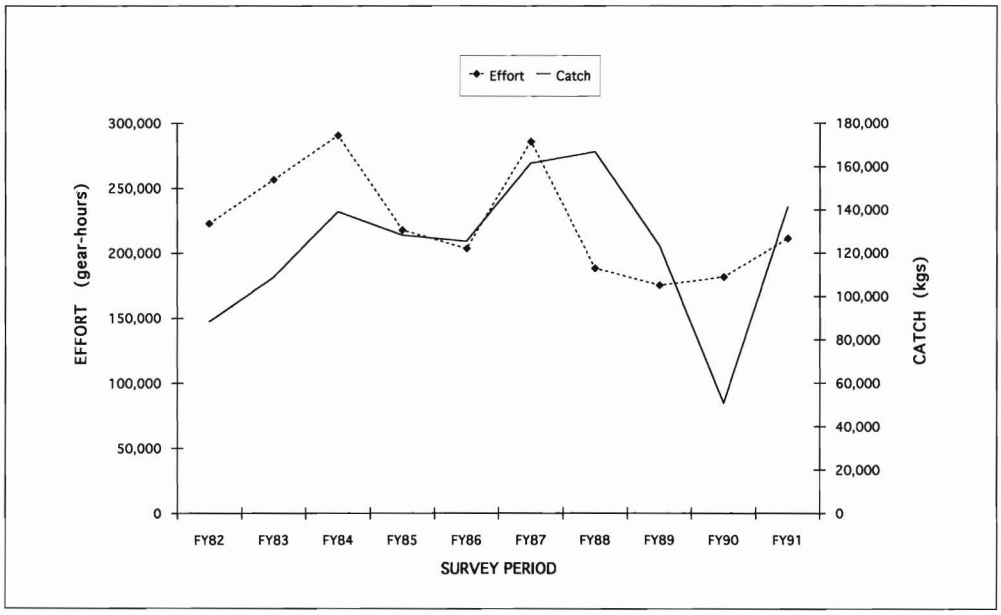

Figure 3.—Estimated effort and harvest of Guam's nearshore reef fisheries from 1982 through 1991 (catch = harvest of all finfish and nonfinfish for both day and night, FY = 12-month fiscal year).

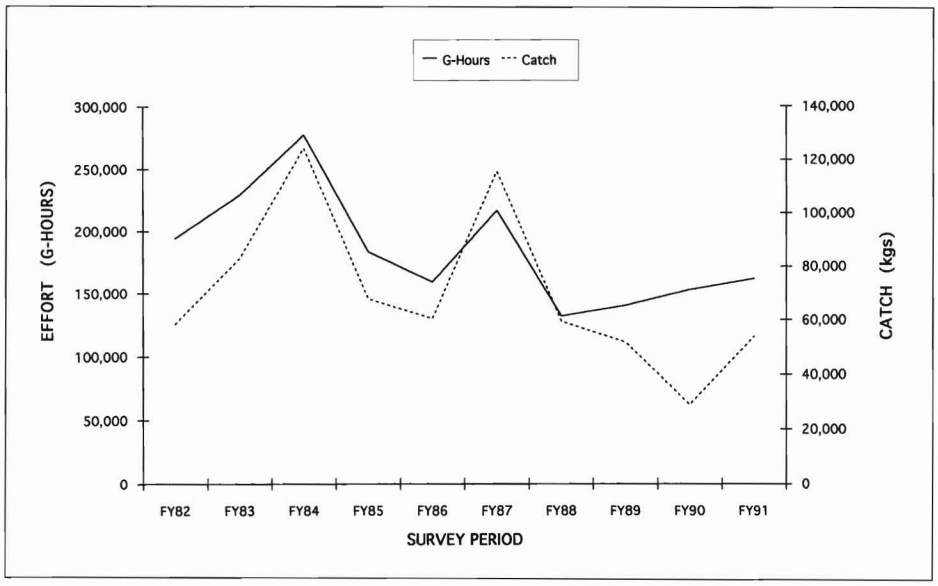

Figure 4.—Estimated effort catch of Guam's inshore fisheries for the daytime from 1982 through 1991 (catch = total harvest of finfish without mañahak or atulai harvest, FY = 12-month fiscal year).

