Hawai‘i Pelagic Handline Fisheries: History, Trends, and Current Status

- Final Background Document -

Prepared for the

WESTERN PACIFIC FISHERY MANAGEMENT COUNCIL

by

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March 8, 2007

Dear Mr. Dalzell,

We are pleased to submit this final report for the project titled *Background Document on the Offshore Handline and Shortline Fishery (Phase I)*. Per WPRFMC Contract 06-WPC-11, the report was previously delivered in draft form for distribution at the Council's 91st Science and Statistical Committee Meeting, and at the 131st Council Meeting.

We would like to express our appreciation for the opportunity to assist the Council in better understanding the history and contemporary status of the offshore handline fleet in the Main Hawaiian Islands. Additional description and analysis of the fleets will be provided in our FY 2007 report to the Pelagic Fisheries Research Program at the University of Hawaii at Manoa,

Mahalo nui loa for your diligent monitoring of this important project. We look forward to undertaking similar research in support of the Council's sustainable fisheries management objectives throughout the Western Pacific.

Sincerely,

Edward W. Glazier, Ph.D.
Principal Investigator

Acknowledgements

We wish to thank and acknowledge the many fishery participants who are taking part in this ongoing research, and the following individuals who have contributed to the development of this report: Libby Stevens, artist and editorial consultant; Janna Shackeroff, Duke University; David Itano, University of Hawaii, Pelagic Fishery Research Program; Courtney Carothers, University of Washington and NOAA Fisheries; Craig Severance, University of Hawaii at Hilo; Reggie Kokubun, Hawaii Division of Aquatic Resources; Stewart Allen, NOAA Fisheries; Kyle Ward, NOAA Fisheries; Walter Ikehara, NOAA Fisheries; and Rusty Scalf, GIS Consultant.

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Hawai‘i's Pelagic Handline Fisheries: History, Trends, and Current Status

1.0 Introduction

The following pages describe the history and current condition of small-boat handline fisheries in the Main Hawaiian Islands (MHI) and the social and economic processes that have characterized and affected those fisheries over the course of time. The report is submitted as a resource for decision-making processes undertaken by the Western Pacific Regional Fishery Management Council (WPRFMC), including those associated with the WPRFMC Pelagic Plan Team and Science and Statistical Committee Meetings held in 2006.

The effort was undertaken by the Pacific Islands Office of Impact Assessment, Inc. (IAI) under WPRFMC Contract Number 05-WPC-11, and relates to an ongoing human dimensions study of MHI handline fisheries being sponsored by the Pelagic Fisheries Research Program (PFRP) at the University of Hawai‘i at Manoa. That study, in turn, is intended to serve as the human dimensions component of ongoing PFRP projects titled "Trophic Ecology and Structured-Associated Aggregation Behavior in Bigeye and Yellowfin Tuna in Hawaiian Waters," and "Private FADS - Catch Composition and Aggregation Dynamics of Bigeye Tuna" (Holland et al.).

1.1 Administrative Background

The WPRFMC (the Council) is the policy-making body for the management of fisheries in the U.S. Exclusive Economic Zone (EEZ) of the Western Pacific, including fisheries conducted around the Hawaiian Islands, American Samoa, Guam and the Commonwealth of the Northern Marianas, various remote island areas, and in the vast open ocean areas of the region. The Council monitors fisheries and marine resources in the region with the cooperative interaction of NOAA Fisheries, and develops and adjusts policies to ensure their sustainability over time. Pelagic fishes and fisheries are critically important elements of this process.

1.2 Information Need and Rationale

The stock structure and migratory patterns of tuna species in the Pacific Ocean are subjects of extensive and ongoing research. Some species, such as bigeye tuna (BET; *Thunnus obesus*), are subject to extensive fishing pressure, and pan-Pacific and regional stock assessments indicate that maximum sustainable yield is collectively exceeded by the various fishing fleets active in this broad region (Hampton et al. 2004; Harley and Maunder 2004; Hampton et al. 2003). The situation has led the U.S. Department of Commerce, National Marine Fisheries Service (NOAA

Fisheries) to submit a Determination of Overfishing for BET, with an accompanying request to the Council to take appropriate and timely action to end overfishing of this species in its area of jurisdiction. A similar determination and request were made regarding yellowfin tuna (*Thunnus albacares*; ʻahi) in late March of 2006.

However, efforts to assess and manage BET and ʻahi stocks in the central and western Pacific are complicated due to the following circumstances: (a) migratory patterns, foraging behavior, stock structure, and related oceanographic factors associated with these species are subjects of ongoing research, (b) fishing pressure occurs as a result of deployment of various types of gear by both domestic and foreign fleets active across each of the eastern, central, and western Pacific regions, (c) multiple island and continental government agencies and regional entities (including the Inter-American Tropical Tuna Commission and the Secretariat of the Pacific Community) are involved in the management of such diverse activities, and (d) it appears that stocks may already be in a state of decline, thereby increasing both the challenges to and urgency of effective management strategies.

The situation is further complicated by the need for resource management decisions that effectively balance the benefits of BET and ʻahi stock conservation measures against the potential liabilities such measures could present to fishery participants active in the Western Pacific region. In this regard, various data is needed to better understand how tuna species are pursued and why a certain method was employed, and how such activities might be modified to conserve or improve the populations while minimizing potentially deleterious economic and social effects for contemporary resource user groups.

Various Pacific fleets exert pressure on tuna populations. Hawaiʻi-based fleets are responsible for a fraction of overall landings. Indeed, the Hawaiʻi-based longline fleet typically accounts for only about five percent of Pacific-wide longline fishing effort in terms of total hooks set per year (WPRFMC 2003:1). Further, although various reporting issues obviate a complete picture of small-boat pelagic catch and effort, landings by the MHI by small-boat[1] operators are consistently minimal relative to those of the Hawaiʻi-based longline fleet. Reported landings for the entire commercial small-boat fleet were about 18 percent of total reported pelagic landings for all Hawaiʻi-based fleets in 2004. More specifically, Hawaiʻi-based MHI and offshore handline operators reported landing about 1.4 million pounds of pelagic fish in 2004, or about six percent of combined total.

But the harvest is undeniably significant to Hawaiʻi small-boat operators in an absolute sense, and periods of high return on investment has led to effective harvest and marketing strategies for some participants, with as yet uncertain implications for populations of ʻahi and BET. Moreover, it should be noted that ʻahi and BET landed by the Hawaiʻi small-boat fleets are important not only for their export value but also as sources of fresh seafood in an island setting

[1] "Small-boat" is loosely defined here for the nearshore ika-shibi and palu ahi fisheries as including vessels of a size that would allow them to be transported by trailer - *typically* not much longer than about 32 feet in length overall. But given some degree of variation in vessel size across the fleet, somewhat larger vessels may also be included in the analyses that inform this report. Vessels frequenting Cross Seamount and other offshore areas are typically longer. Hamilton and Huffman (1997:47) report mean length for palu ahi boats at about 20 feet, ika-shibi boats at 26 feet, and seamount vessels at about 40 feet.

where quality tuna products are highly valued in both economic (DBEDT 2002) and socio-cultural terms.

There is evidence that pursuit of BET and ʻahi around various types of fish aggregating devices (FADs) is increasingly important for purse seine operators in the eastern Pacific (Pelagic Fisheries Research Program 1999:4), and for participants in artisan fisheries elsewhere in the tropical Pacific (Hampton et al. 2004:3). Research of small-boat operations focusing on public and private FADs in the MHI may serve as a means for understanding the mechanics and motivations of FAD fishing and associated fishing pressure here and elsewhere in the Pacific.

But FAD-focused fishing is a relatively new phenomenon in Hawaiʻi waters, and private FAD (PFAD) fishing is yet newer. In fact, small-boat handline fisheries in Hawaiʻi have undergone a series of major changes prior to and following widespread use of FADs. The following pages describe and explain these historical changes, and discuss research findings following from our initial hypothesis that the trend of diminishing participation and production in the ika-shibi fishery relates to a widespread shift to use of PFADs.

1.3 Historical Overview

Ancient Beginnings. The deep sea fishery has long been a critically important aspect of life in the Hawaiian Islands. Indeed, use of handlines to capture various tuna species is the most enduring form of fishing in Central and Western Pacific. But it has undergone a series of dramatic changes over the course of its history. Use of various deep sea methods helped sustain Native Hawaiians for centuries on each of the main islands, and also on Nihoa Island (and less certainly on Necker Island), in the Northwest Hawaiian Islands (Kirch 1985:89-99). Pelagic fish were originally consumed directly by nucleated groups of residents on the windward sides of the islands. However, as new areas were explored and inhabited, society increased in complexity, and fish became important commodities for trade in and between ahupuaʻa[2] and motus (districts) (see Sahlins 1992).

Dramatic Macro-Social Change. As Hawaiian society was increasingly disrupted through contact and interaction with Europeans, so also were the social processes that sustained deep-sea fishing, such as the expert crafting of hooks (makau) and lines (aho). By the mid and late 19th century, Hawaiians were fishing the depths primarily for purposes of consumption by the extended family (ʻohana), or as a means for earning money in the context of an increasingly dominant cash economy. Interestingly, methods developed during ancient times persisted in certain places, and continue to be used around the Hawaiian Islands today.

[2] Ahupuaʻa were mountain-bounded valleys within which available resources from mauka (mountain) to makai (sea) were managed and utilized. This ancient system is being recognized as a potentially effective way to manage natural resources and their use by humans in the contemporary context.

Japanese Immigrants and the Ika-Shibi Fishery. Immigrants arriving from Japan around and after the turn of the 20th century adapted quickly to conditions in Hawai‘i and developed a productive commercial fleet and various venues for the distribution of seafood. Some *issei* (first generation immigrants) and *nissei* (second generation residents) developed means for catching tuna with handlines, using ika (squid) for bait, and a new era of productive local handline fishing was born. The War era interrupted the fishery; it began to rebound just after the peak of the construction boom in 1970, with participation peaking in the mid-1980's. The fishery began to wane in the late 1990s and has declined significantly in recent years.

The Cross Seamount and Weather Buoy Handline Fishery. Another distinct handline fishery was developed in the early 1970's when enterprising fishermen took advantage of aggregated populations of fish at Cross Seamount and weather buoys in the far offshore zone. The fishery was highly profitable for some operators, but participation and production also peaked in the late 1980s and early 1990s, and few handline operators now frequent these areas.

Handlines as Auxiliary Gear. Many small-boat operators who pursue pelagic fish today occasionally utilize handline gear in conjunction with or as an alternative to trolling gear. Such persons typically fish for a combination of purposes that involve commercial sale and/or consumption or sharing of the catch, and recreation. The extent of landings associated with such gear use is not well known in Hawai‘i.

Change, Decline, and Adaptation. Development and use of new fisheries and strategies have followed each period of historical decline in Hawai‘i-based handline fishing. Small-boat fishermen in Hawai‘i have been opportunistic and innovative over the course of time. Deep-sea bottom handlining and the ika-shibi style of fishing established by Japanese immigrants followed the decline of traditional Hawaiian fishing and associated social systems (though the ancient methods persist in some places and situations). World War II interrupted all manner of fishing in the Hawaiian Islands; commercial handline methods were reinstituted, especially for captains and crew on the Big Island. An increase in the use of PFADs appears to have followed the decline of the ika-shibi fishery, though recent evidence suggests that this form of fishing also is not always a stable source of income. The new short-longline fishery has replaced handline methods at Cross Seamount and other far offshore areas, and appears to be the latest innovation, though very few participants are involved.

1.4 Purpose and Objectives

The intent of this document is to describe the course of this history of development, decline, and new innovation among participants in Hawai‘i-based handline fisheries, and so provide the Council with background information needed to address recurring concerns about small-boat pelagic operations and the deployment and/or use of various handline methods, PFADs, and short-longlines in the federal waters around the MHI. Such information is being generated through fieldwork and archival research conducted by the contractor through ongoing PFRP MHI small-boat fisheries research.

Council information needs will be met through the current report by satisfying the following three basic objectives, as stated in the Contract Statement of Work:

> **(1)** Review historical trends of Hawai‘i's offshore small-boat pelagic handline fishery as it occurs around FADS, PFADs, buoys, seamounts via ika-shibi, palu ahi, short longlines, and other passive hook and line gear used by the different segments of the fishery. Catch volume, catch rates, catch composition, gears used, areas fished, number of participants and their distribution by island will also be included, for each fishery segment;
>
> **(2)** Examine the current status of each fishery segment, focusing on the same topics as above, especially the advent of short-longline fishing; and
>
> **(3)** Examine future management needs such as limited entry, closed areas, minimum sizes for bigeye tuna, and quotas.

1.5 Research Methods

As noted above, the research findings that inform this document derive from an ongoing PFRP project also focused on the course of development, contemporary status, and regulatory aspects of Hawai‘i's handline fisheries. A variety of research methods are being used to conduct that research: compilation and review of historical documents and data, social network sampling procedures to identify highly knowledgeable fishery participants, in-depth interviews with fishery participants and persons knowledgeable of historic aspects of the fisheries, and various observational methods typically used in the social sciences.

1.6 Organization of the Document

This document is organized in relation to the above objectives and per the chronological development of the Hawai‘i small-boat handline fishery. This introductory section has introduced the central elements of the issues, information needs, and related research.

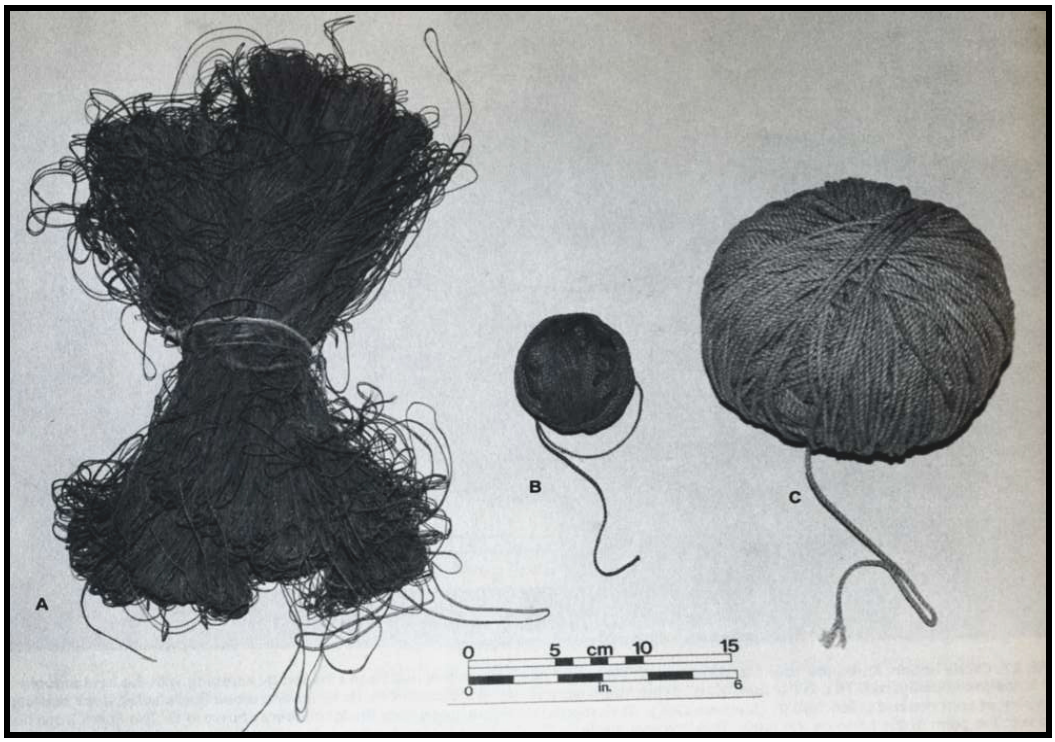
Section Two provides an historical overview of the development of handline fishing in the MHI, with associated description of the fisheries themselves. Emphasis is placed on recent historical trends. We can and do not ignore the deeper past, however, since some of the handline methods still in use in the Islands have evolved from gear and methods used by ancient Native Hawaiians, and from gear and methods introduced by immigrants from Okinawa and elsewhere in Japan around the turn of the nineteenth century. Moreover, analysis of the deeper past is critical in the Hawai‘i context, since it provides evidence that macro-social conditions have had a direct and recurring effect on the small-boat handline fisheries, with similar effects likely in the future.

Section Three describes more recent trends in the fisheries. The primary intent of the section is to present descriptive quantitative data in support of Objectives (1) and (2) above.

Finally, **Section Four** is more analytical in nature. Major trends and changes in the handline fisheries are revisited in brief, and we seek to explain these by elucidating the effects of various social, economic, and cultural factors affecting the fisheries from within and without. These factors have a bearing on the future of the fishery and we therefore examine them in the context of future management possibilities in keeping with Objective (3) above. References follow.

1.7 Prefatory Note on the Human Dimensions Focus of the Research and Report

We note at the outset that the content of the document is reflective of the background experience of the contractor in the conduct of social science in the context of marine fisheries. Thus, the descriptive emphasis is on human behavioral aspects of Hawai‘i small-boat handline fisheries and the observed or reported relationship of participants to the ocean environment. Similarly, its explanatory focus is on the social and economic forces that both enable and constrain the participants at sea and on land. As noted in the final pages of the document, however, we ultimately recognize the need for a better understanding of the migratory behavior and likely future abundance of ‘ahi and BET around the Hawaiian Islands. These are among an array of important variables of which understanding is essential for predicting future levels of participation and production among handline fishers in the region.



Ancient Olonā Net Cord & Fishing Line from Hawai‘i Ethnological Collections
(from Summers 1990:50)

2.0 A Brief History of Handline Fishing in Hawai‘i: ~300 A.D. to 1985

This section of the document describes the history of change in Hawai‘i handline fisheries. The material indicates the adaptive tendencies of social groups dependent on or involved in the harvest of marine resources, and the necessity that some critical mass of social and material capital be maintained to enable the ongoing conduct of a given fishery. The section also serves as a chronology for understanding the changes that have led to the contemporary status of the fishery. In doing so, it makes clear that while change is central to the nature of the culture and technology of fishing, fishing requires functional solutions for which certain traditions remain effective over time.

2.1 The Pre-Contact Era

Ancient Beginnings. The Polynesian mariners who originally explored the South and Central Pacific reached what came to be called the Hawaiian Islands in large part because they were skilled at deep-sea fishing. The acquisition of protein from fish and other marine resources was thus a familiar pursuit and an essential aspect of early subsistence and trade economies. Efficient mechanisms were developed to land, process, and distribute fish, including various pelagic species. As time passed and external influences were encountered, age-old processes were modified and existing knowledge was alternately valued, changed, or lost.

Given that Hawaiians held and transmitted knowledge through stories, accounts of the past often derive from this oral heritage. However, the archaeological record also provides an account. The following pages report on a combination of these sources, and later, the written accounts of explorers and observers and other archival materials.

There is considerable latitude in estimates for when Hawai‘i was first inhabited and the manner of that colonization. According to Kirch (1985:67-88), Cordy (2002), and others (e.g., Streck and Watanabe 1988), it may have occurred as early as 300 A.D. or even earlier. In any event, the early settlers undoubtedly possessed highly refined fishing skills and gear. Goto (1986:54) notes that the earliest evidence of fishing found to date in the Hawaiian Islands is at the Bellows site on O‘ahu, where one- and two-piece fishhooks are found in conjunction with fish bones and mollusk shell in a soil layer dated to as early as the 4th century (Tuggle et al. 1978).

A site at Hālawa Valley on Moloka‘i is thought to have been inhabited by fishing peoples from between the fifth and sixth centuries until about the 13th century (Kirch 1974). There is also abundant evidence of sustained fishing endeavors at Ka Lae (literally "the Point," meaning South Point) on Hawai‘i. Deep water and collision of currents there made and continue to make this a highly productive, if treacherous, fishing locale. Kirch (1985) suggests that some of the archaeological assemblages at Ka Lae may date to the same period as the Bellows site. A wide range of fishing activities occurred here in antiquity, as evinced by the presence of one- and two-piece fishhooks, aku lure shanks and points, crescent points (used for large wooden hooks for sharks and pelagics), and various sinkers (Goto 1986:56).

Fishing and Fish Central to Life and Social Organization. Ancient Hawaiians distinguished by name the waters along the coast (lihi kai), the place before the waters become very dark (kai lū he‘e), the fishing grounds (various ko‘a), and the dark blue sea (kai pōpolohua mea a Kāne), among many others (Kamakau 1976:11-12). The sea was further distinguished in terms of visual characteristics, the resources that might be pursued there, or the activities for which a certain zone was used. Words for waves and sea states captured the finest distinctions. As Kamakau asserts in *The Works of the People of Old* (p. 60), there were as many types of fishing as fish, and Hawaiians were reportedly adept at all of them: "As fishing was done by the ka po‘e kahiki (assembly of ancients) so it is done now, it is impossible to improve on their methods."

Life for ancient Hawaiians involved deep association with resources of land and sea. Political boundaries and subsistence and economic processes were based on the bounds of the rugged landscape and ocean. While the earliest settlers may have been organized in a socially egalitarian manner, over time, ali‘i (royal chiefs) came to lead a hierarchy of royalty and citizens. Residents specialized in various economic and food production activities required for subsistence and effective interaction with other Hawaiians inhabiting other ahupua‘a and islands. Among the highest status individuals were the konohikis (managers), some of whom cared for shoreline and ocean resources and activities, and the lawai‘a haku (master fishermen).

Fishing and gathering shellfish (e.g., ‘opihi or *Cellana*), crabs, urchins, small fish and limu (seaweeds) along the shoreline were daily activities of ‘ohana in any given ahupua‘a. The inshore zone was also productive and much fishing activity took place there with hukilau (seine) nets, spears, and pole and line. Fishponds provided a consistent source of protein after the fourteenth century, as is well documented in the literature (e.g., Apple et al. 1975, Kirch 1985). Sea foods were complemented with taro, sweet potatoes, and other terrestrial resources as gathered or produced by persons in the upland portion of the ahupua‘a. Fish bones are found in upland as well as coastal areas (Goto 1986:452).

Archaeological analysis of fish bones found at camp and village sites in ahupua‘a across the Islands suggests that offshore food resources were generally pursued with less frequency than those in the inshore and shoreline zones (Kirch 1985:208). Goto concurs (1986:448), stating that "it seems that Hawaiians generally preferred using inshore resources, where and when they were available, to using offshore resources." This may be due to relatively fewer fish at depth, increased difficulty and risk of fishing in deep water, seasonality of capture, a gap in the archaeological record, or a combination of these factors.

The Importance of Pelagic Species. But deep water fishing did indeed occur. Kirch differentiates a benthic zone of exploitation between 30 and 350 meters in depth and a pelagic or deep-sea zone in deeper water. The Hawaiians pursued bottom fish such as ulua and ‘ōpakapaka in the former, and the range of pelagic species in the latter, with a particular focus on aku. Handline fishing occurred in both zones (p. 208).

Goto (1986:444) suggests that avidity of pursuit of pelagics in the offshore waters varied across the Islands, depending on practical considerations, such as the tendency of seasonal sea states to restrict availability of inshore resources and ease of access to offshore waters. He notes, for instance, differences in apparent avidity of pursuit of pelagics between the Waikīkī and Wai‘anae areas on

O‘ahu. Reef fish species are abundant in the archaeological record at Waikīkī area sites, where shoreline-fishing activities are possible almost year round. Benthic and pelagic species are more common at Wai‘anae sites, where there is little fringe reef and deep waters offer the main possibilities for fishing.

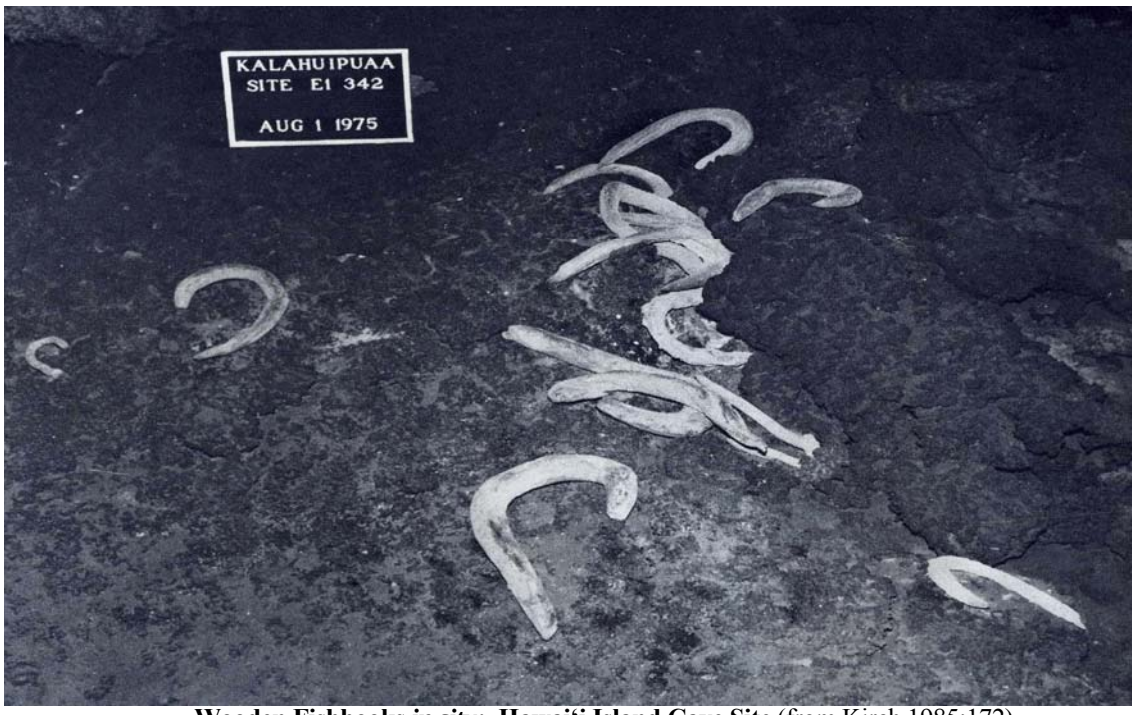
The idea that inshore areas were favored areas for fishing may also have a political explanation. For instance, Scobie cites Campbell (1819) to assert that ahupua‘a boundaries were highly contested inside the point at which breakers would occur. If an ahupua‘a did not have a protected inshore zone, persons living there would have to go to the deep sea to fish rather than share the inshore resources of another ahupua‘a.

Pelagic Methods and Gear. Inshore and benthic zone fish were pursued with a variety of gear, including various nets, handlines, and poles. Pelagic species were caught with palu ahi methods, lure, and live bait trolling with handlines. Palu ahi methods include the drop stone technique a truly ancient method. Bait material folded into a carefully tied bag is attached to a handline weighted with a flat-sided stone. When pulled, a specially tied knot releases the palu, and hopefully the aggression of the fish which may bite the baited hook.