Gear Usage and CPUE

The most popular fishing methods for day and night are seen in Figures 5 and 6, respectively. Hook and line is the most popular method for both day and night, but consistently has one of the lowest CPUE's (catch per unit of effort) ranging from 0.05 to 0.36 for both day and night. The second and third most popular methods for day fishing are cast and gill net. During 1982–84, "other" displaced gill net from the top three. After 1985, most of the participation can be seen with the top three methods (hook and line, cast net, and gill net).

Figure 6 shows the most popular night fishing methods. Spearfishing with snorkel gear ranks second, more often than gill net, drag net, or "other"methods. Except in 1985, when "other" displaces gill net from its third ranking, gill net fishing has increased in popularity where it ranked second for 1986–91.

Many gear use fluctuations are due to the popularity of methods with high CPUE's. The highest day CPUE's (usually about 2.0–4.7) are most often seen with net fishing (mainly drag net, surround net, and gill net) followed by slightly lower CPUE's for spearfishing with scuba and "other". Night CPUE's fluctuate more than day CPUE's and are highest for spearfishing, drag netting, and gill netting. Much of the CPUE fluctuations, especially with net fishing methods like cast, drag, and gill net, can be attributed to the seasonal aspect of the fisheries with respect to traditional fish harvests.

Research

The DAWR has been involved in many aspects of research. For many years, aquaculture potential for freshwater finfish was investigated. Currently, aquaculture research is still conducted (marine finfish and invertebrates) and involves another government agency, private companies, and the University of Guam. Most recently, DAWR began a study of the feasibility of restocking the giant clam *Tridacna derasa*. Studies on the biology and life histories of some recreationally important fishes began in 1984. To date, *Siganus spinus* and *Mulloides flavolineatus* biological profiles have been completed, with *Lethrinus harak* in progress. These biological investigations have been aided by the graduate program at the University of Guam where students investigate important species like *Acanthurus triostegus*, *A. lineatus,* and *Naso literatus* (Molina, 1983; Davis, 1985). Even with the research being done by local and visiting scientists, there is still an enormous amount of information lacking on Guam's fishes.

Work toward identifying the many fish species in Guam's waters has occurred (Kami et al., 1968; Kami, 1971, 1975; Myers and Shepard, 1980; Shepard and Myers, 1981; Amesbury and Myers, 1982; Myers, 1988, 1989). This documentation continues as new species are recorded. The species composition of the fishery on Guam has been made possible by the various check-lists of the fishes in Guam's waters. Aerial surveys are periodically performed to monitor inshore fishing activity in nonsurveyed areas of Guam. Incidental information acquired includes offshore fishing information and turtle abundances[5].

Future investigations are planned for other recreationally important reef species to make sound management suggestions (size, bag limits, seasonal closures). Otolith work has been initiated through the University of Guam.

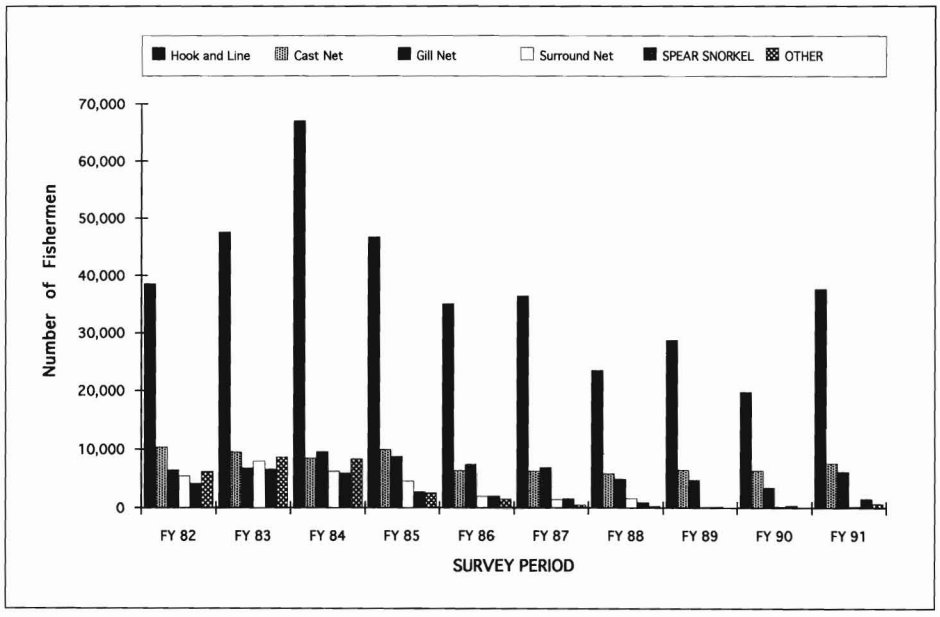

Figure 5.—The most popular fishing methods in Guam's inshore fisheries for the day from 1982 through 1991 (number of fishermen = number of people using specific method; FY = 12-month fiscal year.)