Emory et al. (1959, 1969), Sinoto (1962), Newman (1970) and others have analyzed fish hooks in their archaeological and functional contexts. Goto (1986) provides analysis of the topic with reference to prehistoric ecological and social conditions in Hawai‘i. Stylistic variety abounds in the archaeological record, but most hooks appear to have been sufficiently functional for trade to other areas in the Islands. Different functional solutions existed to attain similar economic goals for the fisher (Goto 1986:477), thus hooks constructed of singular materials or as composites, including various mammalian bones, pearl, cowry shell, wood, and ivory were employed.

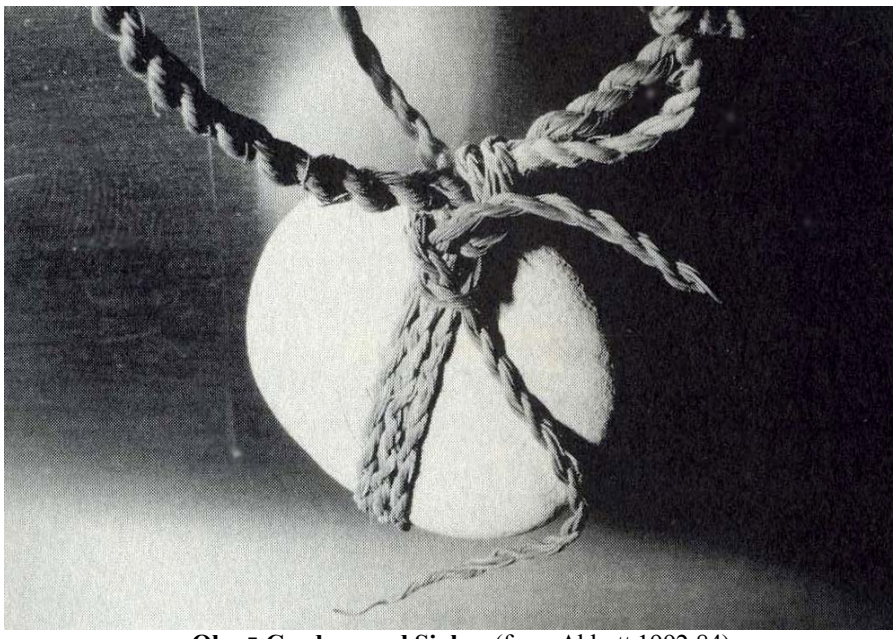
Of interest to pelagic fishing by handline methods, the dimensions and shape of certain hooks and their occurrence in the archaeological record with pelagic fish bones indicates some specialization of fishing for deep-sea species. Large hooks made of wood and pointed with bone apparently were used for sharks and large pelagic fish.

Two-Piece Bone Hook with Olonā Leader & Gum-treated Lashings from Vancouver Voyage of 1792
(from Summers 1990:53)



Wooden Fishhooks *in situ*: Hawai'i Island Cave Site (from Kirch 1985:172)

Abbott's work with plant materials and her review of historical sources relating to use of plants reveals that olonā (*Touchardia latifolia*) was a highly functional and favored material for fishing line (1992:59). The relationship between aho makers and fishermen was an important form of social interaction in the ahupua'a system, as line-making was very labor intensive and fishing was highly specialized (Kamakau 1976:76).



Olonā Cordage and Sinker (from Abbott 1992:84)

With respect to *method*, Goto reviews (p. 155) Kahaulelio's description of the ancient aku fishery. Nets were sometimes used for aku, but trolling with lures via handlines was favored. Note that poles were used in some fisheries, but in all cases lines were retrieved by hand. Other carnivorous pelagic fish such as ʻahi, billfish, ono, and mahimahi could be caught incidentally while pursuing aku, but the relative paucity of their remains in the archaeological record and the predominance of aku bones suggests that aku was the principal target:

> Kahaulelio (1902) mentioned that fishermen would set out to catch aku only when the sea was calm and smooth enough to see schools of nehu and other fishes. These small fishes are eaten by aku and therefore they are the indicators of the presence of a school of aku around them. The location of bird flocks was also a good indicator of aku . . (Scobie 1949:96-97).

Fishing Vessels. Efficient hooks and cordage were critical to fishermen in ancient Hawaiʻi, but the fishermen could not reach the deep-sea fishing grounds without a vessel. This was the outrigger canoe made from the strong, durable and buoyant koa (*Acacia koa*). Holmes (1993:109) cites Hawaii archaeologist Robert Hommons (personal communication) who estimates there were as many 12,000 canoes in the Islands at one point in history, and that in addition to normal travel, most were used for one kind of fishing or another. Kahaulelio (1902:72) described different types of canoes used for different kinds of fishing. Those used for aku were called hoʻomo, and those that carried numerous paddles were called panipani. Holmes cites Corney (1896) who describes the process of catching aku from canoe with barbless hooks (similar to the modern dangler fishery):

> A canoe that pulls seven paddles goes to sea with two good fishermen (besides the paddlers), each with a stout bamboo, about 20 feet long, and a strong line made from the oorana [olonā] . . the line is about three-quarters of the length of the pole, and has a pearl hook made fast to it. The canoe is then paddled very swiftly with the hooks touching the surface of the water, one at each side, the fisherman holding the rod steady against their thigh, and the lower end resting on the bottom of the canoe; they steady the pole with one hand, and, with the other keep throwing water on the hook, and when their prey gets hooked, by lifting he pole upright the fish swings in, and is caught under the left arm and secured. In this manner they will take 40 to 50 in the course of a few hours.

Sail power was used when possible, but in calm areas the power of paddlers was needed. Sometimes special double canoes with malau (baitwells) would be used, and nehu or ʻiao would be added to the water to simulate a feeding frenzy. Kahaulelio notes that when malau canoes were being used, single canoes could not come close or would suffer the penalty of gear confiscation. The author said that "his father and many others had given up on malau fishing around 1848, since it involved too much work" (Holmes 1993:113), perhaps suggestive that the social system was faltering and could no longer provide the means to conduct communal fishing operations as in the past.

Turn-of-the-Century Fishing Canoes (from Holmes 1996:111)

Kamakau (1976:73) provides a similar description, but also discusses the use of aku and nehu or ʻahi lures trolled behind canoes in the manner of modern boats. He notes that this kind of aku fishing was enjoyed by chiefs and rulers (who probably fished more than paddled), but also that ʻahi and aku had diminished by the time of the passing of King Kamehameha I (p. 71). The author describes the red cowry aku trolling lure (p. 75):

> At the base of the pā there is a ridge, and through this was a hole drilled as a foundation for the cord of the snood, kaʻā. The cord ran from the hole to the edge of the hook that was fastened to the tip of the shank lure, pā. The hook was made of human or dog bone, filed smooth and curved nicely. Pig bristles crossed the base of the hook where it joined onto the tip of the shank so that the hook would not fall over. The bristles ruffled the water behind the lure as those on the canoe paddled in unison, and the aku mistook the lure for an ʻiao or other small fish and crowded around to seize the pā hī aku.

Increasing Social Complexity. Abbott (1999) asserts that because relatively few persons lived in any one ahupuaʻa in very ancient times, there was probably little strain on food resources and so deep sea fishermen might go fishing as little as once a week. One big catch could provide enough for the community for a sustained period. Goto (1986:471) suggests that in the early years of settlement, production, consumption and distribution of food and other goods was probably based on kin relations, but as aliʻi set themselves apart from the rest of the population, surplus economies developed. The author asserts that aliʻi probably began to require increased harvest of pelagic fishes as part of a developing socioeconomic system that highly valued those species. This situation and the challenges of deep-sea fishing in general, explain accounts that pelagic fishing was a highly

organized venture with a select guild of experts whose knowledge of the deep-sea and its resources would ensure a high likelihood of capture. Oliver (2002:92) discusses this as a common aspect of Polynesian societies in general.

The lawaiʻa haku was differentiated from lawaiʻa ʻiliʻili (assistant fisherman), indicative of a hierarchy of skill, experience, and related status (see Kamakau 1976:74). Fishing knowledge was transmitted to chosen pupils, often relatives or friends. The expert fisherman was accorded high status in ancient Hawaiian society (Titcomb 1972:5). He knew best how to judge weather, the presence of fish, navigate, and manage the affairs of fellow fishermen, for deep-sea fishing was a cooperative enterprise. Communication was necessary between fishing canoes so as to organize the fishing effort harmoniously. Titcomb (1972:5) states that this was done with the help of bamboo poles or waving of arms, under the direction of the lawaiʻa haku. According to Beckley (1883), fishing canoes would sometimes travel great distances to fish, and were forced to use distant mountain tops to determine their position, since the usual nearshore landmarks were out of sight.

Women were not part of the actual act of deep-sea fishing, but did participate in certain processing and preparation phases. They also engaged in shoreline fishing.

Offerings and Regulations. Deep sea travelers appear to have assumed high status among ancient Hawaiians. The dangers and mysteries of the depths invoked reverence for such fishermen who, in turn, revered and sought the assistance of the gods. Abbott (1999) relates her understanding that much prayer and conciliation to Kāne and other gods of the deep sea surrounded the deep-sea fishing trip. Titcomb notes that the lawaiʻa haku possessed functional knowledge of the sea and fishing, but was also adept at interpreting dreams and omens, and maintained a good relationship with the gods (1972:5-6). Kahaulelio states that some fishermen observed strict kapus before entering their canoes to fish. Fishing, and especially fishing in the deep sea for aku, appears to have involved both a spiritual dimension and ongoing communal involvement. Thus, a successful trip led to an offering of appreciation to the gods and proper distribution of the resource among those involved. For instance, Kamakau wrote:

> He (the master fisherman) cast down the fish for the male ʻaumakua (family god) and for the female ʻaumakua, and then returned to give the fish to the canoe men, to those who had done the chumming, and to those who had done the actual fishing. A portion went to the owner of the fine-mesh nets, nae puhi, that had been used to catch bait and to those who had driven the bait fish into the nets. The rest was for the head fisherman or for the land holder, if it had been the land holder's expedition (1976:4).

Goto argues that because aku bones are sometimes found in association with inland religious sites, the fish had assumed value beyond that of its caloric worth and had become part of a system of ritual offerings. He also suggests that the seasonality of the capture of this fish contributed to the social order of ancient Hawaiians, a situation that can also be viewed as an early system of resource conservation. Kapus on the taking of fish had the effect of conservation, and though it remains unclear whether these were instituted primarily for that purpose, it is reasonable to assume that they were. The konohiki was undoubtedly a keen observer said to know the best manner of mālama (care) for the ocean resources of the ahupuaʻa.

It may be that the ancients sometimes experienced a shortage of fish and learned the value of conservation the hard way, as might be predicted by Newmann (1970:58) who notes that "not only is aku unpredictable in fishing, it is a seasonal resource, for aku migrations [large specimens] arrive primarily in the summer months in Hawai‘i." As Titcomb notes (1972:14), "the nature of the fish population doubtless necessitated special [seasonal] tabus [sic] in some areas."

The beginning of the aku season corresponded with the end of the annual Makahiki festival. Thus, fishing for aku was kapu from October to January, during which time ‘ōpelu was gathered. Pukui (as cited in Titcomb 1972:14) states that in Ka‘ū "there was never a time when all fishing was tabu [sic] . . when inshore fishing [viz. ‘ōpelu] was tabu, deep-sea fishing [viz., aku] was permitted and vice-versa."

‘Ahi was also subject to regulation. Iverson (1990:36) cites Sahlins (1989) to note that ‘ahi fishing "appears to have been an integral part of a sacred chiefly rite associated with the Makahiki . . ritual ‘ahi fishing would have begun around the middle of December and continued until the end of the month when a five day prohibition on fishing began." Hosaka (1944:124) states that the Hawaiians gave the fish the name ‘*ahi* which means fire, "because it pulled the line over the side of the outrigger canoe so fast that the wood smoked as a result of the friction."

Religious Rites and the Value of Aku. Various pelagic species were caught and consumed in ancient Hawai‘i, but aku was a particularly important food. Aku was eaten fresh and/or salted for preservation and assumed socioeconomic importance as a trade item, and as an item desired by the ali‘i (Goto 1986:369) for purposes that are not entirely evident but which appear to relate to symbolic-religious phenomena. From a more practical perspective, Goto reports that the fish has 129 calories per edible part, totaling 839 calories per kilo gross weight, and has the highest percentage of protein of fishes then available to Hawaiians at 25.8 grams per 100 edible grams (ibid., pp. 119-120). This is more than pig, which has 17.5 grams of protein per 100 edible grams. Aku is also an excellent source of vitamin E, and its eyes and organs are rich in minerals; there was a strong custom of consuming these (Titcomb 1953). Seafood and aku especially, was not just supplementary to the Hawaiian diet but an essential component balanced by tuber crops, limu, and other foods (Goto 1986:126). This, combined with its seasonal abundance, may partly explain its apparent religious importance and ubiquity of specialized pursuit by Native Hawaiians over the course of time and across the Islands.

2.2 Continuation and Change Approaching and Entering the 20th Century

Loss of the Ahupua'a System. The forces that led to rapid change in Hawai‘i's long-established and evolving system of social relations were based on Euro-centric ideas about the morality and lifestyle of ancient Hawaiians and imperialistic designs on the land and its resources.

A more centralized and less place-specific system of kapus was enacted when the islands were united under Kamehameha and while under the rule of his successors who, in turn, were influenced by the haoles (foreigners). The ali‘i and konohiki began to possess less control over the land and water than when ahupua‘a, moku (districts), and islands were relatively more autonomous (see Titcomb 1972:15-17). Obviously, the changes in land division that were to come had a profoundly negative impact on the ahupua‘a.

Whatever faults it might have had, rules associated with the Hawaiian ahupua‘a system tended to both conserve and encourage the use of natural resources. But the gradual infiltration of foreign viruses, combined with aggressive exploitation of resources, expropriation of land, and institution of a cash economy ultimately devastated the Native Hawaiian population and dismantled the social systems that enabled functioning ahupua‘a around the Islands. There is also some indication that the changes affected fishery resources: certain fish populations were in bad shape by the turn of the century (Scobie 1948, Titcomb 1972), a situation the authors blame on the loss of conservation practices championed and enforced by the konohiki[3] and ahupua‘a system.

The Persistence of Native Hawaiians. However, Hawaiians persisted in fishing endeavors and continued to interact with the moana (ocean) for purposes of survival and recreation. Many were pushed into plantation work or marginalized in some other fashion, but the ocean remained an escape and a source of food. Access and opportunity were diminished by oppressive forces and hegemony, but never entirely lost.

But if new materials that were introduced from elsewhere offered practical value to the fisherman, they might ultimately be used. Western materials arrived with incoming ship deliveries and fishhooks were sometimes made from metal wire and nails.[4] As Scobie notes (p. 289) "many of the changes were substitutions of materials in old forms . . spears were tipped with iron, metal hooks were fastened into the cowrie shell by molten lead, floats might be of cork and sinkers of iron or lead . . new methods came with new fishermen."

[3] Konohiki fishing rights remain an important topic today. Provisions in law allow for the kuleana of ahupua‘a resources extending into the ocean as far as one mile to be maintained by Native Hawaiians. In many places, the one-mile boundary includes waters frequented by pelagic species such as the nearshore ledge along the Wai‘anae Coast of O‘ahu. That coast has three areas where konohiki rights were established: Keawa‘ula fishery between Keana and Kahanahāiki ahupua‘a, ‘Ōhikilolo fishery between Mākua and Kea‘au ahupua‘a, and Makaha fishery between Kea‘au and Wai‘anae ahupua‘a. Kosaki (1954) and Meller (1985) review the history and nature of the konohiki provisions.

[4] For example, a nail that had been fashioned into a fishhook was found during a recent exploratory investigation at Kaniakapupu near Nu‘uanu Pali on O‘ahu. This was the summer residence of King Kamehameha III during the 1850s.

Hawaiians continued to fish during and after the Great Mahele,[5] and as the new century approached, the old methods were sufficient to contribute significant amounts of seafood to the diets of growing populations of Japanese, Chinese, and Filipino plantation workers and others living in Hawai‘i. Schug (2001) cites Cobb (1905) to note that the first regular market for the sale of fish was established in Honolulu in 1851, and that Native Hawaiian fishing operations were the principal source of seafood. Scobie (1948:288) examines U.S. Commission of Fish and Fisheries statistics to note that of the 2,345 persons who sold fish in Hawai‘i in 1901, 1,571 were Hawaiians, 485 were Japanese, and 238 were Chinese.

These figures apparently shifted rapidly in the succeeding two decades, as some immigrant plantation workers, especially those hailing from Japan, began to fish and compete with those Hawaiian canoe fishermen who sold some of their catch. Some came from Asia with specific intentions to fish on a commercial basis (Schug 2001:19).

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Although enterprising immigrants gradually superseded small-scale Native Hawaiian fishing operations, these never disappeared altogether. While the first vertical crankshaft outboard motors were invented in 1907 by Ole Evinrude, mass produced in 1910, thus making them available for use on small boats in Hawai‘i, most Hawaiian fishermen probably did not desire them (Abbott 1999) and/or could not afford them. Even at this late date, it is clear most Hawaiians preferred the old ways, the silence of the paddled canoe, the feeding of the ko‘a. Scobie (1948:289) notes similar resistance in the previous generation, stating that "the Hawaiians still preferred the fishhooks they made themselves rather than those that could be bought."

But the social structure of the ahupua‘a that had enabled the physical manifestation of traditional knowledge in the form of bone hooks and cordage line was largely dismantled. Thus, olonā was rarely used unless it had been saved from days gone by. Abbott (ibid.) recalled her childhood days in the 1920s and 30s, and noted that her uncle possessed some cordage made from coconut fiber, but mainly used butcher string for his fishing line.

There are gaps in the written and statistical historical record which preclude a continuing account of Native Hawaiian handline fisheries in the years following the rise of the Japanese aku fleet and predominance of the sampan. It seems most authors living through that period (e.g., Scobie 1948, Handy and Pukui 1972 [1950], Titcomb 1972 [1952]) were focused on recalling the distant past rather than recording the events and status of the present, which itself would eventually become of interest to students of fishing history in Hawai‘i. It should be noted, however, that many accounts derive at least partly from the memory of informants then living, suggesting that the ancient traditions lingered on into the twentieth century.

Despite the loss of the ahupua‘a system, there undoubtedly was some continuity in use of outrigger canoes, and old style lures, lines, and methods, if practiced only sporadically and in isolated areas. But data is sparse. Shomura (1987:2) notes, for instance, that data descriptive of fish landings provide no valid clues to the scope of the subsistence or recreational small-vessel fisheries, since only commercial landings were reported between 1900 and 1986.

[5] That is, the reorganization of land holdings that occurred between 1848 and 1850 when the institution of fee simple rights allowed haoles to purchase land, dispossessing many thousands of Hawaiians from their ancestral ahupua‘a.

Unfortunately, most Native Hawaiian persons who would be able to speak empirically of the pre-World War era have passed. A number of informants have referred to their deceased parents or grandparents having been avid fishermen during that period, but much knowledge was lost with their passing. Maly and Maly's (2003) oral histories of fishing experts in the Hawaiian Islands has filled in gaps of understanding that would have otherwise remained obscured by time. Their work makes clear that Native Hawaiian fishing traditions and ecological knowledge continued to evolve across the Islands, even amidst the hegemonic tendencies and capitalist practices of the haoles (foreigners). The work includes a very detailed historical account of indigenous fishing practices - so detailed, in fact, that there may be some risk of contemporary fishers re-adopting the hyper-efficient methods of old without the framework of conservation and kapus formerly associated with their use.

It is clear that modern materials eventually replaced the old even in the more remote areas around the Islands. Holmes (1993:114) notes that by 1940, the waʻa pā (three board canoe) had virtually replaced the traditional dugout koa outrigger along the South Kona Coast in villages such as Keahoʻu, Hoʻokena and Miloliʻi. The demise of the once expansive koa groves had led to reliance on other materials. The three-board canoe resembled the ancient outrigger, even in the manner of its lashings, but also utilized non-traditional features such as steel and, later, aluminum pipe for ʻiako (booms), metal chain plates and screws, and outboard engines. The vessel remains a commonly used craft at Hoʻokena and Puʻuhonua o Hōnaunau on Hawaiʻi, and palu ahi methods also remain in common use here and elsewhere in Hawaiʻi.

2.3 Japanese Immigrants and the Advent of Ika-Shibi Fishing in Hawaiʻi

Introductions. Residents of Japanese ancestry who came to Hawaiʻi to work in the burgeoning sugar industry (United Japanese Society of Hawaii 1971) increasingly took to the sea to fish in first years of the twentieth century. They too were avid deep-sea fishermen, having refined their own methods over the eons along other Pacific shores. But theirs was a more commercially-oriented endeavor than generally practiced by the Native Hawaiians, and the introduction of gasoline and, later, diesel-powered engines were adapted for use on sampans. This endeavor intensified the commercial possibilities of deep-sea fishing in Hawaiʻi. It should be noted that by Gorokichi Nakasuji, who first brought the first sampan to Hawaiʻi in 1899, was likely backed by investors (Tomita 1940:20).

Konishi (1930) takes a patronizing view of the situation, championing the commercial success of the sampan and labeling the Hawaiian manner of fishing as "primitive."[6] But he also notes that the Hawaiians resented Nakasuji and the technology and efficiency he introduced, and that they threatened to kill him on the high seas. However, they did not, and an era of highly productive commercial fishing was initiated in Hawaiʻi. Schug (2001:18) reports that Cobb's early data makes clear Japanese immigrants were leading deep-sea handline operations for bottom species as early as 1900, and that predominance in the commercial tuna fisheries soon followed.

[6] This kind of perspective was common at the time. Indeed, most accounts of Hawaiian life, European accounts especially, reflect ethnocentric perspectives that failed to recognize the social, economic and human ecological complexity and efficiency that was actually characteristic of ancient Hawaiian life.

Sampans Moored in Honolulu, Early 1900s (Courtesy of Japanese Cultural Society)

Commercial fishing on Hawai‘i Island was enabled in part by the opening of Suisan Kabushiki Kaisha Ltd. in 1907, a company of Waiākea fishermen and buyers that later became an auction house (and recently a private distributor once again). Commercial operations were advanced on O‘ahu when the F.W. Macfarlane tuna cannery opened in 1917, later becoming Hawaiian Tuna Packers. As increasing numbers of Japanese immigrants went to work at sea, sampans provided most of the product. The nearshore aku pole and line fishery (see Boggs and Kikkawa 1993), and offshore longline fishery, nascent in 1917, were the primary source of seafood in the region during this general period (Schug 2001:19). The aku fishery continued to be highly productive for many years, as facilitated by the Hawaiian Tuna Packers cannery until its closure in 1984 (Pooley 1993).

Hawai‘i's ika-shibi fishery was initiated not long after. At some point during the 1920s, Okinawan immigrants fishing for ika (squid) with handlines at night in the waters offshore Hilo, grew tired of losing their bait and shifted their focus to the apparent predator - shibi (yellowfin tuna). They refined their methods over time, and a new handline fishery was born in the Islands. Yuen (1979:7), then examining the fishery for National Marine Fisheries Service (NMFS) Honolulu Laboratory, describes his reckoning of the origins of the ika-shibi fishery in Hawai‘i as follows:

> Immigrants from Okinawa are believed to have started the fishery. They went out at night to catch squid as they had done in Okinawa. Occasionally something large would strike and snap their lines. Upon checking with the native Hawaiians they learned that the strikes were probably made by large tuna. They subsequently equipped themselves . . to catch the tuna.

Such gear would ultimately include handlines, squid-baited hooks, and some source of light to help attract biomass, squid, and shibi. The scenario described by Yuen is quite probable. Fishing was

central to life in Okinawa Prefecture. Net fishing was common, but traditional single hook handline methods similar to Hawaiian palu ahi and drop stone were also used there. Moreover, people from the Ryuku Islands in Okinawa Prefecture were deeply involved in ika fishing, and use of torches for night-time fishing was common. The Suisan market would provide a venue for distribution of fish. Finally, as noted below, there was ongoing interaction between Okinawa and fishing immigrants. The elements were in place for development of a new fishery targeting tuna in the deep waters of the Big Island.

There is little or no documentation about the experiments conducted by the ika-shibi originators, nor extensive written evidence of their activities over the subsequent years prior to World War II. We do, however, know that there were problems just prior to World War II, when immigrant Okinawans were seen as potential traitors, subsequent to attending fishing schools in Japan in order to increase their skills in Hawai‘i (Schug 2001:28). The photograph below depicts members of one such interaction, a training group sent to Hawai‘i from Okinawa (though it is not clear who was training whom). The banner in front of the fishermen reads: "Congratulations on the ambitious enterprise of overseas trip. Fisherman Trainee Group. Ryukyu Government Labor Department."

Fisheries Training Group from Okinawa in Hawaii Prior to WWII (courtesy Japanese Cultural Center)

Yuen (1979:7) further indicates that the earliest ika-shibi vessels were sail-powered. But the fishery became quite popular during the 1930s, with as many as 40 motorized vessels involved. Of note, there appear to have been problems associated with treatment of the fish at sea during this early period. These would continue to affect the fleet through most of its history:

> . . . because the boats were too small to have the fish on board and did not carry ice to chill the catch, these tunas were towed alongside the boat on the way to port. Consequently, the ika-shibi had a reputation for having poor quality and could not compete on the market with tuna caught on longlines (Yuen 1979:7).

World War II. Regrettably, local Japanese fishermen were denied access to the ocean during World War II, and many boats were confiscated. Schug (2001:29) reports that at least six such fishermen were killed at sea by U.S. soldiers who believed they had colluded with enemy forces during the attack of Pearl Harbor.

Although there is some indication that fish populations that ostensibly had suffered prior to World War II rebounded as restrictions on fishing were emplaced for security reasons (Markrich 1994), Nakayama (1987:44) asserts that many fishermen did not return to the fishery after the War. Representatives of the Japanese Cultural Center of Hawai‘i (1999) suggest that fishermen actually prospered during the immediate post-war years and that these were peak period years for ship building due to a scarcity of vessels; by 1950, many found the seafood market too highly competitive and began to enter other vocations.

Subsistence and small-boat commercial fishing from canoes and sampans continued- to some extent- across the Islands after World War II. Since large sampans required considerable investment to operate, many were reinstated primarily for commercial purposes. However, because some such vessels were reportedly as small as 18 feet (Uchiyama 1999), logic suggests that these could be used to gather food for the local Japanese ‘ohana with relatively little operating cost.