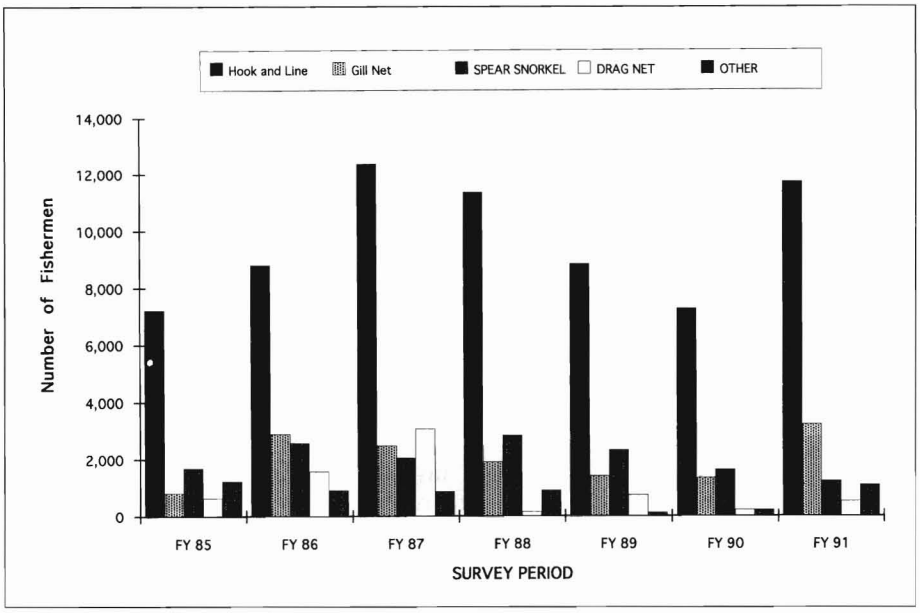

Figure 6.—The most popular fishing methods in Guam's inshore fisheries for the night from 1985 through 1991 (number of fishermen = number of people using specific method, FY = 12-month year).

Analyses of the stocks and future fishing potential is continuing through the modifications in existing expansion methodology and creel survey information[6].

Management Concerns

As the human population grows, modern fishing techniques improve, and fish stocks decline, the need for the management of Guam's tropical coral-reef fisheries increases in order to protect the reef habitat from overfishing as well as from pollution and destruction. The effects of pollution are seen as a result of development and population growth. Much of Guam's southwestern coral reefs are covered with silt from freshwater runoff. Because water quality is extremely important to viable coral reefs (and fish populations), strict standards for development, land clearing, and chemical use should be initiated and enforced. Other major causes of reef destruction includes the use of explosives and poisoning (chlorine bleach and *Barringtonia* root) as fishing methods. Both types of fishing are illegal, but through an education program (with respect to problems associated with destructive fishing practices) and strict enforcement, these have been declining.

Besides pollution and destruction of the reef habitat, it is imperative that a comprehensive management program be established for Guam's fisheries. There are enough indicators that fishing pressure on Guam's inshore resources has reached the point of overexploitation of many of the key species. The proportion of juvenile fish in fisheries landings is increasing rapidly. "Growth overharvesting" has been occurring, and the overall yield has declined as a larger and larger portion of smaller fish are harvested. It is very likely that "recruitment overharvesting," where the reproduction and recruitment of the stocks show a decline, is currently occuring in some of the recreationally important species.

Management Recommendations

Currently, there are several seasonal, area, gear, and size restrictions and bag limits on Guamanian fisheries. These pertain mostly to nonfinfish such as the spiny lobsters, tridacnid clams, *Trochus,* and crabs. Gear restrictions are the only regulations pertaining to finfish harvest. Minimum mesh sizes of $1\frac{1}{2}$ inches on gill nets (except for traditional or juvenile harvest) and hook restrictions for atulai (no snagging) are the principal restrictions. Other gear restrictions include length and time limits for gill net fishing and the prohibited use of fish weirs.