2.4 Hawai‘i Small-Boat Pelagic Handline Fisheries: Post-WWII to Mid-1980s

Technological Change and Population Growth. Wooden sampans continued to be used after the war, but small-boat hull designs popular on the Continent were also used, having benefited from wartime advances in marine technology. For persons who could afford them, small cabin and open console vessels became available, powered at first by inboard diesels and later by the more affordable, increasingly efficient and reliable outboards, such as the modified Johnson Seahorse.

Yuen (1979:7) reports that when the ika-shibi fishery was resumed after the war, three or four captains equipped their boats with ice boxes and resumed operations. These operators provided tuna to local buyers and markets available to the roughly 60,000 persons comprising the total population of the Big Island during that period.

By the 1950s, small trolling operations began to use equipment available to charter boats, which had become popular after the War, servicing middle class patrons at harbors such as Kewalo (Markrich 1994:2-2). Rizzuto (1977:232) states that "by 1957 the Kona [charter] fleet had grown to seven vessels" and that "the simultaneous development of [relatively] reliable outboard motors meant that the offshore grounds became the playground of marauding bands of 'mosquitoes' like the Kona Mauka Trollers and Kawaihae Trolling Club, ready to put their stingers into any big fish willing to fight."

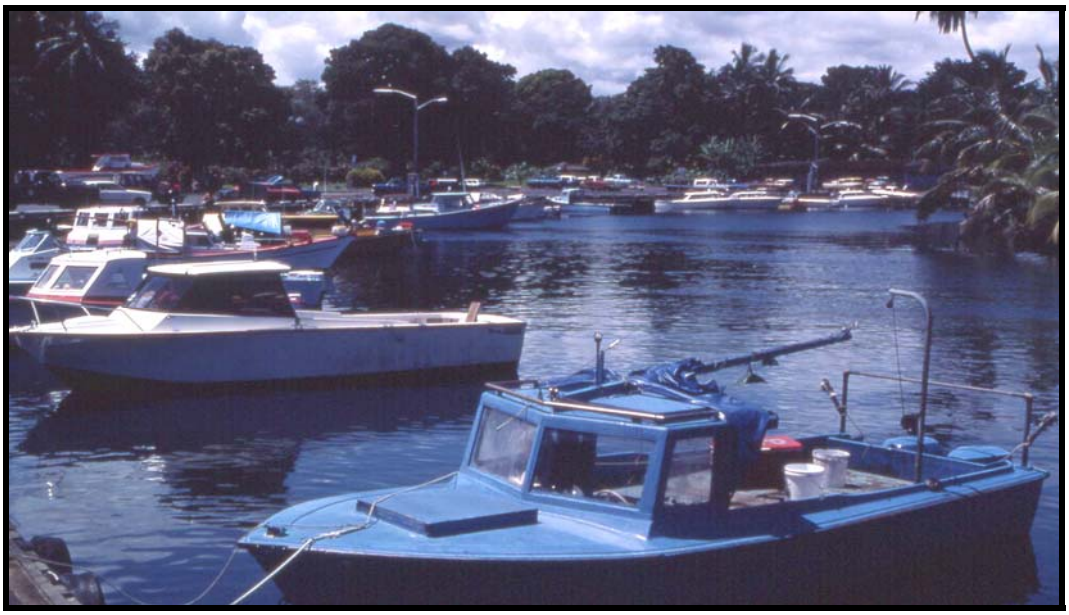
The small boat fleet did grow dramatically with the introduction of fiberglass technology and the refinement of inboard and outboard engines in the late 1950s and 60s. A field survey conducted by Lubin, McGaughy and Associates in 1961 revealed that nearly 5,300 small boats putatively used for recreational purposes including fishing were active in Hawai‘i. There were also 83 charter vessels,

532 commercial fishing boats and 24 workboats active in offshore and inshore waters. A study conducted by Hawai‘i's Fish and Game Division between 1958 and 1961 confirms the increasing popularity of small-boat fishing at the time, determining that an average of 55,000 sport fishing trips were made yearly along O‘ahu's coastline during that period (Hoffman and Yamauchi 1972:5).

Johnson's introduction of the loop-charged 55 horsepower in 1968 revolutionized the outboard by providing increased power, efficiency, and especially reliability for the small vessel fisherman at sea. Marine communications electronics also developed and became more affordable. From a macro-economic perspective, this was also a period of booming growth in parts of O‘ahu, with construction activity peaking at 8.2 percent of the Gross State Product in 1970 (Department of Business, Economic Develoment & Tourism 2000). The sugar and pineapple industries still employed many workers at that time.

The luxuries of increased range and safety thus became accessible to the average fishing enthusiast in Hawai‘i during a time when many in the working class had good jobs and could afford to buy and operate a small boat. Law (n.d.) reports that some 7,689 "pleasure boats" were registered and documented by 1970, and although the number of these boats regularly engaged in fishing is unknown, Research Associates (1977) estimated that as many as 100,000 small-boat trips were taken in pursuit of pelagic species in 1976.

This period of general growth of the economy and small-boat fleet coincided with increased demand for and enhanced market value of tuna in Hawai‘i. One of the early operators then living on the Big Island notes that only four ika-shibi boats were active in the area during the early 1970s (Kalthoff 2003). But enhanced transshipment possibilities and incentives enabled Hilo-based buyers to market sashimi-grade products on O‘ahu and in foreign markets (Yuen 1979:7). Demand related in part to population growth on O‘ahu, which had grown from around 150,000 at the turn of the century to about 763,000 persons at the time of the 1980 Census. At some point early in the 1970s, the ika-shibi fishery began to grow.



Vessels Typical of the Era at Wailua Ramp, Late 1970s (Courtesy of Walter Ikehara)

The Ika-Shibi Fishery: 1973-1985. Yuen's (1979) discussion of the growing popularity of the ika-shibi fishery on Hawai'i Island during the mid-1970s is in part a statement of encouragement for the further development of the technique elsewhere in Hawai'i. This is clearly suggestive of the success being enjoyed by the fleet of 30 captains/boats active in the Hilo-based fishery by 1976. This number reportedly rose to 40 in 1977, ten of whom were operating from the Kona side of the island (p. 8). As noted in Table 1 below, based on records provided by Suisan for landings between 1973 and 1975, the author reports extensive variability in the amount of both bigeye and 'ahi brought in for sale during the period. The combined reported ex-vessel value of all tunas was $131,000 in 1973 and $328,000 in 1975.

Table 2-1 Reported Ika-shibi Landings: 1973-1975 (reported weights in rounded pounds)

Species	Year		
	1973	**1974**	**1975**
Bigeye	144,200	265,000	139,000
'Ahi	51,300	50,500	166,400
Tombo	800	400	35,500

Source: Yuen (1976:10)

As regards reported size of BET, in 1973 almost 88 percent were reported to be under 100 pounds. Abundance of larger fish and/or efficiency of methods appear to have improved over the subsequent two years, as about 78 percent were under 100 pounds in 1974 and about 72 percent in 1975. Median weights ranged from about 69 to 73 pound during the reporting period. Reported median weights for 'ahi were highly variable: 48 pounds in 1973, 180 pounds in 1974, and 124 pounds in 1975. Yuen reports that September and October were peak months for landing both BET and 'ahi during the period, but that the distribution of BET landings was more evenly distributed.

There is no mention of challenges associated with proper identification of bigeye or 'ahi juveniles by handlers at Suisan. Once again, however, Yuen makes mention of tuna burn problems, this time with indication of related tension at the marketplace (p. 12):

> The burnt condition cannot be detected until the fish is dressed and the flesh exposed. Because tuna are transported whole to preserve their quality, the burnt condition is not detected until after transportation expenses have been incurred. The problem is compounded when the seller who must accept the distant buyer's judgment of quality begins to doubt the integrity of the buyer (Yuen 1978:12).

The author also makes clear the importance of local knowledge in successfully conducting the fishery. In particular, he emphasizes the need to know the timing and location(s) of the bite - suggestive of the indispensable social attributes of communication and transmission of knowledge across participants and generations of participants. Most ika-shibi fishing was conducted from Hilo at this time.

Large Tuna amidst Social Scene at Suisan Auction, Late 1970s (Courtesy of Walter Ikehara)

Ikehara (1981) later conducted a subsequent examination of the ika-shibi fishery under contract with the NMFS Honolulu Laboratory. He also recognized the productive and lucrative nature of the fishery, and its clear development potential. Of significance to the current analysis, the author begins his discussion by noting challenges associated with collection, reporting, and analysis of ika-shibi fishery data (challenges that persist in various ways into the present):

> Since there is no separate category for ika-shibi in the catch reports of the Division of Aquatic Resources . . ika-shibi catch data are usually reported in the deep-sea handline category. Because the deep-sea handline category may also include catch data from the day handline and bottomfish handline fisheries, it is difficult to distinguish the ika-shibi catch. It is also possible that some of the ika-shibi catch may not be reported at all.

Ikehara consequently set out to examine wholesaler figures in order to assess landings, ex-vessel value, and extent of participation in the fishery. The fishery had clearly grown in all respects by 1980, with increasing participation from Pohoiki and Kona side. As regards extent of participation, the author reports that 233 fishermen reported using ika-shibi methods that year, with 175 reporting use of the gear 15 times or less, and 55 reported its use more than 15 times (Ikehara 1981:5).

Table 2-2 Reported Ika-Shibi Landings by Species: 1980 (reported weights in pounds)

Species	Pounds	Pieces	Ex-Vessel Value $
ʻAhi	814,871	21,110	2,618,945
Bigeye	29,266	819	108,611
Tombo	43, 645	1,837	71,374

Source: Ikehara (1981:5)

Bidders at Suisan Auction, Late 1970s (Courtesy of Walter Ikehara)

Ikehara also indicates strong economic incentive to participate in the fishery, estimating average gross fishing incomes of between $40,000 and $80,000 per year, with highliners estimated to earn as much as $140,000 per annum. Ex-vessel revenues were estimated to exceed $2.9 million (p. 6). This is countered with discussion of tuna burn and its potential to limit export potential.

Of note at this juncture are assertions made by some present-day informants involved in the fishery in the early days regarding the establishment of the state-sponsored FAD system beginning in 1980. The FADs, situated in various nearshore waters 2.4 to 25 miles from land in waters 80 to 1,510 fathoms in depth, are said by some to have disrupted traditional feeding and spawning patterns of BET and ʻahi (Field notes 2005), while increasing general small boat fishing traffic on the water (e.g., see Severance 1985).

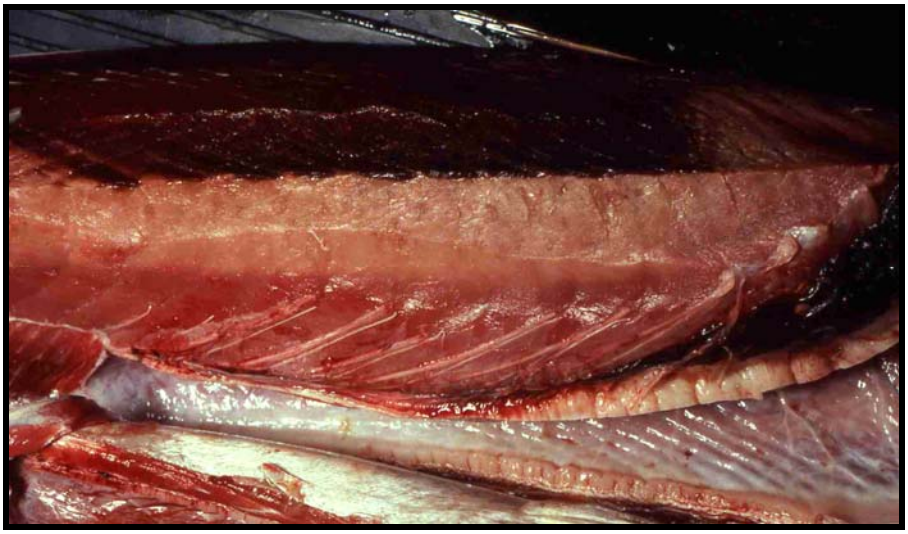
The fishery had further grown in terms of participation, and significantly so by 1984. During this period, the fleet of small fishing vessels active in the state had grown to about 8,000 (Skillman and Louie 1984). The State of Hawaiʻi, Division of Aquatic Resources (HDAR; 1986) reports that about 125 captains were involved in the ika-shibi fishery on a full-time basis that year - a 46 percent increase above the figures reported for 1980 by Ikehara (1981). An additional 45 captains were said to be operating on a part-time basis. Four full-time captains were said to be operating from Kauaʻi at that time.

It is at this point (in 1986) that various problems were noted via analysis of the fishery. The HDAR authors assert that minimal trip overhead and high rates of return had initially attracted many to engage in the ika-shibi fishery with avidity, but that participation had leveled off and catch rates and revenue had begun to decline - by over 49 percent since 1979 (HDAR 1986:80). It was reported that declining catch rates were first noticed during the year following Ikehara's 1981 report, and that some fishermen had been forced to drop out of the fishery as expenses started to exceed revenue:

> With current expenses averaging $170 per night, fishermen say that six consecutive trips without catching ʻahi will force them out of business because their line of credit for necessities such as fuel, ice, and bait will be exhausted. The decline is evident in reported catch rates between 1979 and 1983. The 1979 catch rate was reportedly 2 fish per hook per night (Yuen 1979), while the 1983 catch rate was .5 to .7 fish per hook per night . . . As catch rates declined, many fishermen found themselves unable too meet mortgage payments which resulted in increasing foreclosures on full-time ika-shibi boats (HDAR 1986:81).

The authors suggest that a number of problems underlay the decline, including and in addition to the availability of tuna and (ostensibly) related environmental factors:

> The current depressed condition of the fishery may be attributed to several factors, including: 1) noticeable decline in availability of large tuna, which could be partly attributed to the "El Nino" phenomenon; 2) the financial burden on the fishery created by heavy capitalization in the face of declining catch rates; 3) difficulty in obtaining access to overseas markets by means of air freight and 4) a lack of quality control in the fishery partly the result of the tuna burn problem.



Tuna Burn - a Common Problem in the Early Days of the Ika-Shibi Fishery
(photo courtesy of Walter Ikehara)

Inset A **The Ika-Shibi Technique**

Ika-shibi is a nighttime small-boat tuna fishery that was developed in the nearshore waters of Hawaii Island during the second decade of the twentieth century. Captain and crew (typically one or two) deploy a parachute-type sea anchor to keep the vessel in a relatively stable and slow drift, typically above or near favored drop-offs such as the 600 and 1,000 fathom curves, and around koʻa, FADs, or other features. Some captains occasionally clip leadered and baited hooks to the chute line (these are called kaka lines).

The summer months have been particularly productive for the ika-shibi fishery in years past, though some years involve a winter bite as well. Production and use of chum lines by cooperative captains is common. Lunar phase is considered important by many fishermen. Underwater 25-50 watt lamps and 25 watt above-water lamps running from a 12 volt power source attract biomass, baitfish, and squid to the vessels. Squid are preferred bait, but ʻōpelu (mackerel scad) or frozen squid are used on occasion and may initiate a night's fishing until squid are caught (Rodgers 1987). *Palu* (chum; in this fishery often anchovy or sardine) is intermittently dispersed as an attractant in the water column during the course of the operation. Three or four long braided polypropylene or nylon lines are equipped with strong leaders, baited 14/0-16/0 circle hooks, and lead-filled tubular weights, and cleated at staggered depths for fishing between 15 and 35 meters. A breakaway line enables the fish to run with the bait before snapping and setting the hook.

Once the hook is set, the fish is allowed to tire, and is hauled to the boat by hand on the main line. Strikes often occur in clusters, making for periods of high activity on board. Fish are stunned with bat, and terminated by bullet or by stiff wire run through spine/brain cavity. Consistent use of ice and icy brine has reduced burn problems characteristic of historic ika-shibi operations.

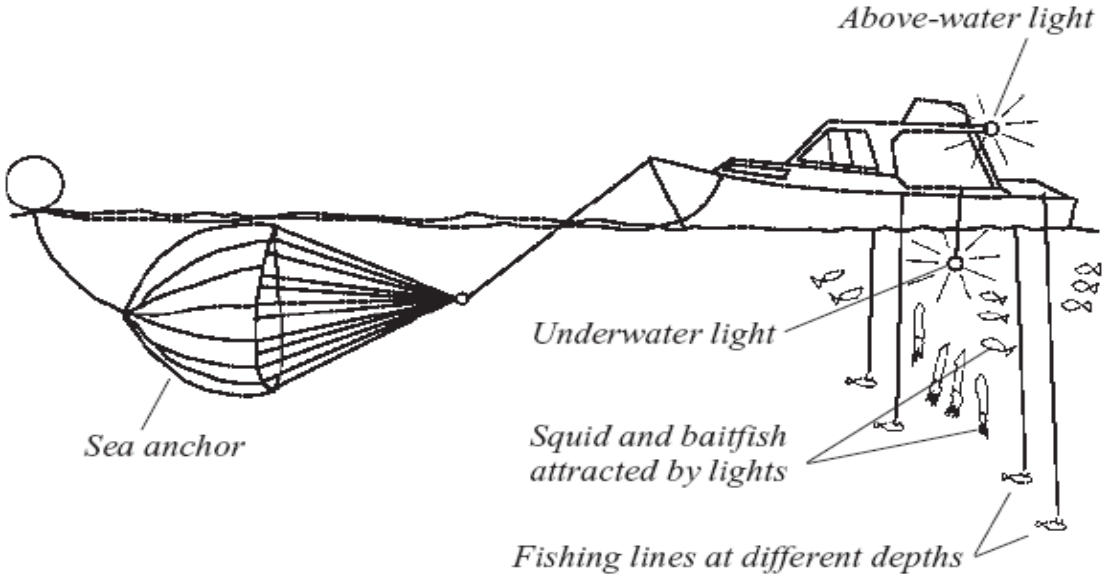


Illustration from Preston et al. (1998:56)

The Daytime Palu ahi Fishery: WWII to 1985. Use of the technique called palu ahi does not as readily define a distinct fishery as does "ika-shibi." First, palu ahi fishing actually involves several sub-techniques, including drop stone, make dog (mah-kay dog), and variations thereof. Second, the history of palu ahi is both very ancient and quite new - with little data available to describe the interim. The commercial palu ahi fishery did not attract the attention of HDAR as did ika-shibi, and thus there was no directed data collection effort associated with the fishery until a distinct palu ahi data category was added to the commercial catch reporting form in 1986. Even at the point, as further described in the following section, reporting of palu ahi activity was sporadic and uncertain until about 2002.

Palu ahi does indeed have a very long history of use in Hawai‘i, likely beginning long before Cook arrived in Hawai‘i. Maly and Maly (2003:41) describe the basic mechanics of palu bag methods based on readings of various historic accounts, including those of Beckley (1883), Kahauleleio (1902), and others:

> Fishermen had many customs and devices. The lihi was one kind of hook; another was a baited hook; octopu palu or chum was the device used by some fishermen; release (ho‘oholo) was the bait of others. A hook baited with flesh (pa‘i‘o) was another bait. One kind of palu was handfuls of whole fish - ‘ōpelu or akule or puhi ki‘i perhaps - pounded until soft, and wrapped in coconut cloth, a‘a niu, with a stone inside. This was let down to the bottom of the ko‘a, and then shaken until the stone rolled out and the palu scattered . . . Those who understood the properties (mana) of good bait would come to shore with a good catch . . (Maly and Maly 2003:41)

The modern techniques are similarly straightforward, as noted in Inset B below. But there is little data available to describe the extent of use of such methods over the course of time. Based on ongoing research along the Big Island, we surmise that it was used consistently by a relatively small number of Native Hawaiians fishing over and along various ko‘a in remote areas offshore the Big Island, and more recently by a broader subset of local residents who eventually recognized its efficacy and simplicity.

Lyman et al. (1984:II-2) assert that "few if any" fishermen practiced palu ahi techniques until the early 1970s, but that by 1979 some 100 or so operators were fishing in this manner. The increase undoubtedly relates both to the general increase in small fishing vessels in Hawai‘i, as previously discussed, and to the dramatic increase in the number of operators using ika-shibi methods at the time. In fact, it is clear from interviews with former participants that many operators staggered use of both nighttime ika-shibi and daytime palu ahi methods, and would occasionally use both methods during the course of a single trip. As regards landings during this period, the author provides some indication of approximate volume (one million pounds), but these are combined with ika-shibi landings- indicative of the ongoing difficulty of accurately assessing catch for any specific component of the handline fleet.

It should be noted that there is some debate about the appropriate type and use of palu for a given fishery. Native Hawaiians developed distinct palu bait formulations and approaches for different target species. For instance, vegetable matter such as taro and pumpkin[7] was traditionally used to attract and train ʻōpelu at ʻōpelu koʻa along the Kona side of Hawaiʻi Island (Abbott 1999). This was confirmed in various field and interview research by Glazier (1999), though not clearly and specifically for ʻahi or BET. However, many Native Hawaiians and other local residents do definitely refer to specific ʻahi koʻa, to behavioral patterns of tunas over and around such features, and appropriate preparation of palu for use at the koʻa. The latter has indeed been of concern to Native Hawaiian fishermen for some time, as indicated by Cobb (1903):

> The natives are very expert in the preparation of palu, or baits, from various substances. In making these a small section of the sharp end of a cocoanut [sic] shell, about 1 1/2 inches in height, and a small stick of wood are used, in the same manner as a mortar and pestle.

Knowledge and techniques associated with preparing to fish and fishing ʻahi koʻa were and remain intricate and important in Hawaiʻi, and for this reason we include relevant parts of an interview conducted between Kepa Maly and a kupuna (elderly knowledgeable person) with deep familiarity with the topics of interest (Maly and Maly 2003, Volume II, pp. 406-407). The Native Hawaiian informant was born along the South Kona Coast in 1925. His lack of familiarity with the term "make dog," but his deep understanding of that and related drop stone methods and their historic use in the region make clear that socio-cultural changes continue to influence the conduct and terminology of handline fisheries in Hawaiʻi. The passage of time undoubtedly will continue to obscure knowledge once critical to many Hawaiians and others residing in rural Hawaiʻi:

> [The kupuna] discusses fishing for ʻ*ahi*, ʻ*ōpelu* and other fish; and the relationship of baits to the health of the *koʻa*. When young, never heard of "*make dog*" or other "*pilau*" [smelly] baits:
>
> KM: One of the things that has happened in your *āina* out here, is that your folks *palu*, when you *kaʻaʻai*, it's *kalo*, *palaʻai*…?
>
> EK: Yes.
>
> KM: Now people are coming in with…they started this thing called *pilau*, *make dog*, chop-chop. What is your thought about that in your folks *āina*?
>
> EK: [chuckling] When you talk about *make dog* [chuckling], that's another thing. When I heard that, when I came back, "*make* dog!" I asked, "What's that?" Oh, they go out for *ʻahi*. *ʻAhi* fishing. And they talk about "*make* dog." "Yes, we put down out *make* dog in this and that." I never knew, what that is. But it's not the *palu*. When we go out *ʻahi*fishing…Well to begin first with the old folks, the way they fished before, they use *kēpau* and everything, it was all stone.

[7] Pumpkin was introduced by either Cook or Vancouver and thus could not have been used in pre-Contact times (Abbott 1999).

KM: *‘Ae*.

EK: Even night time and everything, they go with stone. That what takes their things down, yeah?

KM: Yes.

EK: You get your line, you hook, your bait, and how you coil your line, with your *‘aho* on top. That’s how you’re going down. Then you drop ‘um down, you *huki*, one, two times, you can feel that *pōhaku* rolling, *hemo.* And that is how you have to tie that with the bait on, or some you put the *palu* on top. That is how you tie [gesturing with hands], you get so many turns around, you tie, and you let it go. As soon as you [gestures jerking with hand], one, two times, you can feel the stone roll and roll. As soon as it’s clear, you know your hook and bait is out waiting for the fish, but you have to hold it, you have to feel ‘um. Sometimes roll and roll and then you feel heavy one time, ah, the line went *pa‘a* with the hook, the stone never *hemo*. You got to bring ‘um up.

KM: Hmm, and deep some, yeah?

EK: Sometimes deep if you’re going for *‘ahi*. Shallow fishing not so bad, the small kinds of stones. But the *‘ahi*, you have to do that. So everything is on top, you *palu* and everything. You get your *ōpelu,* the whole *ōpelu,* you *kaha* one side, the meat. You *kaha* right down and drop down, then you hook the head. Then the other half of that, you chop ‘um, and then you put it on top of the *pōhaku*. You *wili* your leader with the *makau*. the [sic] you make ‘um like a little coil and you put all your meat inside there. Then you let it go, and you *hemo*, and that’s how you *palu*.

And then later on, they started to use cloth, *welu*, like the *ōpelu ka‘a‘ai*. The *welu* and they still use stone. So naturally, when you put your *palu* in side, you *wili* the *welu*, you just tie one time, *pau*. You let ‘em go. And that way, the *palu* all *pa‘a*. ut that way is good. Sometimes they say when some *‘ahi*fishermen go, and when they cut their chunks. You have to cut pieces not too small. You will, you make sure you *pa‘a*, so the pieces stay *in.* But if you make *kāpulu*, when it’s going down, then the *palu hemo* all over the place, and then the fish are running all around the place. And sometimes you’re not catching because all the fish are concentrating on that area with the *palu* and you’re not catching. But if you make good, as soon as you make the place, everybody the same place, all catching the fish. And that’s when they came with the *welu*, the *ka‘a‘ai*.

KM: *‘Ae*.

EK: You put the *welu* and you wrap ‘um. And you know *pa‘a*, the meat doesn’t *hemo* when you go down. That’s how it started.

But actually, I don’t know if any of them know this, because before they had the *welu*, only the *pōhaku*. You know the *noni*leaf?

KM: *‘Ae*.

EK: You pick up he *noni*leaf and then you wrap the *noni*leaf around that *pōhaku*, and then you *wili*. That way, *pa'a* all the meat inside there. And that was the idea that they wanted to *pa'a* that meat. Because once the fish run a certain depth, where the *'ahi* running, you go over there, hit that, every time, everybody is putting in. Sometimes I go, we go. Morning time is a certain depth, afternoon time a certain depth. Certain kind of *'ahi* run deep. So you have to know all of this.

KM: Yes. Were you folks still using *pā* or were you using metal?

EK: The *pā* is when you go *hī aku.*

KM: So you use hook on your *'ahi*.