New regulations are currently awaiting approval with one of the most promising avenues being the development of marine conservation area(s). These should be established to provide a refuge for recreationally important fish so they can grow, mature, and reproduce to increase stock health and recruitment. Besides the ability of an area closure to protect fish from harvest, there are many other benefits that make this an increasingly popular form of management and conservation. The closure limits the catches on adjacent reefs without closing down the entire fishery and provides areas where user conflicts are minimized.

Gear restrictions should be implemented and enforced. Because no other method for the seasonal harvest (with mesh sizes as small as $\frac{1}{4}$ inch) is as

[6]Hensley, R. A., and T. S. Sherwood. Unpubl. data. Texas Parks and Wildlife Department, 1231 Agnes St., Corpus Christi, TX 78401.

dangerous to the entire fishery as the nonselective method of gillnet fishing, this method should be heavily regulated. The minimum mesh size for gill nets should be 3 inches, maximum length of time used should be decreased, and it should be required that all nets be manned at all times. The use of gill nets for juvenile fish harvest should be eliminated (except atulai where a $1^1/_2$-inch minimum mesh size should be kept). Other nets, like cast nets and drag nets could still be used for juvenile harvest without the damage to the fish stocks that gill netting may cause. All commercial fishing for seasonal juveniles using nets with mesh sizes less than $1^1/_2$ inches should be prohibited. Because of the environmental damage that sometimes occurs with drag nets, the use of this method should be restricted to specific areas where minimal destruction of habitat would occur. Spearfishing with scuba gear should be prohibited because the few remaining large fish of overexploited species are being targeted.

Appropriate management strategies are difficult to develop when dealing with multispecies, multigear fisheries. Management is further impeded by the desire to hold on to traditional fishing activities which involve the harvest of juvenile fishes. To ensure that future generations enjoy the traditional harvest of juveniles as well as other fishes, strict management regulations must be implemented. Of course, the ability of any management approach also depends on ensuring a healthy and clean reef environment to provide adequate habitat and optimal reproduction.

Market Description

The DAWR has been keeping track of the catch sold by offshore recreational fishermen (Myers, 1993) and has recently begun to document other catches, including nearshore reef fishes. The market for nearshore reef fish has increased on Guam, especially with the diverse cultures that eat fish as a primary source of protein. With the influx of new people and the desire for local fresh fish, the market continues to expand. Because the prices are high, with the average price of $3–4/pound for whole reef fish, the financial benefit for fishermen using a high CPUE method (gill net, surround net, drag net) is enormous. Many of the net fishermen encountered on the inshore survey are no longer subsistence fishermen but are commercial fishermen.

Reef fish imports from Belau and the Federated States of Micronesia are increasing. It is difficult to determine the amount of fish imported because few restrictions are placed on importation. Further difficulties occur in monitoring sales of local and imported fish because of the manner in which they are sold. Many fishermen sell their catch on the roadside, while others sell to small local stores or the large supermarkets. Continued monitoring is necessary to obtain more knowledge of the commercial aspect of the inshore fisheries.

The Future

The outlook for Guam's inshore fisheries, given the current catch information, is poor. If management strategies are not incorporated soon, the remaining fishery may continue to decline to the point of poor productivity. The need for fishery imports will continue to increase as local stocks decline. This lower abundance and availability of Guam's fishery resources could cause higher fishing pressure on neighboring islands.

The ability to manage Guam's fisheries is limited by local politics. In an effort to protect the traditional fishing practices of the Chamorus, legislation has been passed without any apparent foresight of impact on other aspects of the fishery. Interpretation of the term "traditional" has allowed fishing practices acquired since WWII (i.e., gill netting) to continue with little to no regulation. If allowed to continue, the change from subsistence fishing to "traditional" commercial fishing will continue to strain Guam's fishery resources.

The picture is not as bleak as it may appear, however, because many Guamanians are beginning to become environmentally aware. This is demonstrated by the increasingly high number of informants regarding illegal fishing practices (turtle poaching, coral harvesting, gill net abandonment, etc.). The DAWR continues to address the aspect of educating tourists (over 740,000 in 1990) and temporary workers from foreign lands about local regulations. As Guam's population and a need for housing increases, illustrated by the recent closure of the U.S. military bases in the Philippines and the subsequent transfer of 2,000 families to Guam, we see greater threats to the reef resources than we have now. With the help of the general population and the passage of rigid regulations, there is still hope for the fishery to rebound. However, it is highly unlikely for future harvests to reach pre-1987 totals.

Acknowledgments

We would like to thank M. J. McCoid and G. W. Davis for their critical review of this manuscript and all the data collectors that were involved in this project over the years. We also thank G. Boehlert and two anonymous reviewers for their comments. This project was funded by the Federal Aid in Sport Fish Restoration Act (Guam Fisheries Investigation-Project FW-2R-22).

Literature Cited

Amesbury, S. S., and R. F. Myers. 1982. Guide to the coastal resources of Guam, Volume I: The fishes. Univ. of Guam Press, Mangilao, 141 p.

_____, F. A. Cushing, and R. K. Sakamoto. 1986. Guide to the coastal resources of Guam, Volume 3: Fishing on Guam. Univ. of Guam Press, Mangilao, 110 p.

_____, T. S. Sherwood, and G. W. Davis. 1991. Monitoring a tropical island reef fishery. Am. Fish. Soc. Symp. 12: 84–87.

Davis, G. W. 1985. Reproductive patterns of three economically important surgeonfish species on Guam. M.S. thesis, Univ. of Guam, Mangilau, 44 p.

Hedlund, S. E. 1977. The extent of coral, shell and algal harvesting in Guam waters. Univ. of Guam, Tech. Rep. No. 37, 34 p.

Ikehara, I. I., H. T. Kami and R. K. Sakamoto. 1970. Exploratory fishing survey of the inshore fisheries of Guam. Proc. 2nd CSK Symp., Tokyo: 425–437.

Johannes, R. E. 1978. Traditional marine conservation methods in Oceania and their demise. Annu. Rev. Ecol. Syst. 9:349–364.

Kami, H. T. 1971. Check-list of Guam's fishes, Suppl. I. Micronesica 7(1–2):215–228.

_____. 1975. Checklist of Guam's fishes, Suppl. II. Micronesica 11(2):115–121.

_____ and I. I. Ikehara. 1976. Notes on the annual juvenile siganid harvest in Guam. Micronesica 12(2):323–325.

_____, _____, and F. P. DeLeon. 1968. Check-list of Guam's fishes. Micronesica 4(1):95–131.

Katnik, S. E. 1982. Effects of fishing pressure on the reef flat fisheries of Guam. M.S. thesis, Univ. of Guam, Mangilao, 62 p.
Kerr, A. M. 1990. Chamorro fish names. Micronesica 23(2): 93–118.
Malvestuto, S. P., W. D. Davies, and W. L. Shelton. 1978. An evaluation of the roving creel survey with nonuniform probability sampling. Trans. Am. Fish. Soc. 107(2):255–262.
Molina, M. 1983. The seasonal and annual variation of coral-reef fishes on the upper reef slope at Guam. M.S. thesis, Univ. of Guam, Mangilao, 87 p.
Myers, R. F. 1988. An annotated checklist of the fishes of the Mariana Islands. Micronesica 21(1–2):115–180.
_____. 1989. Micronesian reef fishes. Coral Graphics, Barrigada, Guam, 298 p.
_____. 1993. Guam's small-boat-based fisheries. Mar. Fish. Rev. 55(2):117–128.
_____ and J. W. Shepard. 1980. New records of fishes from Guam, with notes of the ichthyofauna of the southern Marianas. Micronesica 16(2):304–347.
Shepard, J. W., and R. F. Myers. 1981. A preliminary checklist of Guam and the southern Mariana islands. *In* A working list of marine organisms from Guam, p. 60–88. Univ. of Guam Tech. Rep. No. 70.
Smith, B. D. 1986. Reef invertebrate harvesting. *In* Guide to the coastal resources of Guam, Volume 3: Fishing on Guam, p. 68–74. Univ. Guam Press, Mangilao.
Stojkovich, J. O., and B. D. Smith. 1978. Survey of edible marine shellfish and sea urchins on the reefs of Guam. Univ. Guam, Tech. Rep. No. 2, 65 p.