EK: *Makau*, the hook. That's what we used to do. Then when I came home, they started to use that "*make* dog." They get that rag and they put that lead, and then when they throw down and *hemo*, the *palu* bag is over there, and the lead is over there yet. Sometimes, if there's plenty *'ahi* running, no *pilikia*, you use that. Good, no need worry about going to look for *pōhaku*. But sometimes, when the fish are not running, or really biting so good, it's best to go with just the *pōhaku* and the bait and the line. If you get your line over there, and the *welu* is going like that [gestures, fluttering around], and the lead is hanging, that chances that the fish is going over there, he no like see this thing hanging and flapping around. So you catch and you pull in yours. Unless the fish are really excited and running, they'll go with anything. So that's the kind of thing you have to do.

[Excerpts from Maly and Maly (2003,Volume II, pp. 406-407)]

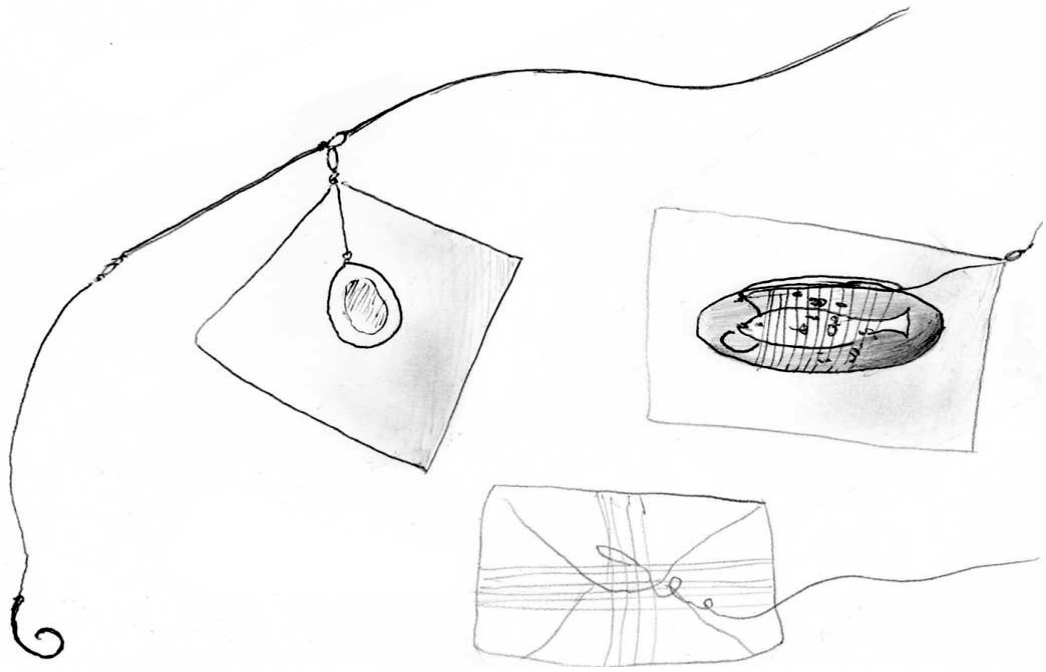
Contemporary *Make Dog* Rig

Inset B **Palu Ahi Techniques**

Palu ahi is a daytime small-boat tuna fishery developed in the Pacific Islands over the millennia. In Hawaiian, "palu" refers to chopped and/or mashed bait. Historically, the material was placed in a bag and lowered to depth over a specific target, usually reef formations called koʻa, where ʻahi (ʻahi koʻa) or other species were known to congregate. Some informants assert that pelagic and other species would be "trained" to come to and feed at such features, and that at the appropriate time a number would be captured by handlining methods. The type of palu and the manner of its preparation were critical in the traditional context. In more recent years, the daytime palu ahi has been conducted most typically on the leeward Kona Coast of Hawaiʻi Island, often around FADs or koʻa. Some modern captains use parachutes for slower drift; others do not. The palu ahi method is also called "bust bag" in local vernacular.

In the case of the "drop stone" technique, a hook baited with ʻōpelu is wrapped with leader and chunks of bait around a flat-sided beach cobble or similar stone and lowered in a cloth or canvas bag to the proper depth, often in the range of 15 to 35 meters - depending on the nature of the targeted feature. The mainline is jerked, thereby releasing a double-curl slipknot securing the bag. The contents are spilled, ideally incurring a feeding reaction by the tuna. The bag may be retained, but the stone falls off onto the bottom.

Make dog is similar in nature, and probably a natural evolution of drop stone in that is that allows the fisher to retain the weight. The technique may also have origins in Japan or in Japanese immigrants in HawaiʻI, as the phrase "make doggu" is also sometimes used, meaning "wrapped device." The method involves use of a flat, ovoid lead weight - one side of which is convex and amenable to placement of the dead ʻōpelu. The gear is wrapped and lowered in similar fashion, but is rigged such that the lead weight remains tethered to the mainline and can be retrieved. 13/0 to 16/0 circle hooks are used in both techniques, and thus constant and movement-sensitive pressure on the mainline is essential during retrieval.

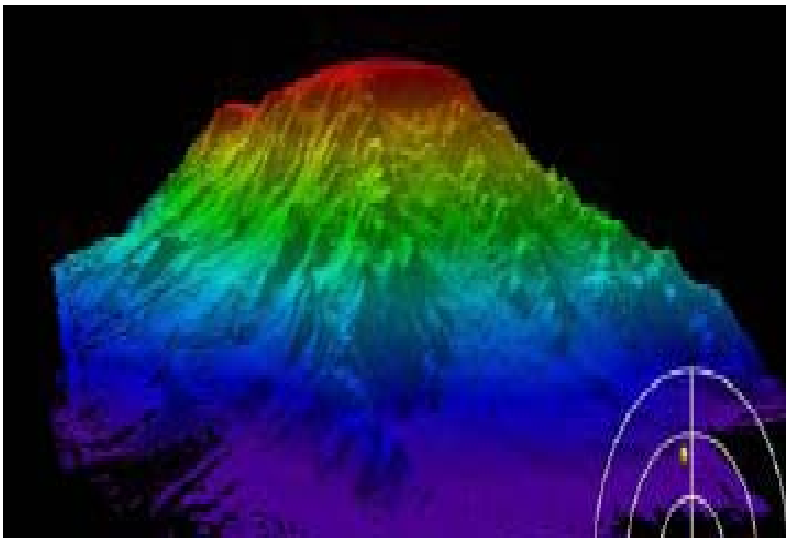


Advent of the Cross Seamount and Weather Buoy Handline Fisheries. Work with some of the early "pioneers" of small-vessel fishing activity at Cross Seamount suggests that pelagic resources at these relatively distant waters were first pursued by a couple of operators in the mid-1970s. Key informants assert that crowding in historically used areas and perception of diminishing resources originally led to exploration in the far offshore zone.

Activity at the seamount slowly increased as word of success gradually spread through a network of prospective participants. While only four to six operators fished the area through the 1980s, as many as 14-20 captains and crew were making the voyage when the fishery ultimately reached a peak level of participation in the mid-1990s.

Given that Cross Seamount is located at 180 40' N, 1580 10' W, or about 160 nautical miles south of Honolulu, some of the vessels involved in the handline fishery at the feature have been longer than what might typically called small boats in Hawai'i. While many have been in the range of 45 feet and occasionally longer, some have been as small as 32 feet.

Cross Seamount is part of the Navigator Seamount chain. The mountain rises from a seafloor depth of about 4,000 meters to about 330 meters from the ocean surface, and tends to influence current flow in the area. 'Ahi, BET, and various other species aggregate here and have been the subjects of pursuit by the handline fleet, which tends to land juveniles at relatively shallow depths (Itano and Holland 2000:215).

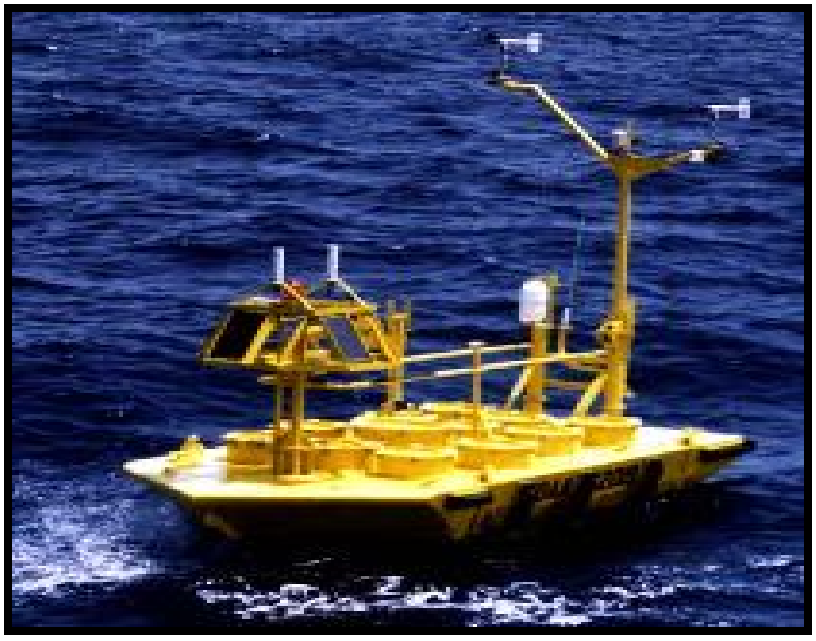


Thermal Image of Pacific Seamount

The full range of handline methods are used at the seamount, including the drop stone and make dog palu ahi techniques during the day, and night-time methods similar to those used in the ika-shibi fishery. Strategic timing and speed of drift in the localized current pattern is typical. Locally caught squid or frozen scad are used for bait, and frozen anchovy or other fish are typically used for palu. Most captains also troll while steaming to the grounds. Hydraulic line haulers are sometimes used to haul fish aboard.

Cross Seamount has also been of sporadic interest to the Hawai‘i-based longline fleet. Captains in that fleet tend to pursue relatively large BET along the slopes of the seamount (Itano 2004:22). Handline-longline fleet interaction issues have been problematic at times, especially when longline captains conduct shallow sets over the seamount near the smaller vessels. This has led to incidents in which longline gear and handline vessel parachutes have become entangled. Additional offshore handline issues that have periodically proven to be challenges to effective management include reported pricing issues when large quantities of handline-caught tuna arrive at the auction block (saturation) and extensive landings of juvenile BET and ‘ahi.

Some handline captains and crew also fish the offshore buoys maintained by the National Weather Service. No data are available for buoy 51001 (buoy one) northwest of Kaua‘i, but buoys 51002 (buoy two) and 51003 (buoy three) south-southeast of Cross Seamount have been fished for some years now. Limited handline activity also occurs at 51004 (buoy four). The buoys have detached numerous times during large swell events.



6-meter NOMAD Buoy 2, 215 nm S-SE Hilo
(Courtesy NWS National Data Buoy Center)

3.0 Recent Trends in Hawai‘i Pelagic Handline Fisheries

This section continues the history of the Hawai‘i handline fishery into the last two decades (1986-2006). We describe basic patterns of participation, production, and related social and economic factors for each of the previously described fishery components. Also described are the most recent innovations undertaken by the fleets. These involve use of PFADs and vertical longline methods. Although some basic analysis is provided, the section is primarily descriptive in nature and intended to set the stage for more in-depth analysis and explanation of trends in Chapter Four.

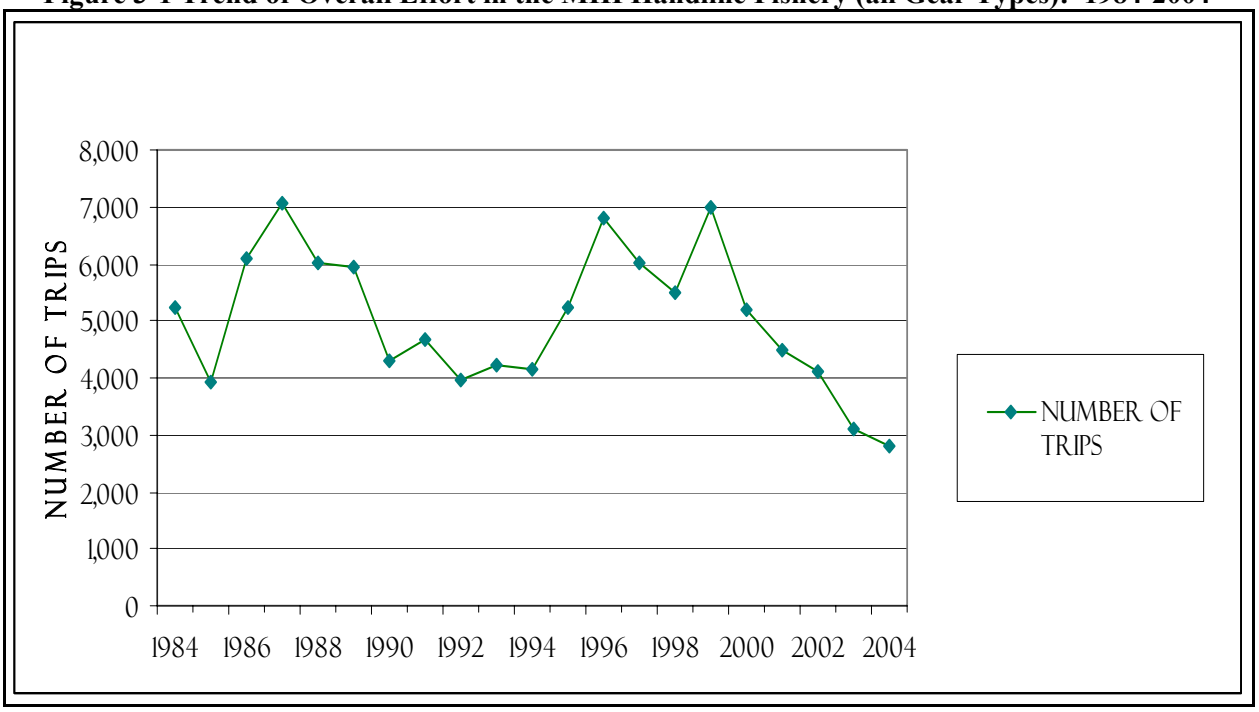
We begin the period of description in 1986 for several reasons. First, this was the first year in which HDAR systematized a mandatory small-boat commercial catch reporting system - a necessary and laudable step in the history of its efforts to effectively manage marine resources in the region. It should be noted however, that as for other regions in the U.S., establishment of the system was and is an evolving process that has necessitated ongoing administrative adjustments and work with fishermen to enhance data validity and reliability.

For instance, Kokubon (2006) notes that for purposes of reporting and analysis, ika-shibi and palu ahi catch data were not as clearly and consistently discernible as distinct components of the Hawai‘i handline fishery prior to 2002 as thereafter. Until that point, many fishermen would tend to report their catch in the generalized offshore handline category rather than indicating specific gear usage. This reflects both the realities of opportunity-based multiple gear usage and the interpretation and completion of catch reporting forms. Indeed, while many trips involve focused use of specific gear, a high percentage of trips involve use of multiple gear types. For instance, most captains and crew troll on their way to the ika-shibi or palu ahi grounds, and many offshore handline trips involve numerous methods and gear types, including ika-shibi, palu ahi, danglers, and so forth. There have also been ongoing reporting challenges associate with proper identification of juvenile BET and yellowfin.

HDAR has worked with the fishermen and data to improve accuracy and resolution, but certain challenges remain. Such is the nature of fisheries data everywhere. We attempt to parcel trends by gear type in subsequent subsections of this report, but necessarily condition the analysis here and as appropriate throughout the narrative.

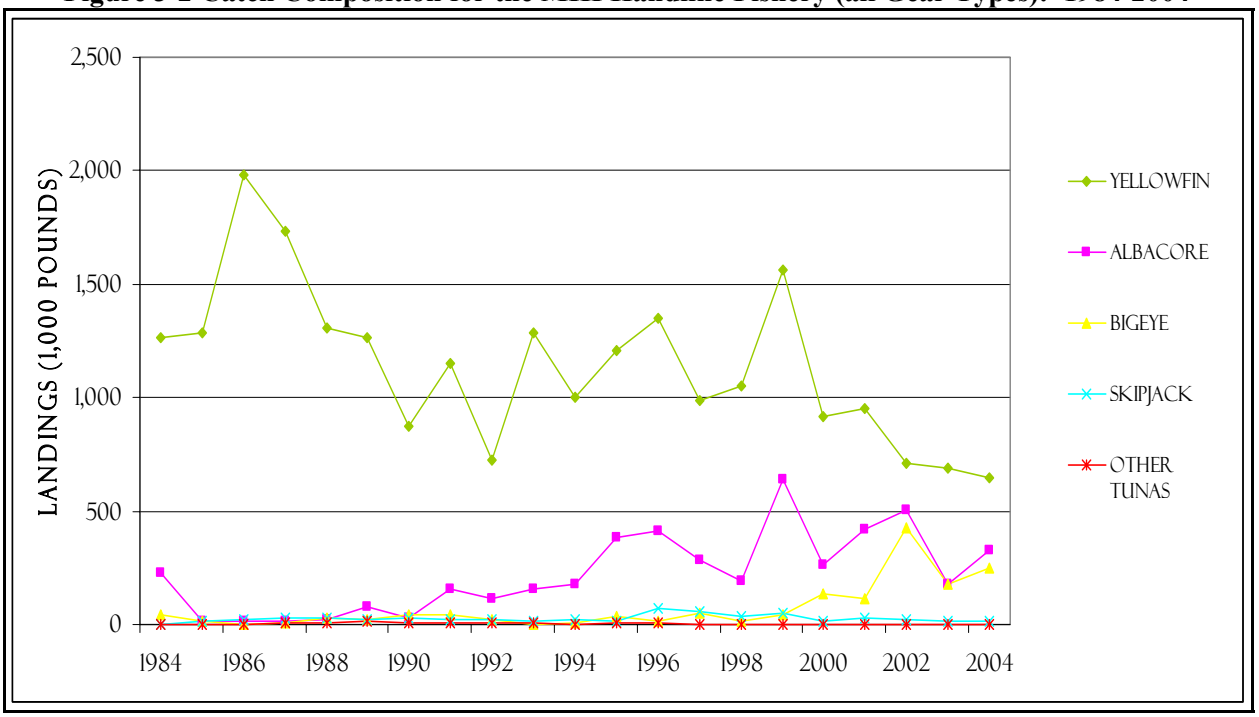
Given reporting uncertainties and our interest in describing overall trends in the Hawai‘i handline fishery, we present catch, effort, and tuna-specific catch composition trends in Figures 3-1 through 3-3 below. Of particular note in the charts are the: (1) trend of diminished effort, (2) trend of diminishing landings of ahi, and (3) trend of increasing landings and catch per unit effort of BET, all based on catch report data provided by HDAR.

Figure 3-1 Trend of Overall Effort in the MHI Handline Fishery (all Gear Types): 1984-2004



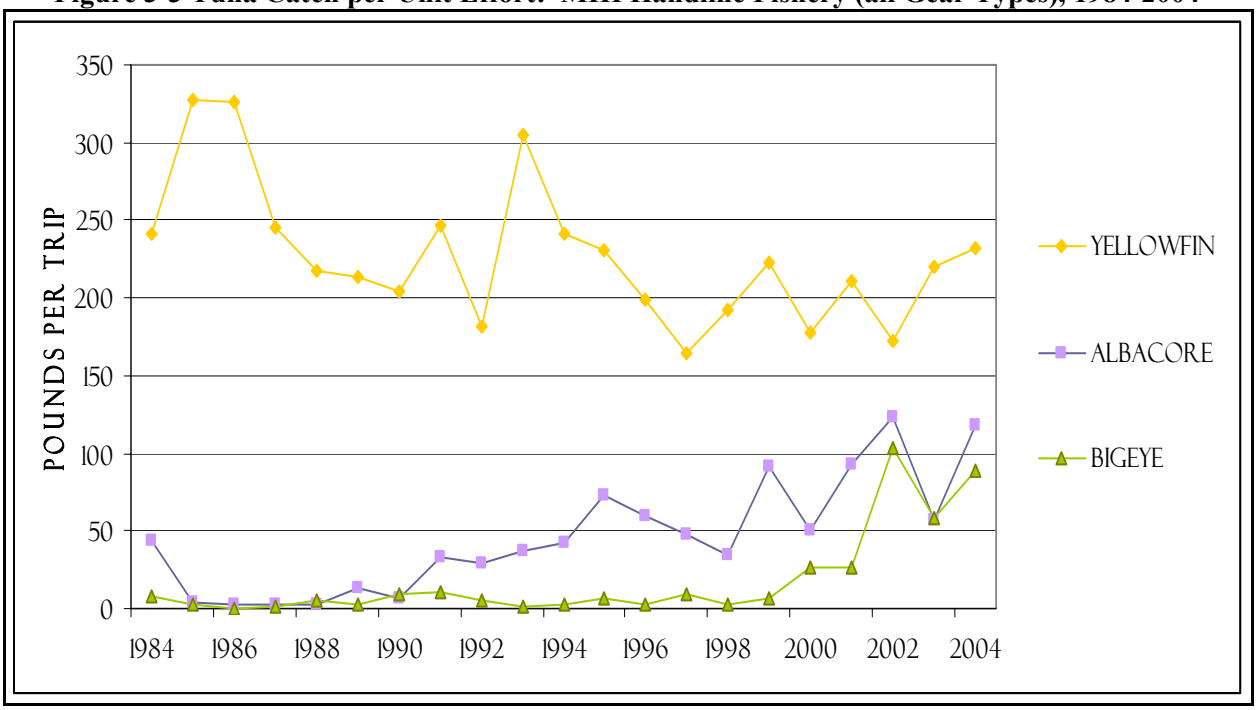
Source: Hawaii Division of Aquatic Resources

Figure 3-2 Catch Composition for the MHI Handline Fishery (all Gear Types): 1984-2004



Source: Hawaii Division of Aquatic Resources

Figure 3-3 Tuna Catch per Unit Effort: MHI Handline Fishery (all Gear Types), 1984-2004



Source: Hawaii Division of Aquatic Resources

We further condition the description and analysis in terms of non-reporting. The extent of non-reporting in Hawai‘i small-boat fisheries is largely unknown, but it clearly occurs and warrants discussion and perhaps more directed research (e.g., see 2005 WPRFMC Pelagic Plan Team Recommendations). Part of the problem is cultural and relates to the close-knit nature of local society and close interpersonal relationships that enable "under-the-table" sales via restaurants or other venues, or through licensed proxies who accept fish from unlicensed operators for legal sale at point of distribution. The vast ocean areas and related challenges of enforcement (and associated fiscal issues) also clearly have a bearing on non-reporting problems.

Second, the ika-shibi fishery appears to have undergone a series of highly active and productive "peaks," with subsequent periods of diminished production. One occurred prior to the mid-1980s, leaving analysts with the task of explaining the decline. We break our analysis at this point and resume it in 1986, which was a point of renewed production. This section of the report describes that and the following years of punctuated decline.

Third, and finally, the mid-1980s initiated a period of broad economic change in Hawai‘i, and especially on the Big Island, where the sugar industry first went pau hana and with little alternative job opportunities. We anticipate that this could lead to two kinds of effects. First, given that many participants in the ika-shibi fishery, (and by logical extension the palu ahi fishery) were part-timers who depended on wage and salaried positions to cover vessel loan payments, other fixed costs, and at times even trip costs, one would expect that participation could begin to decline in relation to a departing sugar industry and as other factors that rendered the economic climate in the region increasingly difficult through the 1990s.

But in fact there appears to be a notable *increase* in overall participation through much of the period, suggesting that participants were at the ready with capital investment in vessels, gear, and sufficient fiscal and social capital to fish in greater numbers. As such, participants may have turned to fishing as a source of income. This trend begins around 1986. But it ultimately falters, and while some of the part-timers and full-timers remain active in the fishery, a period of rapid decline is noted after 2000. This continues today, despite an improving overall economic climate in Hawai‘i. We note, however, that fuel prices have risen precipitously during this period, and a range of social, demographic, and biological factors may underlay the decline, as described in Section Four of this report.

3.1 Ika-Shibi and Palu Ahi Operations and Trends: 1986-2004

Hamilton and Huffman's (1997) survey work stands as the most exhaustive and representative examination of Hawai‘i small-boat operations and economics. The effort generated an ideal template for assessment of commercial palu ahi, ika-shibi, and troll operations in Hawai‘i. Table 3-1 below summarizes key findings from that research so as to further inform the reader of the basic nature of the operations as conducted during recent years.

The figures are based the responses of participants involved in ika-shibi or palu ahi operations for more than 50 percent of their trips. While the data are specific to Hawai‘i -Island fishermen and address a single year of operations (1995-1996), they are presented here as reasonable indicators of recent overall full-time commercial activity for the fisheries of interest.

Table 3-1 Select Characteristics of Hawai‘i Small-Boat Commercial Operations: 1995-1996

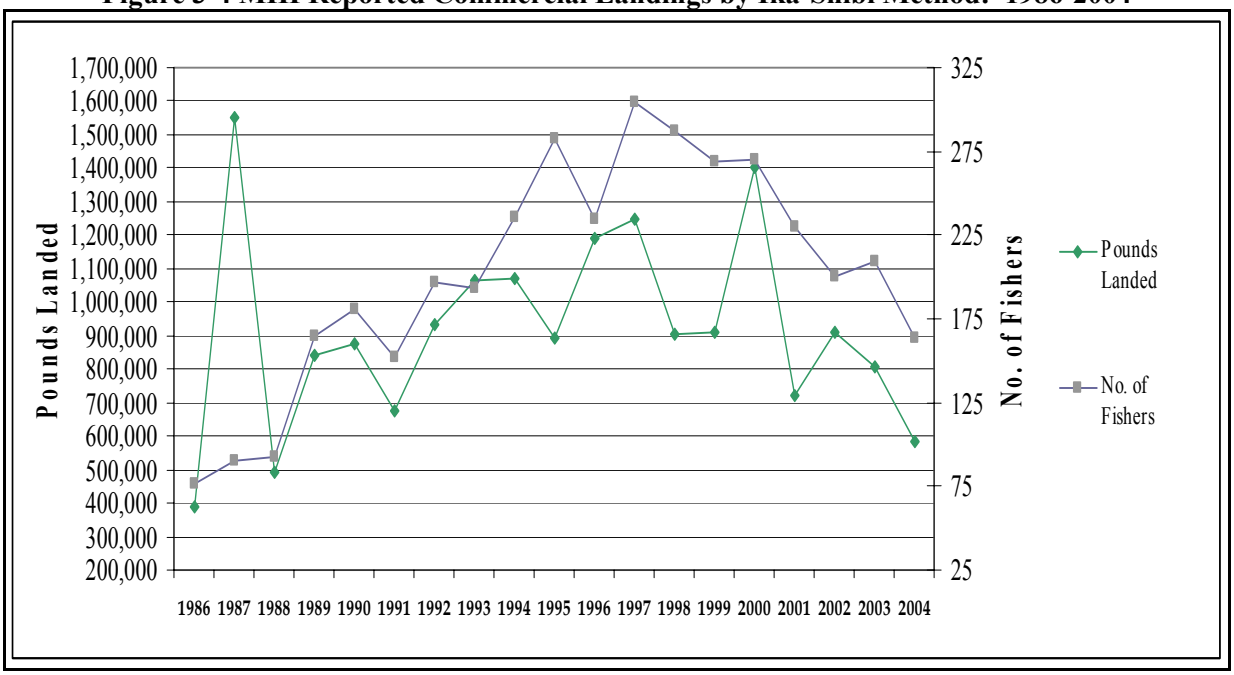
Factor (all figures expressed as means)	**Gear Category** (total n =13)	
	Ika-shibi	Palu ahi
Number commercial trips last 12 months	119	205
Number commercial troll trips undertaken	12	24
Usual operating distance offshore	6	2
Maximum operating distance offshore	14	6
Vessel length overall	27	20
Purchase price	$42,556 (std. 33,409)	$11,667 (std. 8,607)
Major gear costs per annum	$5,510 (std. 6,223)	$3,075 (std. 1,520)
Total fixed costs per annum	$11,223	$5,104
Total trip costs	207	180
Days per trip	1	1.25
Crew size	1.7	1.6
Total sales revenue per annum	$70,813 (std. 57,226)	$46,667 (std. 30,139)
Percent income from fishing per annum	93	87
Total household income per annum	46,111 (42,040)	28,333 (15,275)
Age	42	43

Source: Hamilton and Huffman (1997:45-49)

Participation, Catch, and Effort per HDAR Data. As noted in Figure 3-4 below, the period 1986-2004 can be characterized by extensive year-to-year variation in the ika-shibi fishery in terms of both reported landings and participation. A particularly high volume of reported landings occurred in 1987 when the number of reporting participants was quite low, and again in

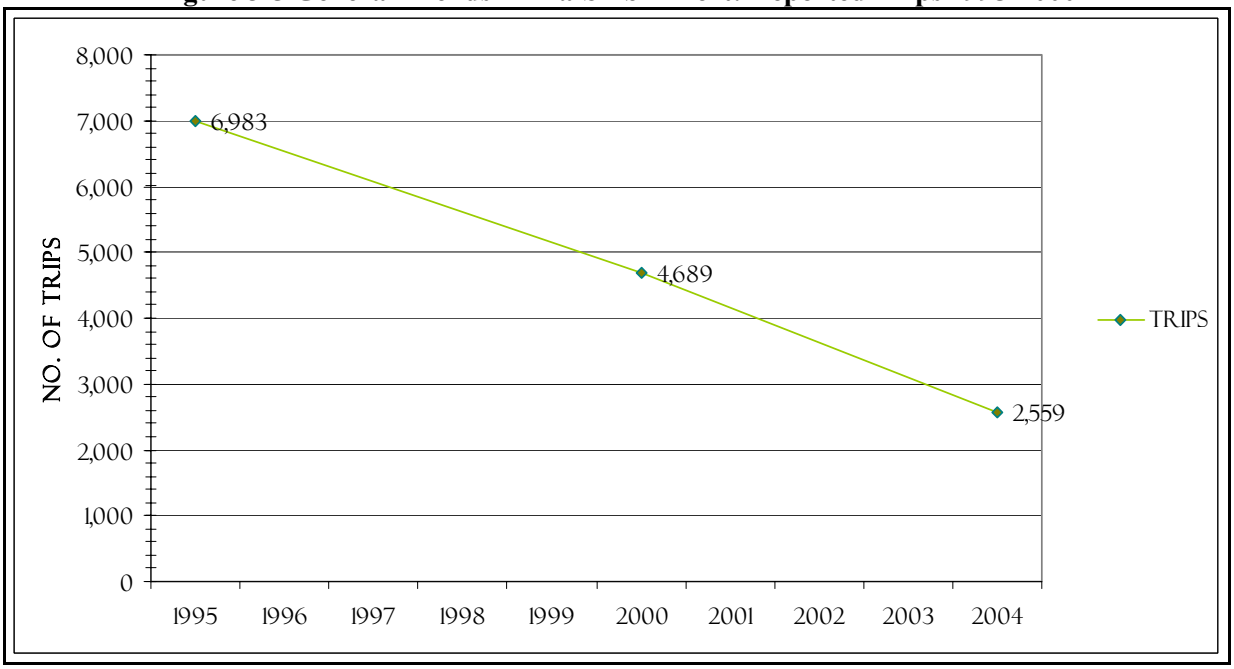
2000, during a period of extensive participation. Reported participation peaked in the mid-1990s and has declined precipitously since 2000. Reported landings have declined in similar fashion since 2000. Note that effort, as indicated by number of reported trips, has steadily declined since 1995 (Figure 3-5).

Figure 3-4 MHI Reported Commercial Landings by Ika-Shibi Method: 1986-2004



Source: Hawaii Division of Aquatic Resources

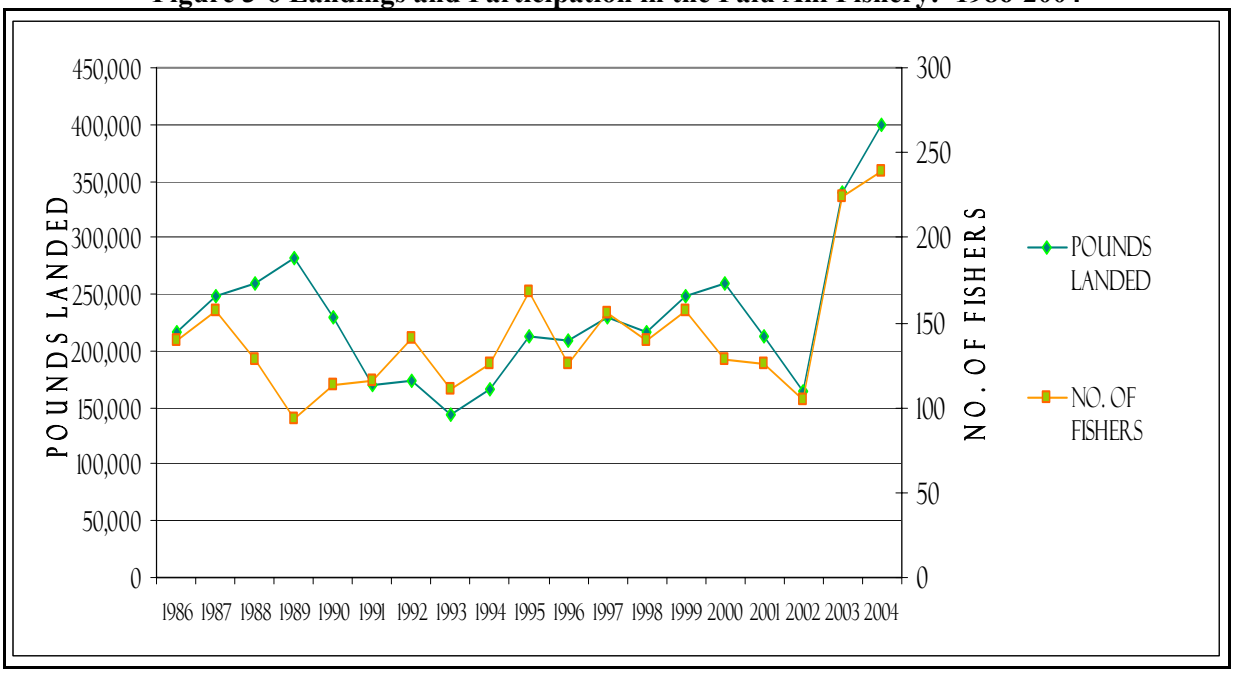
Figure 3-5 General Trends in Ika-Shibi Effort: Reported Trips 1995-2000



Source: Hawaii Division of Aquatic Resources

A different pattern is noted in the palu ahi fishery (Figure 3-6 below), although the reporting issues noted above confound precise understanding. In any case, there appears to be a relatively close association between participation and production in this fishery, and a significant upturn is noted after 2001.

Figure 3-6 Landings and Participation in the Palu Ahi Fishery: 1986-2004

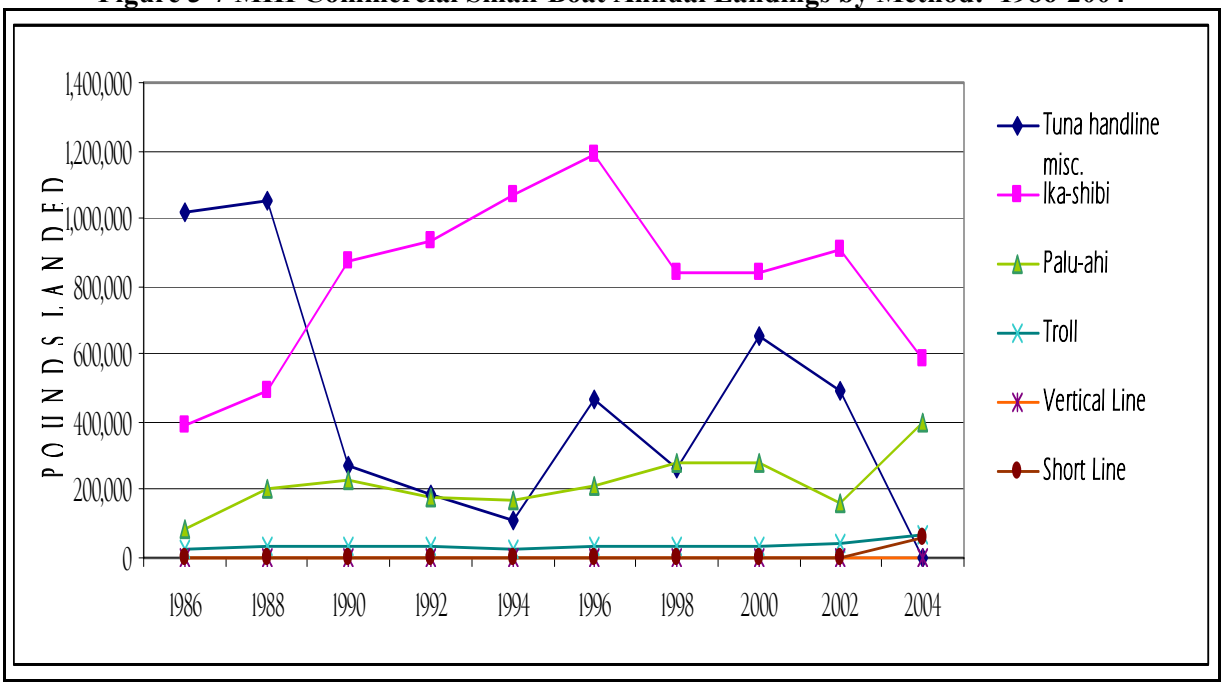


Source: Hawaii Division of Aquatic Resources

Spatial Patterns of Reported Landings, Effort, and Residence. Of note in examination of historic and recent trends across the commercial small-boat fleet in the MHI is the extent of participation and production along the Hilo and Kona sides of the Big Island. Relatively less commercial activity has occurred and is occurring elsewhere in the MHI.

The trend of diminishing participation is especially true for the handline fisheries, clearly the most productive of the gear types (see Figure 3-7 below). Yet that trend holds for all gear types when examined in aggregate and for select years over the period of analysis (Figures 3-8 through 3-12 below).

Figure 3-7 MHI Commercial Small-Boat Annual Landings by Method: 1986-2004



Source: Hawaii Division of Aquatic Resources

Figure 3-8 Spatial Patterns of Reported Harvest & Participation: Average All Years

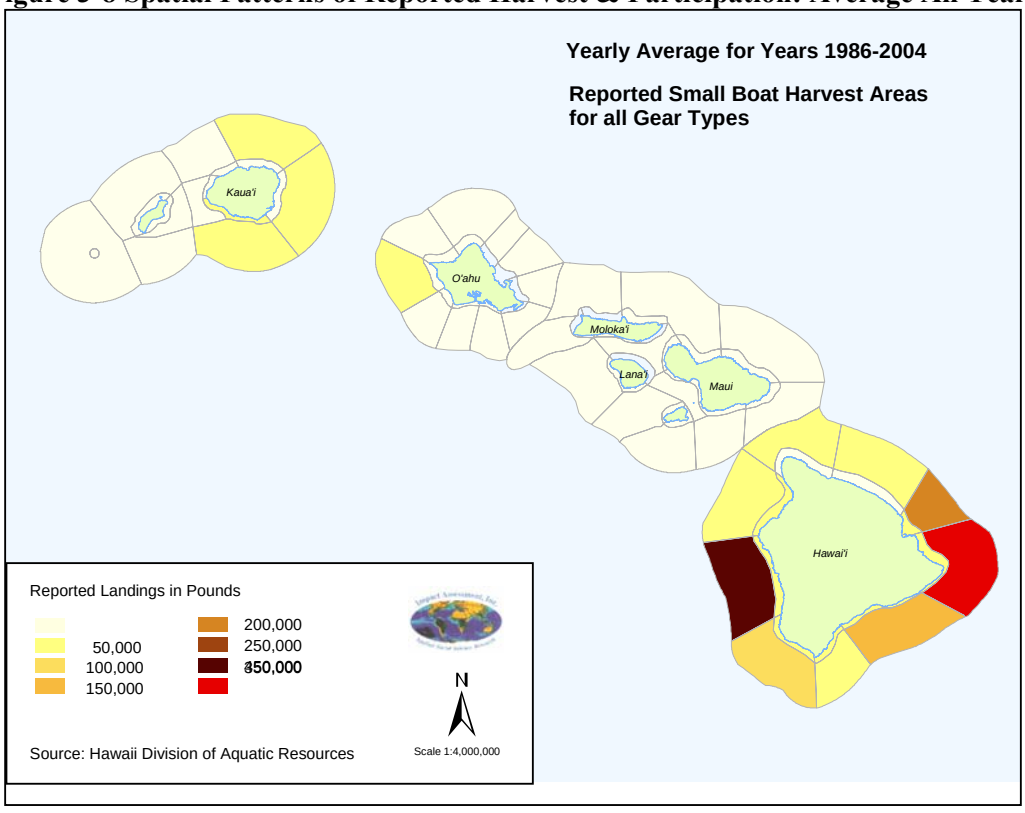


Figure 3-9 Spatial Patterns of Reported Harvest & Participation: 1986

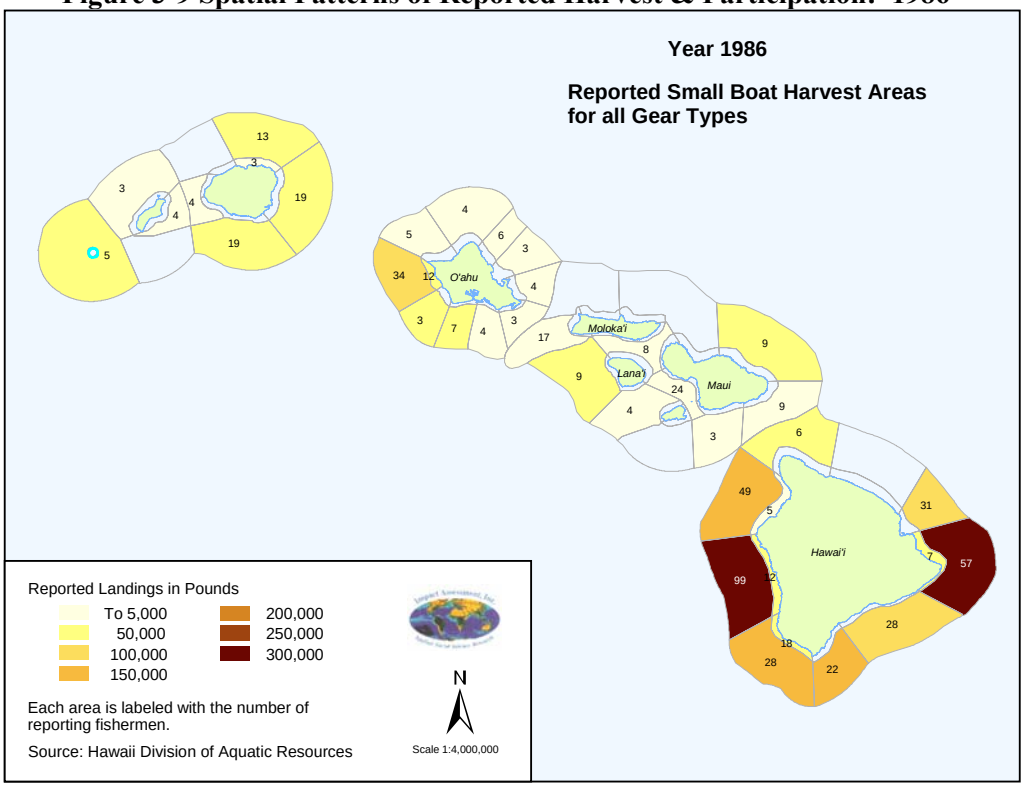


Figure 3-10 Spatial Patterns of Reported Harvest & Participation: 1995

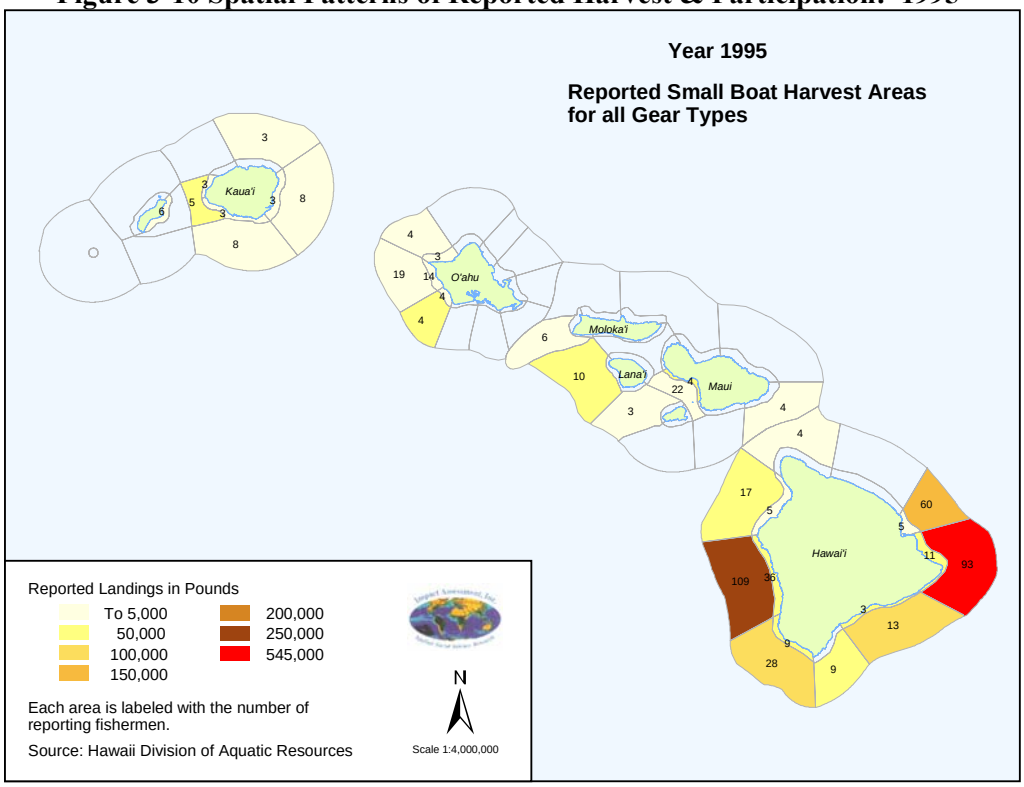


Figure 3-11 Spatial Patterns of Reported Harvest & Participation: 2000

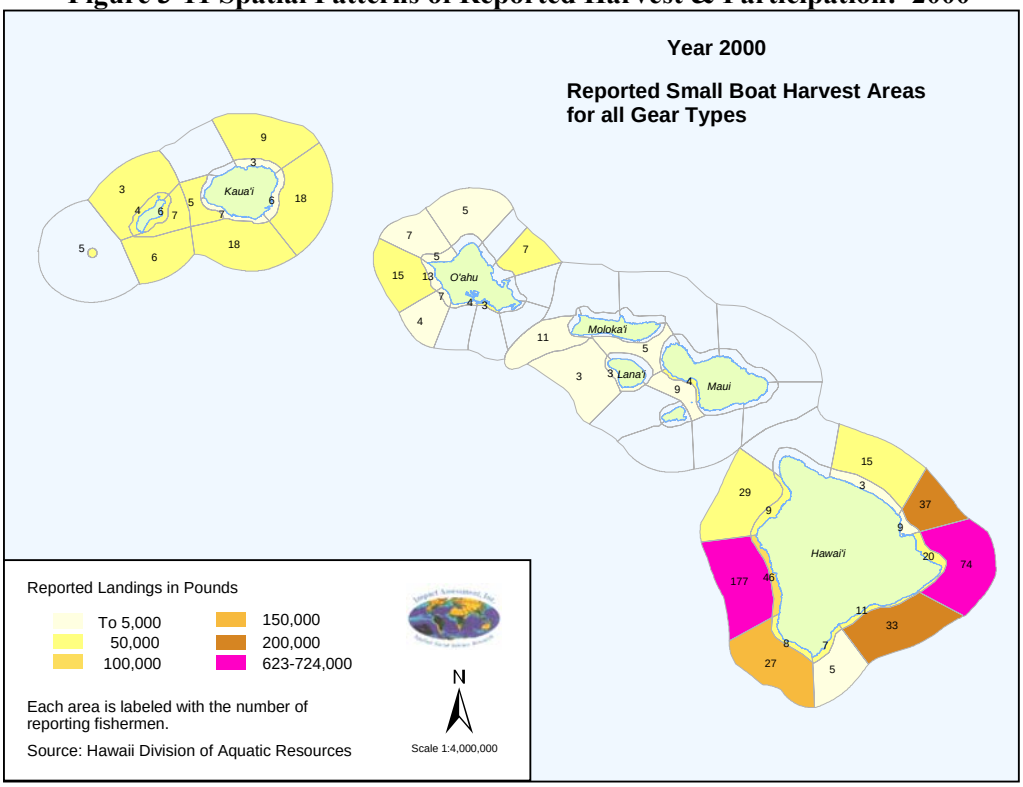
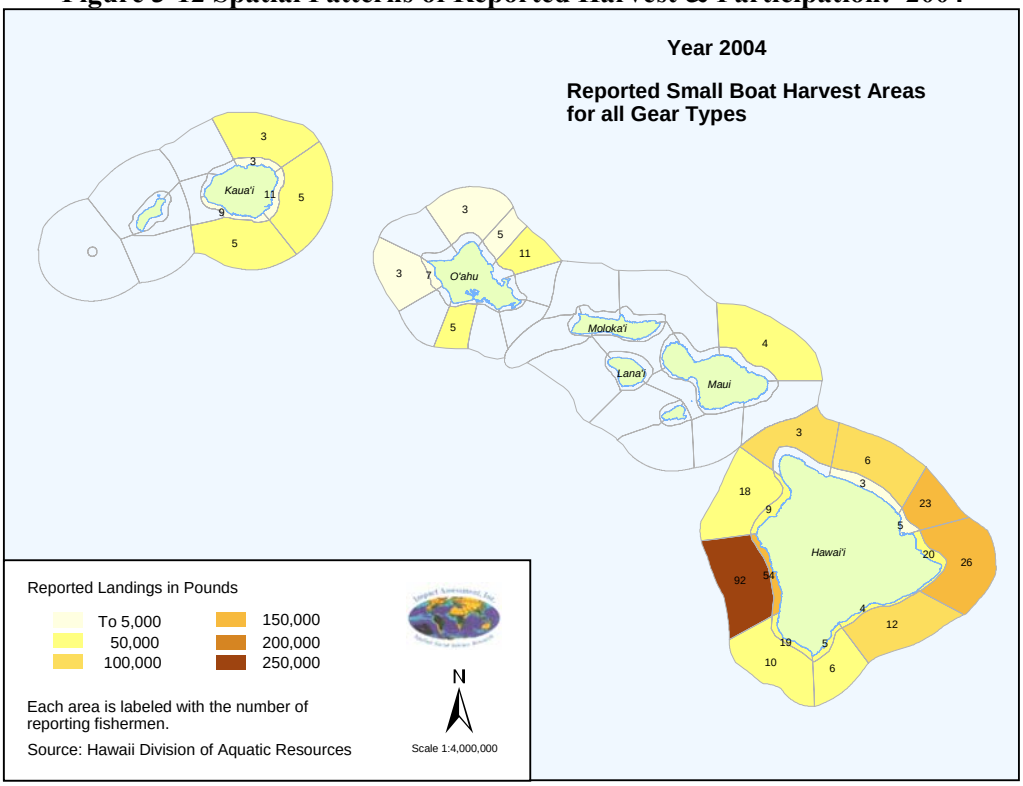


Figure 3-12 Spatial Patterns of Reported Harvest & Participation: 2004



As regards patterns of small-boat activity in the nearshore waters of the Big Island, there has been both a notable decline in overall reported landings since a peak year in 2000, and a clear spatial shift in catch and effort from the historically most active Hilo side over to the Kona side. This is further noted in Figures 3-13 through 3-16 below, which depict reported ika-shibi landings and trips for 1994 and 2004, respectively (all based on HDAR and U.S. Census data).

Figure 3-13 Reported Ika-Shibi Landings by Residence of Participant: Big Island 1994

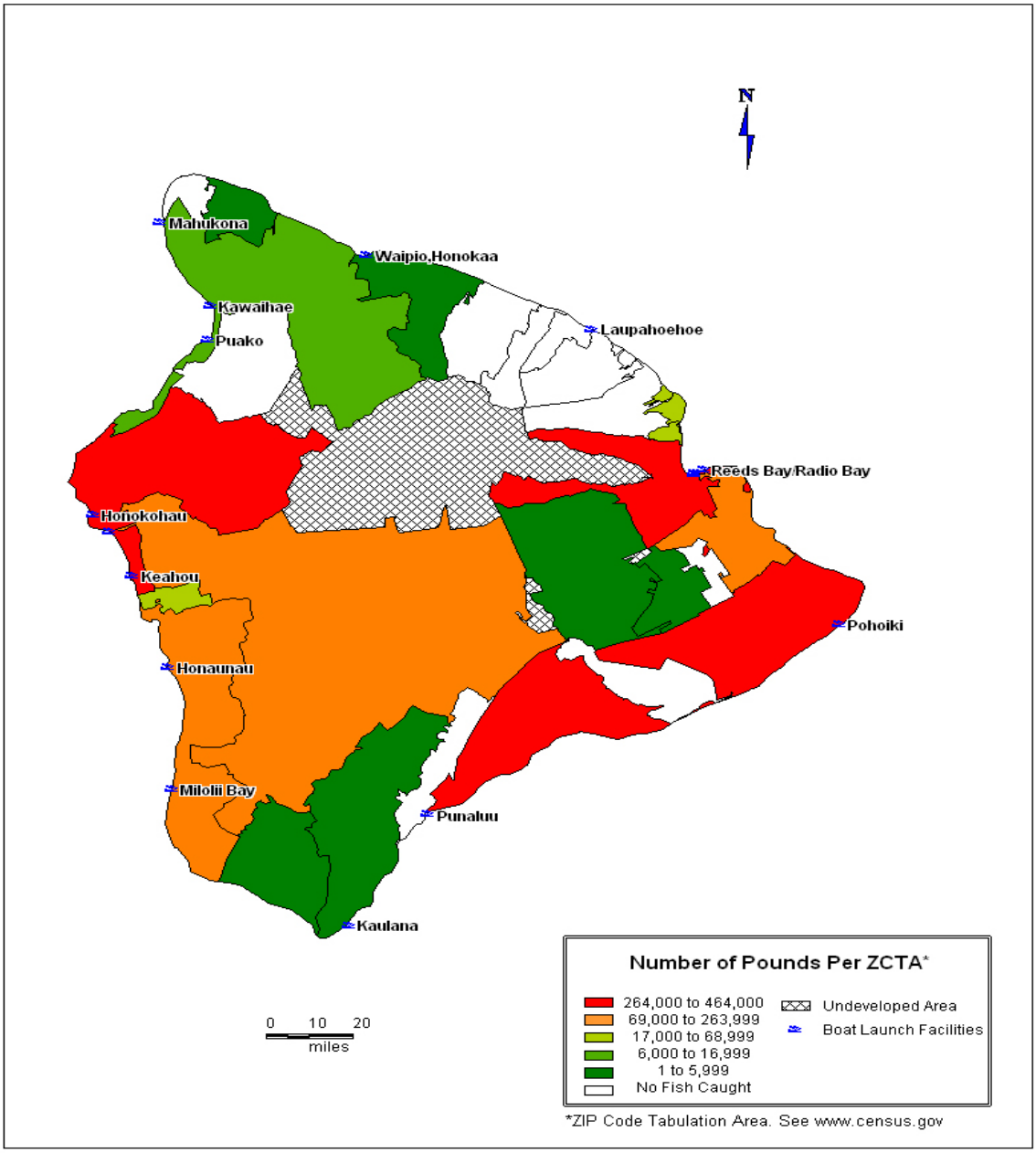


Figure 3-14 Reported Ika-Shibi Landings by Residence of Participant: Big Island 2004

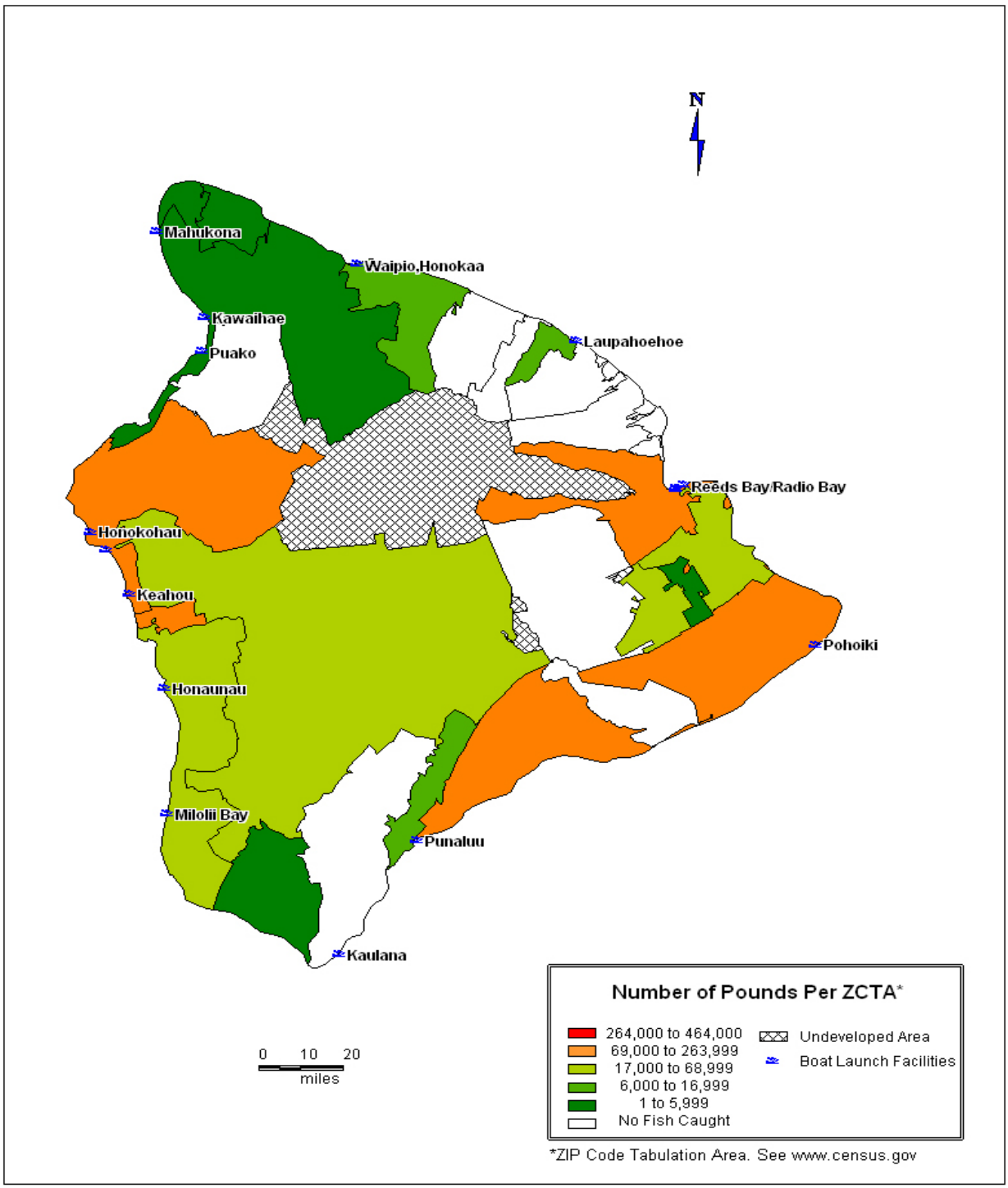


Figure 3-15 Reported Ika-Shibi Trips by Residence of Participant: Big Island 1994

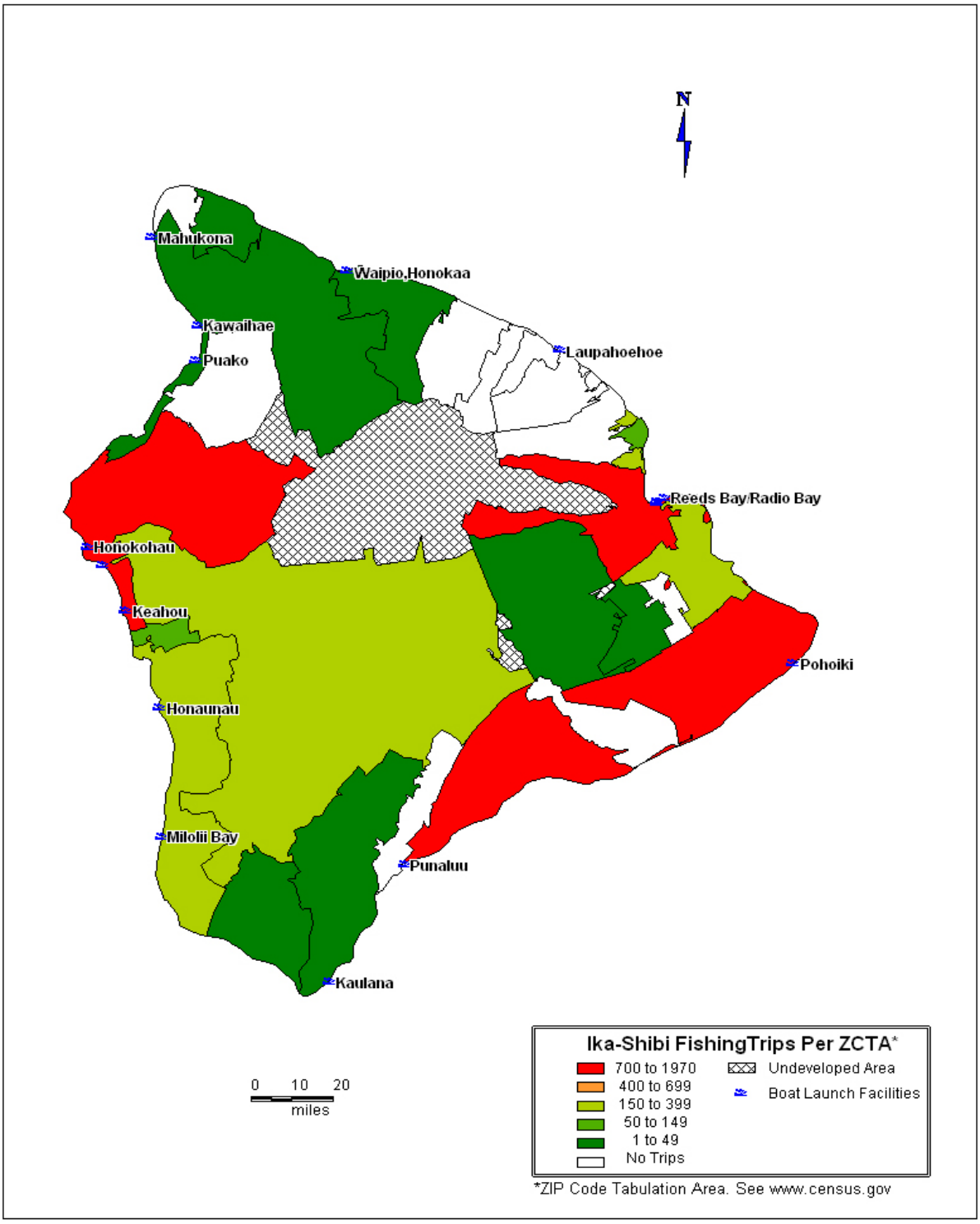
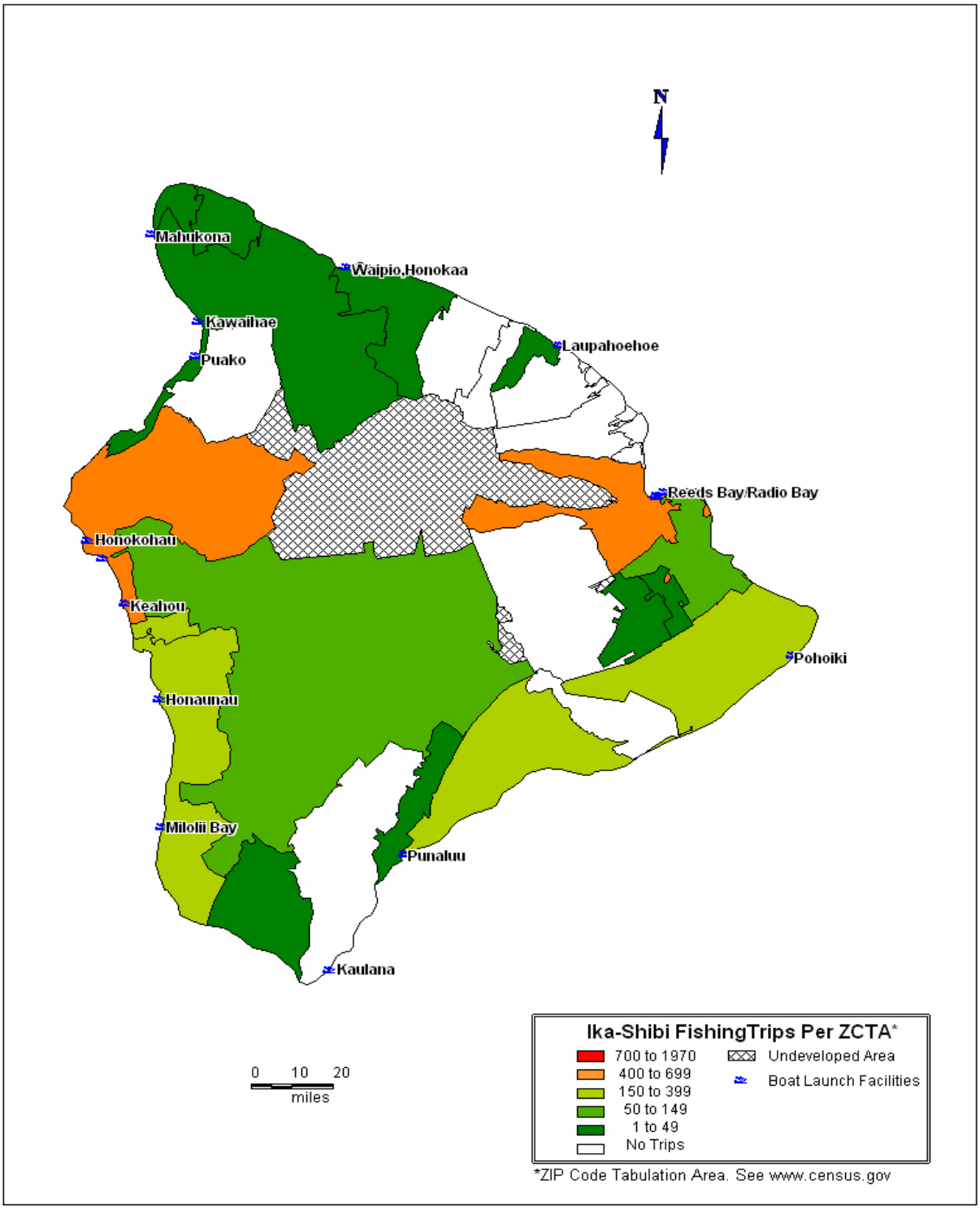


Figure 3-16 Reported Ika-Shibi Trips by Residence of Participant: Big Island 2004



Finally, we depict number of ika-shibi participants by area of residence for 1994 and 2004, respectively (Figures 3-17 and 3-18 below). Note the overall pattern of decline in participation across the island over the period of analysis.

Figure 3-17 Reporting Ika-Shibi Participants by Place of Residence: Big Island 1994

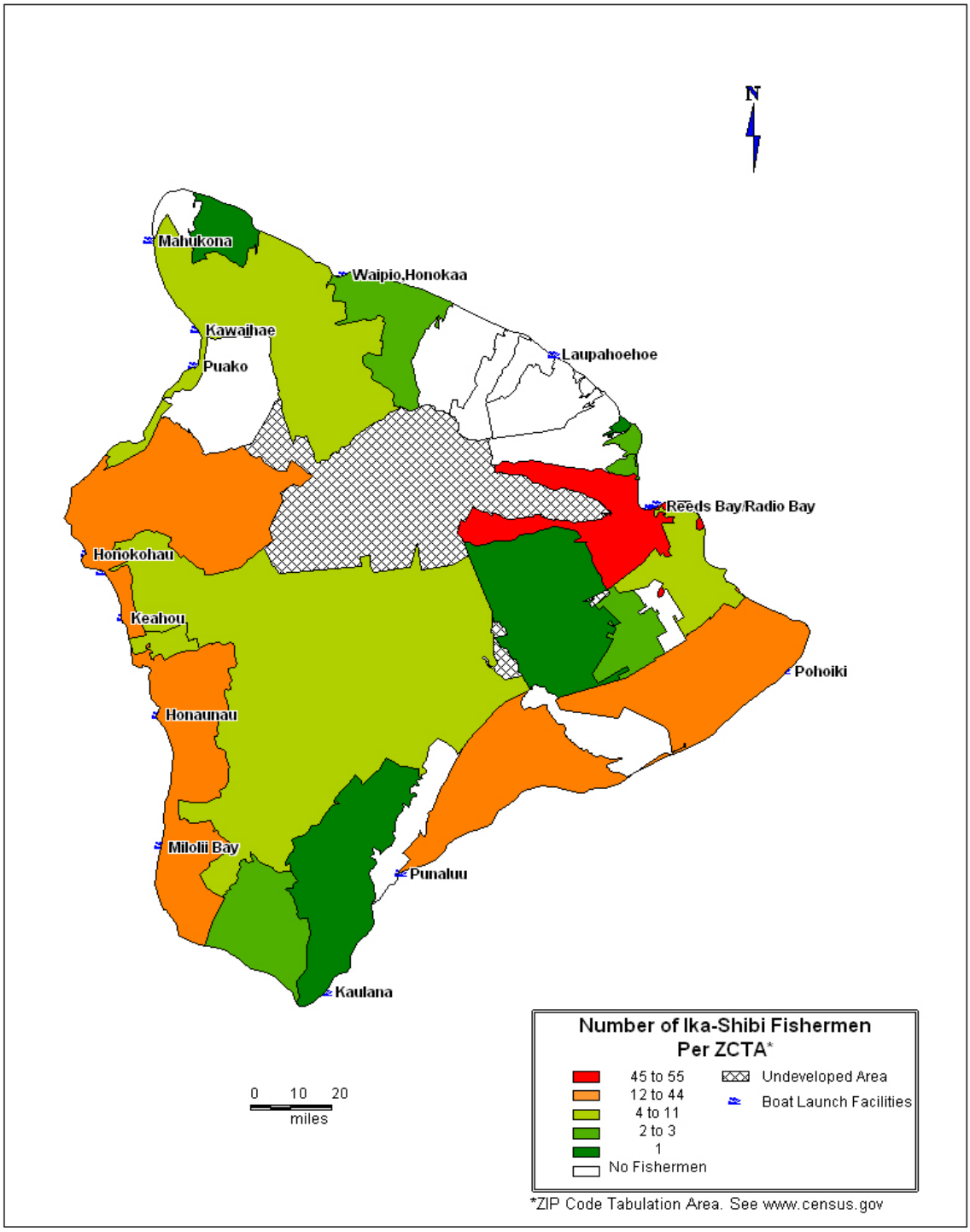
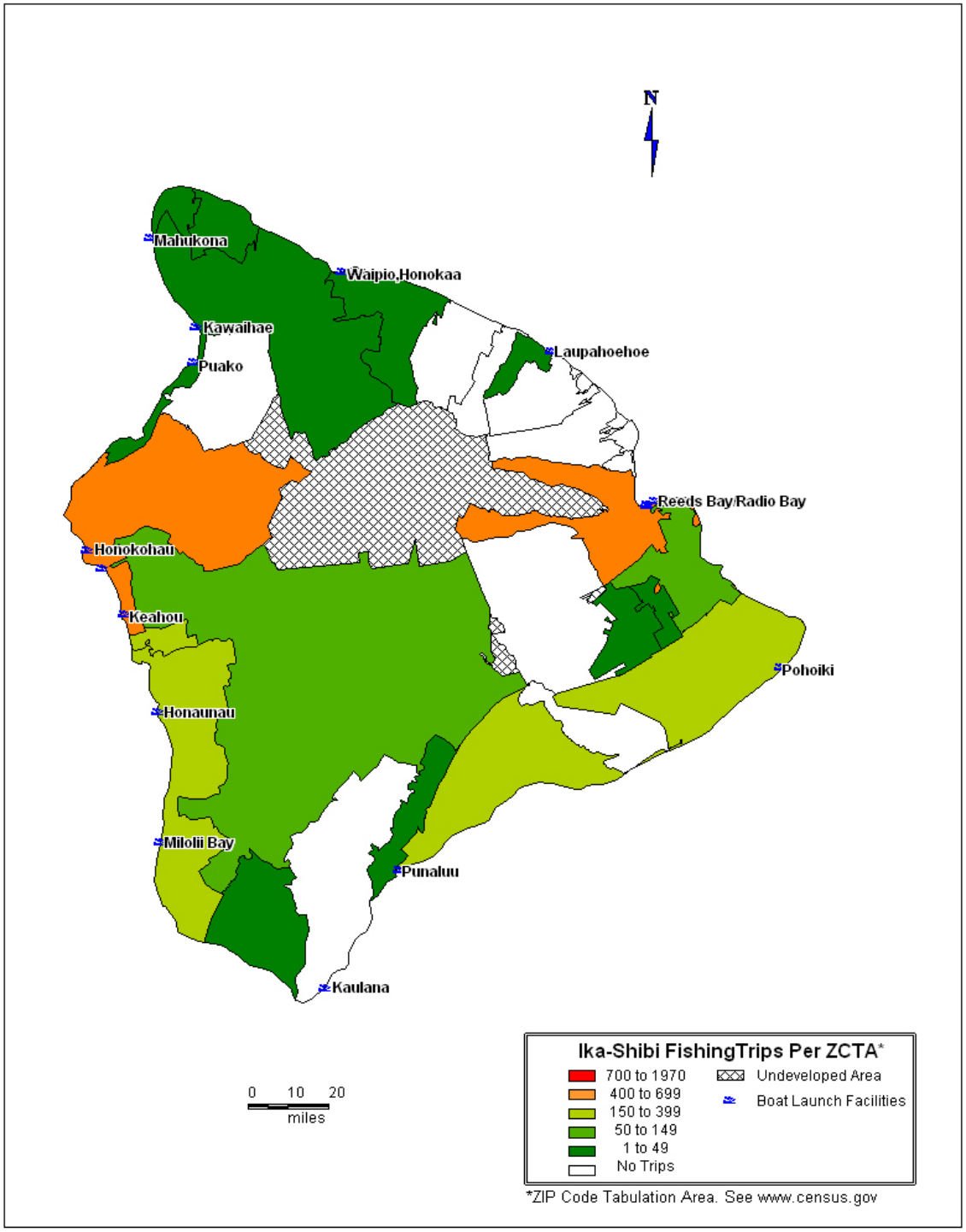


Figure 3-18 Reporting Ika-Shibi Participants by Place of Residence: Big Island 2004



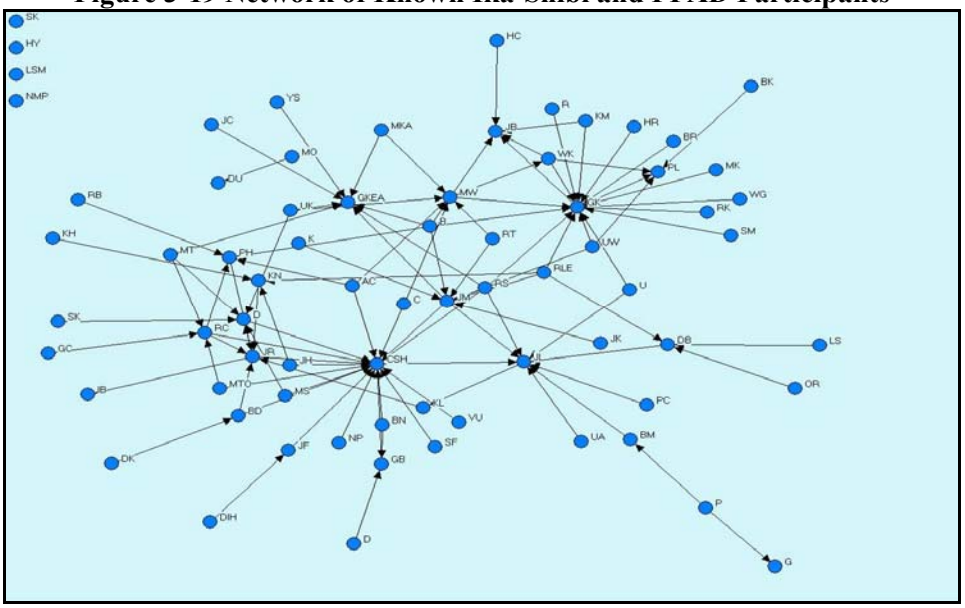
3.2 Establishment of the PFAD Fishery

Our original research into the Hawai‘i ika-shibi fishery and its apparent trend of decline ultimately led to examination of the possibility that numerous former ika-shibi fishermen had moved to a fishery with a more recent history in Hawai‘i - that associated with PFADs. The cogency of this question was furthered by the recent determination of BET overfishing, since it has often been asserted that juvenile BET are frequently landed at PFADs.

Given the topical and methodological focus of this research on human dimensions of the fisheries in question, we set out to better understand from sociological and economic perspectives the decline of the ika-shibi fishery and apparent proliferation of the PFAD fishery. We did so in part by identifying and consulting long-time handline operators who would likely be highly familiar with both fisheries. A social network sampling process was used, wherein persons widely known to possess expertise in and/or knowledge of the fisheries were interviewed and asked to provide the names of similarly knowledgeable persons.

We thereby arrived at a preliminary sample of experts, which was subsequently validated by long-time observers of the fishery. The process of establishing rapport and interacting with the informants was then initiated, with the ongoing goal of widening the network of known fishery participants. Figure 3-19 depicts this network of informants, as determined during its early development. The most seasoned or putatively knowledgeable participants are depicted at the core of multiple incoming arrows, as these represent such status as determined by nominations among the network of peers. The reader is referred to Hanneman (1999) for technical discussion of this research methodology. We have identified a core group of roughly 25 prospective PFAD participants residing on the Big Island. Extent and manner of participation varies within this group, and in reality there were roughly 12 to 15 avid participants in 2005. However, as noted in Section Four of this report, avidity tends to vary in relation to resource availability, and we believe that fewer fishermen were involved in the fishery during the winter of 2006.

Figure 3-19 Network of Known Ika-Shibi and PFAD Participants



The aggregating efficiency of FADs was and is well known to participants in the Hawai‘i handline fishery. In fact, our research with long-time handline fishermen on Hawai‘i Island indicates some ongoing resistance to the program by fishermen who believed (by logic and/or experience) that the buoys did effectively attract BET, ‘ahi, and other species. This is at the expense of prospective or historic aggregation at bathymetric features (such as ko‘a) that had been traditional components of the fishing grounds. Some fishermen from the period also feel that the buoy system increased general small-boat fishing traffic on the water, and led to increased pressure on the resources. While these may have been consequences, the intent of the program was and is to enhance fishing opportunities for the general public:

> Encouraged by the successful results in Hawaiian waters, the Department of Land & Natural Resources, Division of Aquatic Resources, proposed establishing a system of Fish Aggregating Devices (FADs) in 1979 to revitalize the fishing industry and increase sport-fishing opportunities. The State Legislature appropriated funds for the Department to develop and establish the FAD system. Today, principal funding is derived from the Federal Aid in Sport Fish Restoration Program (Fish Aggregating Device Program, State of Hawai‘i 2006).

FAD technology is straightforward; real working models were readily available and heavily trafficked, and no regulatory structure was originally extant to govern their emplacement and use. As such, it should not be surprising that enterprising fishermen would begin building their own devices and strategically locating them in favorable areas around the island (such as above areas of sharp bathymetric relief and associated current patterns). The apparent originator of the trend is well-known among our sample of operators, and it is believed that his PFAD operations have been ongoing since at least 1995. One source suggests a much earlier date of establishment - not long after the state FAD program was initiated. Activity increased significantly around 1999. In any case, the motivation and potential benefits are obvious: by emplacing aggregating devices on a private basis in favorable locations, individuals or small groups of fishermen were able to approximate or surpass the effects of the state buoys, but without the associated traffic and site-specific fishing pressure. Reports of multiple thousands of pounds of BET per trip were not uncommon during past seasons.

As noted in the inset description below, large FADs tend to aggregate tunas more effectively (Nelson 2003), as do multiple FADs, and these obvious rules of thumb are not lost on local fishermen. But there is interplay between incentives, costs, and benefits. While some operators report having grossed as much $200,000 during years of peak operation and production (such as during 2000), abundance of tuna has reportedly varied dramatically. Moreover, depending on quality and extent of materials used, PFADs can cost as much as $10,000 to establish, and depending on weather and sea states, the lifespan of the devices can be quite short -sometimes no longer than three to six months. Using available materials rather than purchasing new components can help cut costs, but may also reduce the lifespan of a given device. The process has been characterized by innovation, trial and error, engineering, capital outlay, and occasionally significant payoff.

Derelict PFAD Found along the South Shore of Oʻahu
(Photo courtesy of David Itano)

Because PFAD-related profit is perceived or experienced to result from opportunities to fish around an aggregating device in the absence of other fishermen, secrecy of emplacement and fishing operations has been the norm. Captains typically transport and set their devices under cover of dark, and take accurate GPS readings before returning weeks later to assess extent of resident biomass. The devices have occasionally been found by accident, and a few captains known to be establishing and fishing FADs have been followed to their devices. In some cases, use rights were asserted and defended, and there have been instances of threats and limited violence following the purposive locating and fishing of devices established by other fishermen.

Moreover, a few PFADs reportedly were emplaced upstream of traditional ika-shibi grounds north of Hilo. This has led to some inter-fleet conflicts, in that some shibi-focused captains believed the PFADs were disrupting established tuna migration routes and behaviors. There has also been some concern about interaction between PFAD and longline operators working in distant waters northeast of Cape Kumukahi during the winter months. Relatively few PFAD fishers operate vessels of sufficient size for establishing buoys in this area, however, and in fact a very poor winter run of BET rendered this issue largely superfluous in 2006. While interaction issues are periodic in nature and in this case have tended to resolve over time, historic events, uneasy perceptions, and secrecy have rendered this research quite challenging. Although we have uncovered information about the specific location of numerous PFADs, we cannot and do not compromise the proprietary nature of that data.

But because large ocean distances are involved, and because the devices are by design often difficult to visually locate (some are now kept at depth), we do provide a (very) general indication of location and reported extent of catch and effort (Figure 3-13 below) associated with PFADs around the Big Island. The maps derive from HDAR catch reports from our sample of known PFAD operators. Interpretation of the data must therefore be conditioned, as the summary may not be exhaustive of the full universe of fishermen who have established and/or exploited the devices over the period of interest.

Thus, it should be noted that the map depicting 1995 data (Figure 3-20 below) indicates participation and production by both the PFAD originator and other fishermen who were at that time pursuing BET, ‘ahi, and other species at the traditionally frequented ko‘a, state buoys, and other localized features with a variety of gear types. As information about the efficacy of PFADs was gradually communicated between and across individuals and small groups of cooperating fishermen (hui) and non-cooperating fishermen, more became involved, capital was located, and more devices were constructed and emplaced. It was estimated that nearly 50 devices were operational around the Big Island by the 2002 winter season. Based on trends in species composition of landings by our sample (Figure 3-21), we surmise that numerous focused PFAD operations began in 2001. Key informants on Kaua‘i report little PFAD-related activity.

Figure 3-20 Spatial Patterns of Reported PFAD Activity

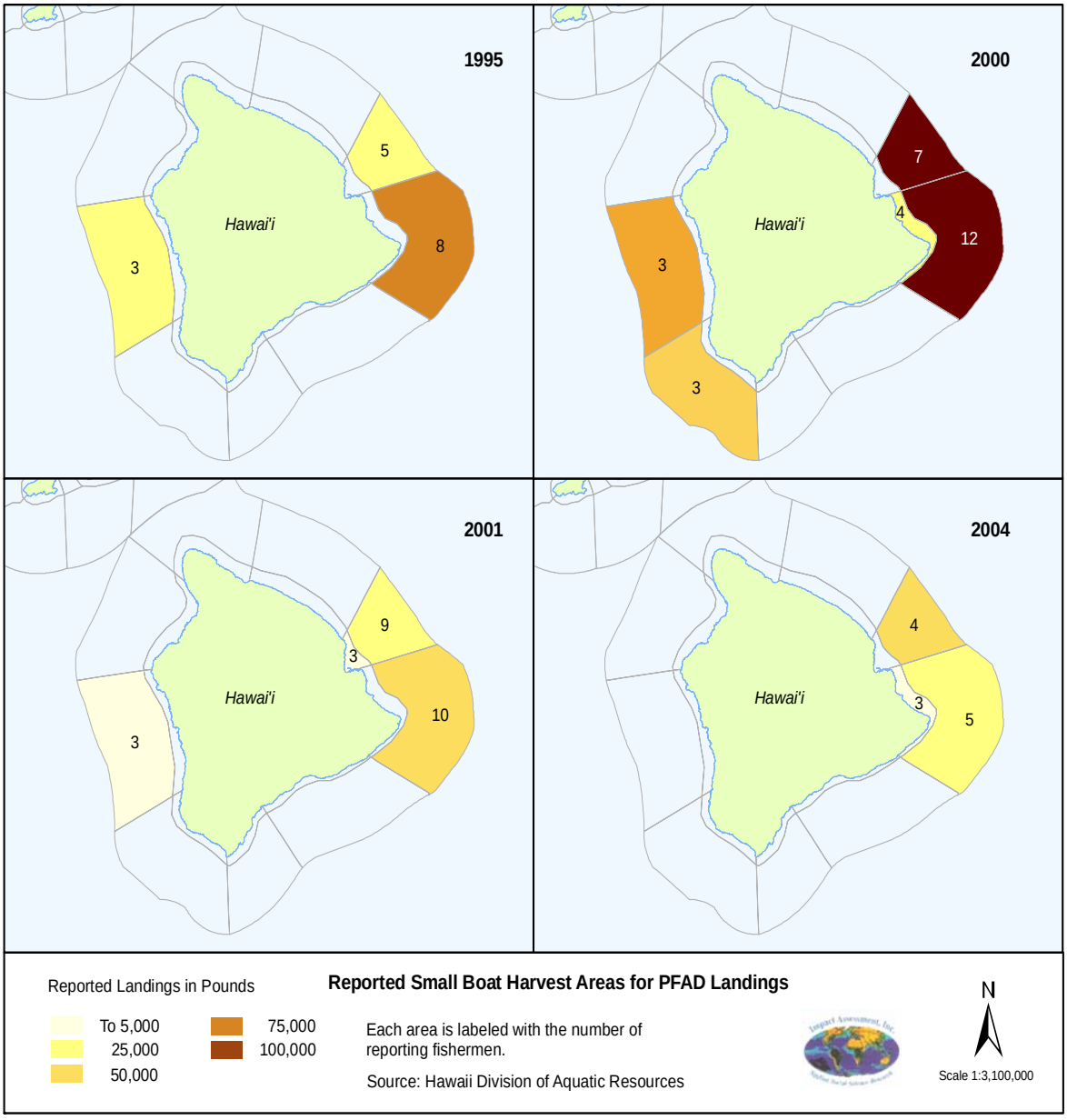
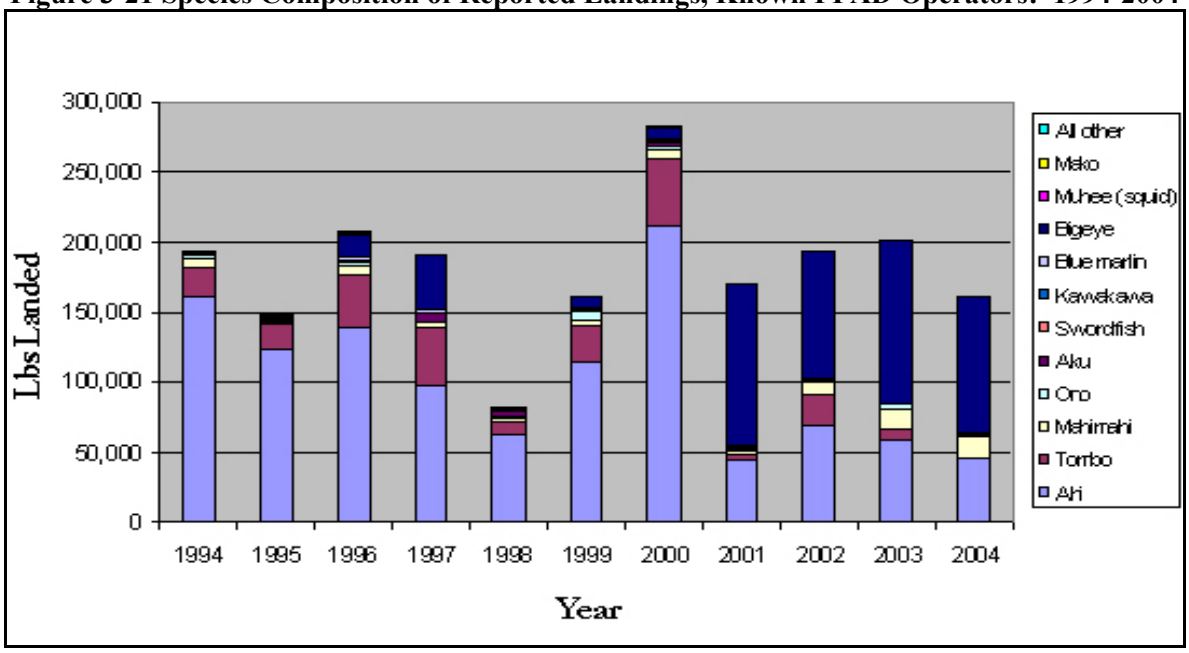


Figure 3-21 Species Composition of Reported Landings, Known PFAD Operators: 1994-2004



Despite reportedly highly productive and lucrative recent seasons, key informants and landings data (Figure 3-22 below) indicate that the PFAD fishery may already be undergoing a period of decline. Some of the factors associated with the downward trend are known and are similar to those affecting the ika-shibi fleet, as discussed in further depth in Section Four of this report.

For example, trip costs have increase in that ice is increasingly expensive and fuel prices have risen dramatically. The latter is reportedly particularly significant since some PFADs have been emplaced many miles offshore. The cost of constructing, emplacing, and replacing ephemeral PFADs should be kept in mind. Resource abundance issues have apparently also affected participation and production. PFAD-related landings reportedly diminished somewhat in 2004 and 2005 and, in fact, conditions over the course of the current year have forced some to consider discontinuing their operations.

In any case, the initial extent of participation and trends in production indicate that the PFAD fishery has not incurred a wholesale shift of effort away from the ika-shibi fishery, nor has it been a panacea for the PFAD operators themselves. Rather, use of ika-shibi and palu ‘ahi methods continue in diminished fashion, often by part-time commercial operators. Use of PFADs has been periodically highly productive and profitable for a relatively small number of fishermen and crew.

Of note, profitability appears to relate in part to one's ability to maintain good relationships with seafood buyers in the area. This appears to have been possible for relatively few fishermen. Some fishermen assert that when the Suisan auction closed in 2001, opportunities for the typical ika-shibi, palu ‘ahi or troll fisherman to readily sell their products were altered, and cost-

effective distribution of their products became more challenging. Interview data suggest that the highliners who had developed strong and resilient relationships with buyers were "pre-adapted" to investment in and operation of PFADs. This was furthered by capital investment in relatively larger boats, though PFADs reportedly have also been installed by captains and crew operating very small vessels.

Figure 3-22 Reported Landings, Known PFAD Operators: 1994-2004

Source: Hawaii Division of Aquatic Resources

PFADs have been controversial in Hawai‘i (and elsewhere). In addition to issues and events associated with secrecy and breaches thereof, their use gained attention from both state and federal governments as potential hazards to navigation and as difficult to assess components of pelagic fisheries. The U.S. Coast Guard now requires operators to submit a statement of consistency from the Hawai‘i Coastal Zone Management (HCZM) Office, and if emplaced in federal jurisdiction waters, the operator is encouraged to consult with NOAA Fisheries on endangered species issues. If the device is to be emplaced within state jurisdiction waters, permits must be secured from the Army Corps of Engineers, the Hawai‘i Department of Land and Natural Resources (DLNR), and the HCZM. The Council continues to assess the Hawai‘i PFAD fishery as enacted in the Exclusive Economic Zone (EEZ).

At present, PFADs continue to be used under the limiting parameters of operational and market economics and as availability of resources allow. Given that the PFAD fishery is by nature secretive, and that it occurs over such a broad expanse of open-ocean, effective implementation and enforcement of regulations may be a highly challenging venture.

Inset C **PFADs and Associated Methods**

Privately-established fish aggregating devices (PFADs) appear to have proliferated in Hawai‘i during the mid-1990s following the success of an innovative local handline fisherman in the waters offshore the Hilo side of Hawai'i Island. Some unverified reports suggest a much earlier start to the trend, perhaps as early as the point of establishment of the State of Hawai‘i FAD program around 1980. BET, ‘ahi, and other species are typically landed at PFADs. The winter season is BET-focused, though the devices also effectively aggregate ‘ahi and other fishes throughout the year. The technology is straightforward and effective, but mooring and float systems and associated components can vary extensively and, in Hawai‘I, these tend to reflect a balance between cost and effectiveness. Drifting FADs are not used by small-boat captains active in the region.

The reader is referred to Chapman et al. (2005) for discussion of FAD planning and construction in the Pacific. In essence, anchor and chain of sufficient capacity are used to retain an appropriate length and thickness of polypropylene line that, in turn, is shackled to a float system. The surface buoy or other flotation, streamers, and associated hardware attract biomass, bait, and ultimately pelagic fishes. Nelson (2003) reports that size of FAD is correlated with aggregating efficiency, and Hawai‘i handline fishermen have experimented with various floating objects such as old boat hulls, multiple buoys, and so forth.

Many operators use multiple devices in close proximity to enhance aggregation. Persons constructing FADs in Hawai‘i have learned through trial and error to configure and construct them in a manner that will enable maximum life in the highly dynamic ocean environment that is the Pacific Ocean around the Hawaiian Islands. The full range of handline techniques are used at PFADs in Hawai‘i. Trolling methods are also used while steaming to and in the vicinity of PFADs. Some PFADs have been fitted with electronics that allow them to be located and/or monitored in some fashion, though the most common means of locating the devices is via GPS readings.

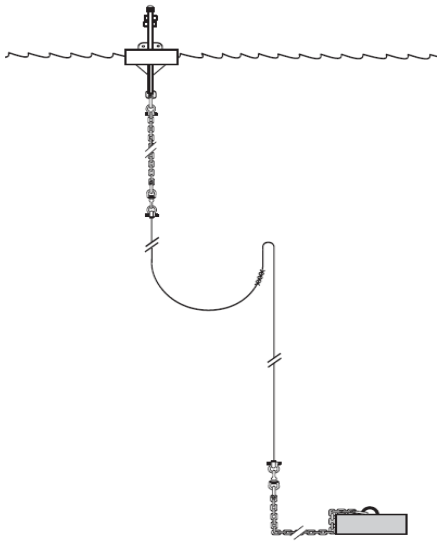
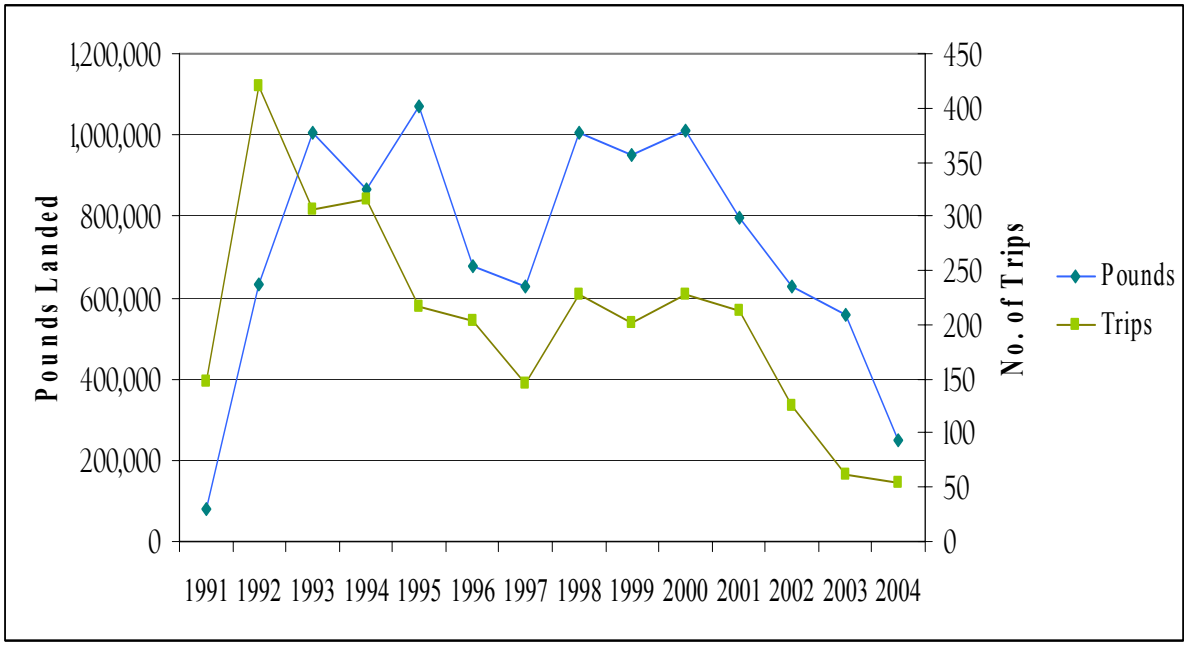


Illustration from Chapman et al. (2005:8)

3.3 Recent Trends in the Cross Seamount and Weather Buoy Fishery

Data from reporting participants in the Cross Seamount and weather buoy handline fisheries indicate a peak period of effort in the early 1990s and peak landings in the late 1980s and mid-1990s (Figure 3-23). As noted in Section Two of this report, participation in the fishery peaked in the mid-1990s with between 14-20 active captains. Catch and effort appear closely related from that period through the present. There has been a clear and steady decline in catch, effort, and participation after the year 2000. By the end of the reporting period, only three to four captains were actively and regularly fishing in the offshore zone. Long-term participants report that many operators dropped out of the fishery subsequent to increasingly challenging economic factors, including cost of fuel and challenges at the marketplace.

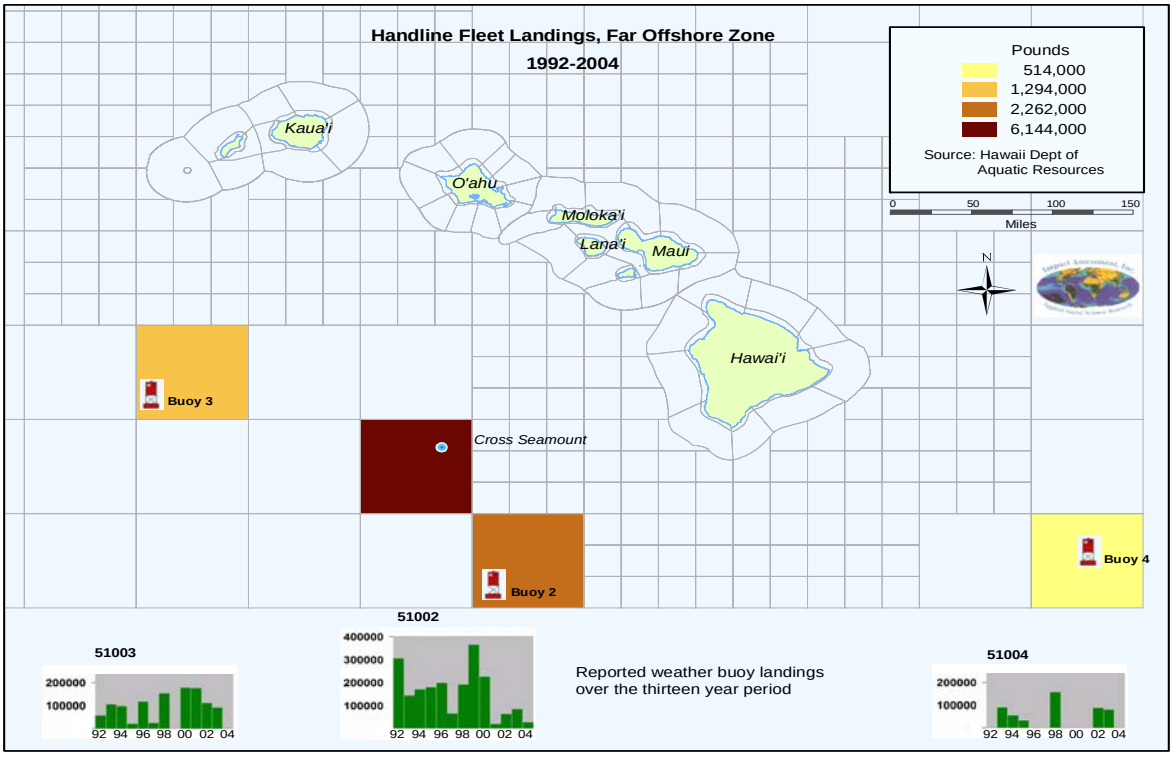
Figure 3-23 Trends of Catch and Effort in the Cross Seamount/Weather Buoy Fisheries: 1991-2004



Offshore Handline Vessel with Hydraulic Line Puller, Kewalo Basin, 2006

As noted in Figure 3-24 below, Cross Seamount has been the primary focus of the offshore handline fleet during recent years. Extensive landings have occurred over time at Buoy Two, with smaller volumes of landings at Buoys Three and Two, respectively. Activity at all far offshore locations has been minimal over the past two reporting years. Key informants report that there may have been some fishing activity at Buoy One northwest of Kaua‘i over the recent period, but HDAR catch report data do not concur.

Figure 3-24 Reported Landings at Cross Seamount and Weather Buoys: 1992-2004



An early pioneer of the far offshore handline fishery reports that theft of his hydraulic line pullers while moored in Honolulu led to some creative thinking during a bite at Cross Seamount. He subsequently rigged a drum with a short length of reserve longline gear and proceeded to the grounds. Subsequent use and experimentation with the gear is described in Itano (2004). In sum, observation of longline operations and use of vertical longline gear at Cross Seamount made clear that when set relatively deep, such gear enabled landing of relatively large BET. It was found that that this could be replicated with precision by setting the short longline-type gear up-current and at appropriate depth and time of day over the seamount. This new fishery appears to be highly effective and is as-yet unregulated, since longline gear less than one nautical mile in length is not addressed by existing management plans.

Inset D **Deep-Set Horizontal Gear**

During the 1990s, handline operators working at Cross Seamount recognized the potential of dropping long, weighted mainlines with baited staggered branch lines from sea surface to seamount summit. The rigs were buoyed at the surface. Success in landing relatively large BET with this "vertical longline" method made clear the desirability of relatively deeper sets (and multiple hooks) than were typical with normal handline gear at the seamount. This later influenced one of the long-term seamount fisherman who began experimenting with deep-set short longline or "short-line" gear. The gear configuration holds promise for reducing landings of juvenile BET and may enhance quality in that fish are said to typically die on the line at depth.

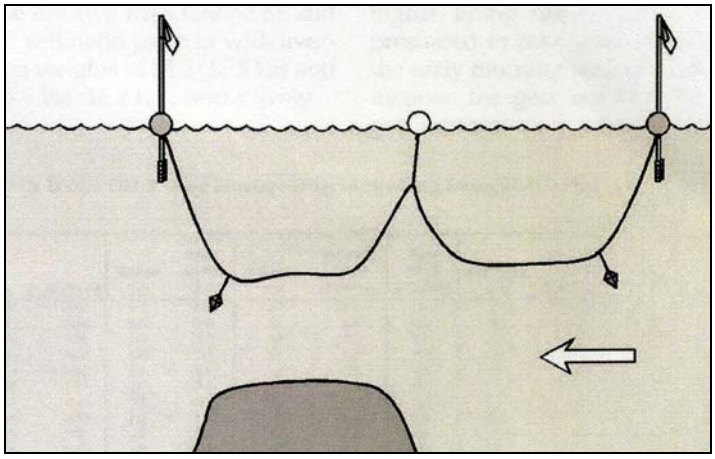


Illustration from Itano (2004:23)

4.0 Summary Analysis and Conclusions

This section revisits major trends and changes in Hawai'i handline fisheries. These are explained in terms of various macro- and micro-social, economic, and cultural factors affecting the fisheries both from within and without. As the patterned history of change bears implications for the future of the fisheries, a concluding sub-section is provided to review those factors in the context of prospective management possibilities. We note that the discussion is preliminary in nature, with finalized analysis pending completion of fieldwork and archival data analysis associated with the aforementioned ongoing PFRP study.

4.1 Social, Economic, and Temporal Dimensions of Change in Hawai'i Handline Fisheries

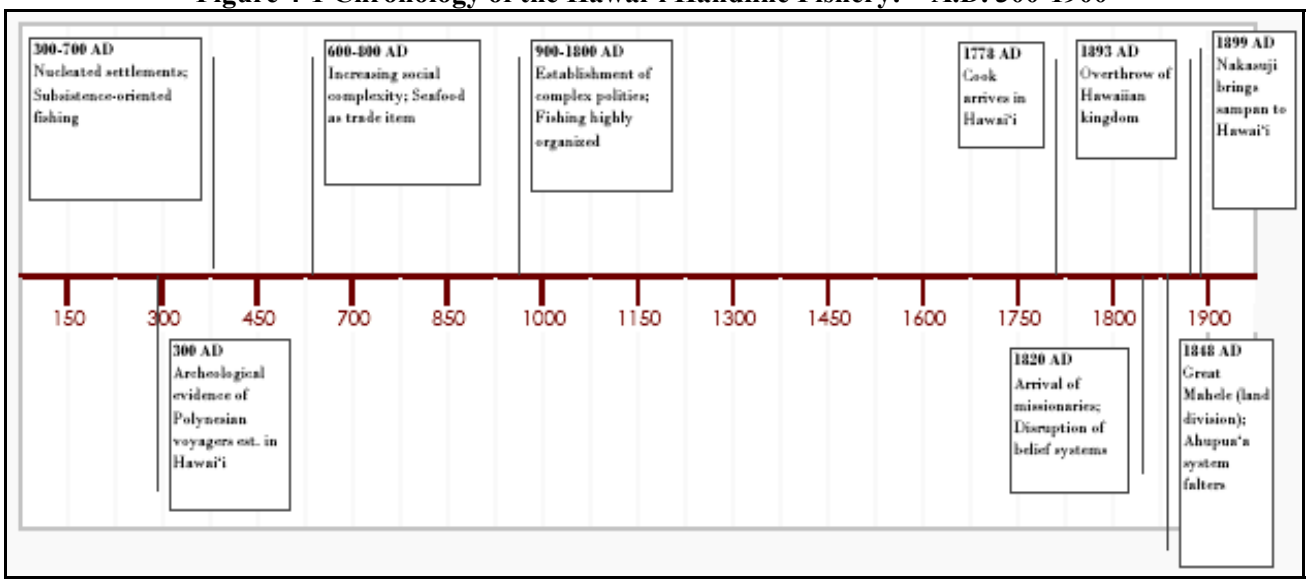
Fishing and Change in Early Hawai'i. The history of deep-sea fishing as conducted by Native Hawaiians is directly relevant to the current analysis. In that case, it is clear that macro-social changes preceded both development of the fishery and its ultimate decline.

As clearly indicated by oral tradition, archaeological evidence, and logic, the early Polynesian navigators were accomplished in the pursuit of pelagic species. A number of researchers have developed evidence-informed models regarding the course of societal development and change in Hawai'i (e.g., Hommon 1976, and Cordy 1981), and fishing is critically important in all cases. Kirch (1985) has also developed a useful model of social change. While new developments in Hawaiian archaeology are modifying thinking about dating and the nature of indigenous society and culture, we base our discussion on his work as it is both synthetic of his predecessors and cognizant of the need for receptivity to new research developments.

In his discussion of initial colonization (~A.D. 300-600), Kirch (1985:298) postulates that the earliest voyager-settlers hailed from the Marquesas. This is indicated in part by the stylistics of their fishing gear. Various fishing and food collection practices sustained small nuclear colonies, in conjunction with tending of rudimentary root crops brought from other lands. Pelagic species were pursued, as evinced, for example, in the rich middens found at Ka Lae on the Big Island. Kirch asserts that political leadership was probably established in a manner typical across early Polynesia, and that it may be characterized as hereditary chieftainship. Relatively little social stratification existed between leaders and other residents during this early phase of development (p. 302).

But as the colonies grew and expanded into new resource zones during a developmental phase (A.D. 600-1100), a distinctly Hawaiian culture and society began to emerge. There were advances in cultivation practices, and Kirch writes that "the fishing gear, in particular, reflects successful adaptation to local marine environmental conditions and material constraints" (p.303) This is clearly indicative of the importance of fishing in the transformation from colony to established societies. As culture and societal norms developed in response to adaptive needs, the population further increased, with as many as 20,000 persons living in the region at the end of this period. Some degree of sociopolitical complexity is evinced in increasingly elaborate burial practices that involved differential treatment of chiefs and commoners.

Figure 4-1 Chronology of the Hawai‘i Handline Fishery: ~A.D. 300-1900



Kirch (1985:303-306) also describes a period of rapid expansion (A.D. 1100-1650) during which social groups expanded to take advantage of available resources throughout the islands. Economic production increasingly involved complex systems of agriculture and irrigation, and there was extensive craft specialization and division of labor. Settlement of new areas under conditions of rapid population growth also led to territorial political organization and inter-group competition for resources. Economic specialization in the realm of fishing and crafting of fishing accoutrements was particularly notable (p. 305). Kirch states that while a distinctive one-piece fishhook design from this period indicates the arrival of immigrants from the Society Islands (p.304), this was of relatively insignificant influence given the rapid internal development of indigenous society and economic specialization. The ahupua‘a system was established during this period - in association with increasingly complex and competitive polities. Trade and tributary distribution of seafood were important aspects of social and political life.

Finally, the author describes a proto-historic phase (A.D. 1650-1795) during which economic specialization and production through agriculture, aquaculture, and fishing practices continued "under the auspices of the chiefly class" (p. 307). There was continual political expansion and conquest between polities on and between the islands. At least 200,000 persons inhabited the Islands just prior to contact, though some scholars argue a much higher number. Following initial contact, and more significantly following sustained interaction with Europeans arriving at the end of the 18th century, foreign items and concepts began to influence a fully established social order and the specialized systems of economic production that had sustained island residents for so many centuries.

Fishing was central to the established system of economic production during each phase of development in ancient Hawai‘i. As previously described, the importance of fishing had evolved to a point at which society was in part organized around the conduct of fishing practices, the crafting of fishing accoutrements, and the production and distribution of seafood. In sum, indigenous populations grew in relation to the critical knowledge and social capital needed to land fish and provide protein to residents of the various colonies and polities.

It was this "critical mass" (Itano 2005) of fishing-related social capital, knowledge, and material culture that was so rapidly affected by the people, ideas, and materials that arrived with the Europeans. The social and economic processes that supported the highly specialized crafting of fishing line and hooks and advocated expertise and cooperative endeavors at sea ultimately failed following the Great Mahele and the dismantling of the ahupua‘a system of managing resources of land and sea. Radical demographic change in the form of severely reduced populations and attendant shifts in governance and social structure had an obvious and immense effect on individual and collective capacity to continue the pursuit of pelagic fishes on the open ocean.

The subsequent years involved adaptation to radically new conditions, and inevitably to blending of long-established principles and knowledge with new materials and ideas. A brief period of flourishing commercial fishing activity on the part of Native Hawaiians was quickly superseded by in-migrating fishermen. A new kind of fishing-related critical mass was established in the 20th century, and indigenous fishing practices and knowledge receded into the background after a period of development that lasted nearly 2,000 years.

Handline Fishing and Social Change in the First Part of the 20th Century. The *issei* and their progeny brought expertise and materials from Japan to conduct marine fisheries in a manner well-suited to the new economy of 20th century. It is perhaps highly significant in this analysis that Gorokichi Nakasuji, the original *issei* innovator, was backed with capital in his pioneering commercial fishing efforts in Hawai‘i. It appears that this was pivotal in enabling an era of successful at-sea operations and development of a profitable system of seafood distribution.

As was the case for the early Hawaiians, cooperative ventures were essential to the success of the immigrant commercial fishermen. Schug (2002) reports that the expansion of commercial fisheries in the early 20th century was based in the efforts of tightly-ordered societies of fishermen, and the support of their families. Relationships between the fishermen and a closely-knit network of buyers, auctioneers, and distributors were similarly important and enabled highly successful ventures on both sides of the equation.

Relatively little is known about the original ika-shibi fishermen in Hawai‘i. But we do know their roots were in Okinawa Prefecture - an island region where, as in ancient Hawai‘i, society was ordered in large part around the production of seafood, and where deep sea fishing skills were highly valued. The innovators were undoubtedly drawing on old skills and knowledge, and their operations benefited from close cooperation and familial support. Moreover, even at this early stage, the harvesters were working closely with buyers and marketers at Suisan Kabushiki Kaisha Ltd.

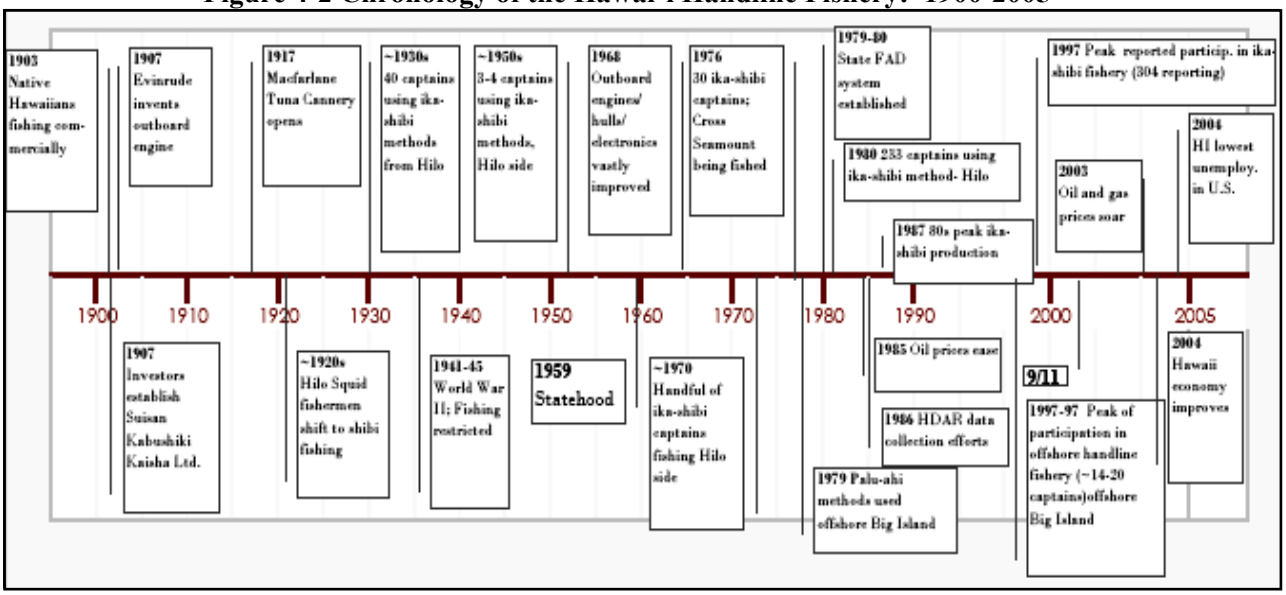
During World War II, fishermen across the Hawaiian Islands were limited to shoreline and occasional nearshore fishing opportunities. The era presents a clear example of the dramatically dampening effect that macro-social processes can have on the conduct of marine fisheries. In this case, war essentially terminated the commercial fisheries then being conducted by the *issei* and *nissei.* This severely reduced the amount and variety of seafood available in Hawai‘i, while perhaps strengthening relationships between Native Hawaiians and immigrant populations, both of which encountered significant economic challenges during the period.

The Land-Based Job-Commercial Fishing Dynamic. Economic opportunities and conditions gradually improved after the War, as did the materials and technology that enabled small-scale fishing. The ika-shibi fleet expanded, and it is at the point that dynamic interaction between employment and wages, generation of capital, and part- and full-time commercial fishing endeavors became important. Some prospective local captains were able to draw on inherited or earned capital in order to buy vessels and gear and begin earning money by fishing on a commercial basis. Some succeeded to an extent that enabled full-time fishing activity for at least part of the year. Others fished commercially on a part-time basis.

These historical patterns are critical in this discussion in that they relate to the contemporary conduct of commercial small-boat handline fisheries in Hawai‘i. Of note, small-boat operations are dissimilar to the more heavily capitalized, vertically-integrated, and expense-laden large-vessel commercial operations such as those of the Hawai‘i-based longline fleet. The latter often require that fishing continues regardless of physical environmental conditions or conditions at the marketplace. Small-boat operations, on the other hand, are such that fishermen can maintain some degree of flexibility in lifestyle. For example, they may fish while resources are abundant or market prices are favorable, and revert to land-based jobs when such conditions are not so amenable. Land jobs may not only meet the demands of the household, but also facilitate future fishing activity and ongoing payment of relatively small boat loans and other fixed costs. When boats and gear go unused, the capital investment may lay dormant as captain and crew await future opportunities to generate revenue by fishing.

But some captains are highly dedicated in various ways to commercial fishing. Some ventures have been periodically highly lucrative, and the goal of maintaining or re-gaining profitable operations is highly motivating. The non-monetary benefits of the lifestyle can also tend to influence some operators to continue fishing, or to focus primarily on fishing regardless of economic constraints. Freedom from the workplace on land and the basic enjoyment of pursuing fish on the open ocean are strong motivating factors for many. These situations and concepts are useful efforts to explain post-War and more recent trends in the Hawai‘i handline fisheries.

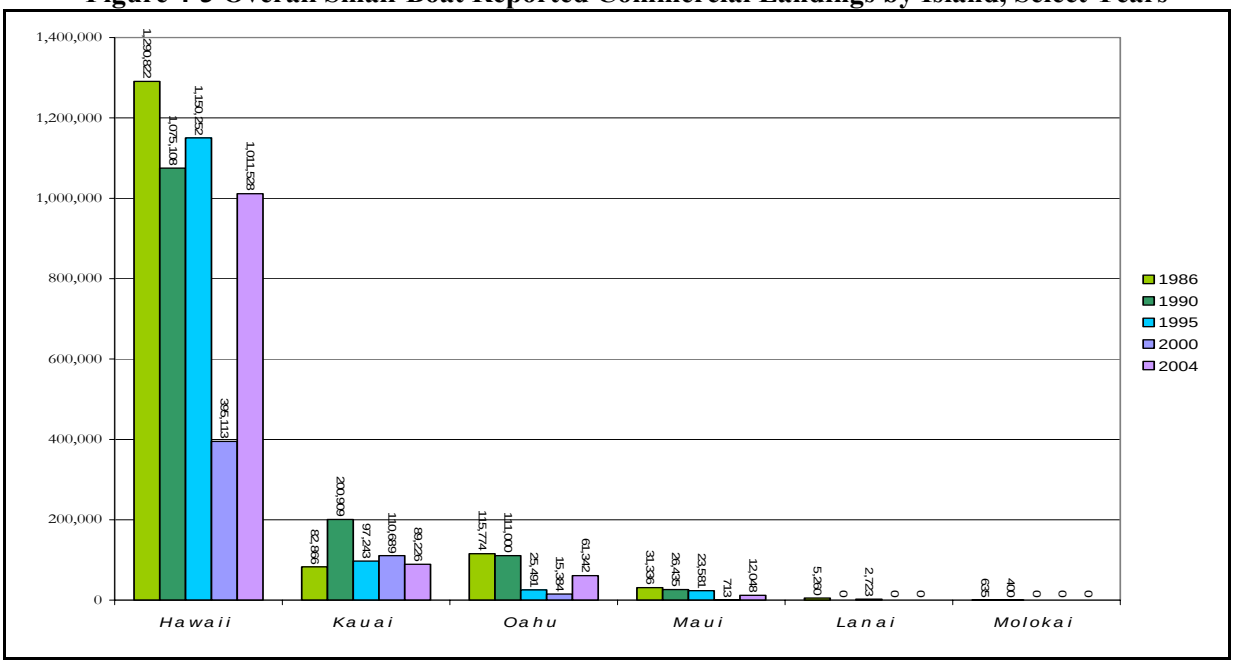
Figure 4-2 Chronology of the Hawai‘i Handline Fishery: 1900-2005



Regarding Recent Trends. Based on findings from both primary and secondary source research, it is clear that participation and production in the ika-shibi fishery has fluctuated most obviously in association with the availability of tuna. There have been periods of extensive and profitable activity, but these have been followed by decline. The initial boost of activity from the mid- to late 1970s was followed by a period of declining participation and production that HDAR explained in terms of "noticeable decline in availability of large tuna," financial burdens associated with capitalization amidst declining catch rates, and marketing problems.

Subsequent improvement of the fishery from the mid-1990s to 2000 has been followed by another period of significant decline that continues into the present. The downward trend parallels that of small-boat fisheries in the MHI as a whole, but with greatest relevance on the Big Island, where the vast majority of small-boat landings occur (Figure 4-3).

Figure 4-3 Overall Small-Boat Reported Commercial Landings by Island, Select Years



Source: Hawai‘i Division of Aquatic Resources

Assuming favorable prices at the point of distribution, and stable trip costs, a steady supply of large pieces would quite obviously have satisfied the operators and led to ongoing and perhaps increasing participation (and levels of production) in the fishery over the years. But the fishermen contacted for purposes of the research almost universally claim that the current period of decline relates to the same explanatory factors advanced by HDAR in the 1980s. That is, the fishermen assert that large BET and ‘ahi individuals have become increasingly scarce. They also typically assert that market factors are increasingly challenging and trip costs have risen steadily.

Constraints related to resource availability, market conditions, and operational economics are obvious and empirically verifiable. Some explanations are more difficult to substantiate and, while one objective of the current research is to document the varied perspectives of fishery participants, verification of certain statements is obviously beyond the scope of the project and within the scope of related biological and oceanographic research.

One such assertion is that there are regional BET and ‘ahi populations and that the genetic composition of these may have been altered through selective removal of large individuals earlier in the history of the ika-shibi and related fisheries. Others argue that the State-maintained FADs and more recently the PFADs have altered former migration patterns of BET and ‘ahi, thereby reducing opportunities for ika-shibi and palu ‘ahi fishery participants to land large and/or many pieces in the traditional grounds. Long-time observers of the handline fisheries will note that the latter argument is similar to assertions once commonly made by small-boat operators: that Hawai‘i-based longline fleet operations have changed regional or local migratory patterns of tuna and/or otherwise reduced abundance of the targeted resources. More recent media discussion of distant purse seine operations now also appears to have influenced the explanations of fishery participants.

We cannot at this point in our ongoing research empirically verify with a high degree of confidence that broad economic forces have affected recent trends of participation in the Hawai‘i handline fisheries. But based on analysis of historic trends and events, we assert that this is a reasonable hypothesis warranting further examination. As indicated above, previous work in this and other regions suggests that a reliable source of income- such as a land-based wage job- enables commercial fishery participants to continue fishing on a flexible basis even during periods of low resource abundance and/or other when other challenges constrain operations. Thus, when the economy falters and jobs become less available, one would expect that it would be difficult to continue fishing. But, again, in the case of the Hawai‘i handline fleet, it appears overall participation may actually tend to increase during periods of regional economic decline.

This may have occurred during the regional recession of the 1990s, when the rate of unemployment on the Big Island increased to ten percent, and participation in the ika-shibi fishery reached peak levels. The situation suggests that many operators may turn to fishing to supplement or earn income during difficult times. But it should be noted that participation does not necessarily equate with effort and, in fact, there was a steady decrease in the number of reported trips throughout the period. Thus, as discussed above, it may be that once small-boat operators have acquired vessel and gear, these may be reactivated during periods of economic decline with the intent of supplementing household income and/or landing fish for consumption - provided trip costs can be covered. It is uncertain, however, how long such operations can be sustained, given the various constraints. Additional examination of patterns of part- and full-time participation and full departure from commercial fishing during periods of macro-social or economic change is required to further our understanding of these processes. Historical patterns of change in Hawai‘i pelagic fisheries clearly argue for such analysis.

Innovation and Persistence. As noted above, some commercial fishermen disdain land-based work. Some are particularly talented at their trade and persist despite the cyclic nature (or increasing trends) of challenge. Persistence and innovation tend to go hand-in-hand. Our sample of key informants include those who initiated the PFAD fishery, the Cross Seamount and weather buoy handline fishery, vertical longline gear, the dangler fishery (a short-lived pole and line tuna fishery), the new deep-set "short-line" fishery, and mixed or hybrid methods in a single trip (including danglers). These participants tend to be resilient and akamai (knowledgeable) of the resources, the ocean and climatic environments, the gear, and the market. Of significance, some have managed to develop and maintain good working relations with seafood buyers and distributors. But even the hard-core operators among this group report occupational plurality and the need for flexibility and opportunism in their fishing operations.

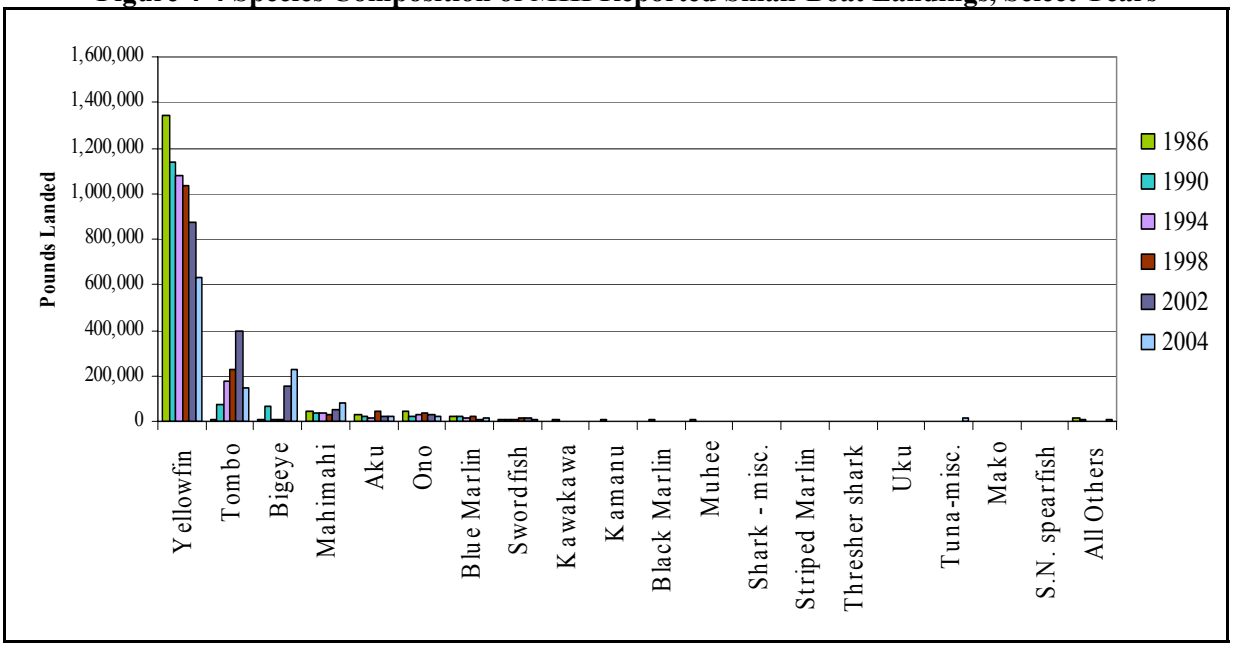
It appears that the many challenges inherent in commercial fishing in Hawai‘i (and elsewhere) have tended to limit the number of operators able to persist on a full-time or perennially avid basis over the course of time. The challenges and costs of fishing Cross Seamount and the weather buoys reportedly ultimately reduced that fleet to its current size. But time itself has also affected the demographic structure of the MHI handline fleet, and informants report that many who were most highly active in the ika-shibi fishery have either passed on or have "aged out" given the physical demands of that challenging night-time method. Others have tended to shift to palu ‘ahi methods, as it is said to be a more relaxed undertaking. Yet others reportedly have

had problems with drug use in association with periods of extensive profit, and have dropped out as a result of those challenges.

In any event, our initial research hypothesis that an increase in PFAD-related fishing activity was the primary factor underlying the recent trend of decline in the ika-shibi fishery appears at least partly false in social terms, and uncertain and out of the scope of this research in biological terms. That is, explanation that declining participation and production in the ika-shibi fishery relates primarily to a shift of fishing effort to the PFADs is verifiably confounded by numerous social and economic factors that have reportedly pushed many out of commercial fishing altogether - at least temporarily. These include: (a) rising ika-shibi trip costs, (b) marketing problems, including those related to fluctuating tuna prices and the shift away from an open auction at Suisan, and (c) demographic changes, i.e., many formerly productive fishermen aging out of or leaving the fishery.

In sum, while a group of highly productive fishermen shifted over to the novel PFAD operations, there was not a wholesale shift to PFAD activity. In fact, some ika-shibi activity is still occurring along the Hilo and Kona Sides of the Big Island, and it appears that expenses associated with installing, maintaining, and fishing PFADs amidst the apparent periodic absence of BET can quickly render that small-boat fishery as challenging as any other. Nevertheless, as indicated in Figure 4-4 below, there is ongoing focused harvest of yellowfin, and a recent trend of increasing BET landings by the MHI small-boat fleet. Although the scope of small-boat landings of these species are truly minimal in comparison to Pacific-wide or even Hawai‘i-specific overall landings, monitoring the trends may bear valuable information about ongoing human interaction with the species in this current climate of concern.

Figure 4-4 Species Composition of MHI Reported Small-Boat Landings, Select Years



Source: Hawai‘i Division of Aquatic Research

4.2 Concluding Management Considerations

The present decline in participation and production in the ika-shibi fishery is best explained by a range of interactive human and biological factors. This project has attempted to describe and explain the former. Today, most participants say, "fished 'em 'til four, five years ago." The fishery appears to be on its way to becoming another historical aspect of the centuries-long history of handline fishing in the MHI. But this cannot yet be said with certainty, as both the biological and social parameters of BET and 'ahi fisheries are highly complex and subject to both endogamous and exogenous constraints.

In the absence of more complete understanding of the structure, distribution, and behavioral tendencies of BET and 'ahi populations in this context, and of the effects of contemporary macro-social and economic processes on fishery participants, establishment of inflexible regulatory constraints on the new PFAD fishery may be premature. While a temporary limited entry program and/or temporary limitation on the number of allowable PFADs in the EEZ could potentially serve as effective means for controlling overall effort until such knowledge is attained, such action would be superfluous given the situation of very limited BET abundance and attendant effort being observed during the current season. Key informants participating in the fishery generally tend to support the idea of limited entry insofar as entry is based on historical performance.

Participants in the new deep-set "shortline" fishery have argued for establishment of a limited program. The rationale is that the gear enables productive fishing for mature rather than juvenile BET and 'ahi, but that such activity should be limited to a small group of participants *a priori* potential resource problems. Recommended limitation criteria would require entrants to possess knowledge of proper use of the gear and a history of performance in the fishery. Only four such captains have thus far participated. In the spirit of exploration and fisheries development, participants also desire freedom to utilize the new methods at other seamounts in the region, and for a range of potentially marketable species such as armorhead, walu, alfonsin, kawakawa, and various sharks.

The descriptive and analytical elements of this document are based in part on catch reports provided by the fishery participants. As noted in previous sections, reporting has been problematic at certain times and for various reasons that are by no means specific to this region. An obvious management consideration and unavoidable recommendation of this effort is advocacy for means that would further efforts to collect valid and reliable data regarding catch, effort, and relevant socioeconomic conditions and factors across the fleets and fisheries in question.

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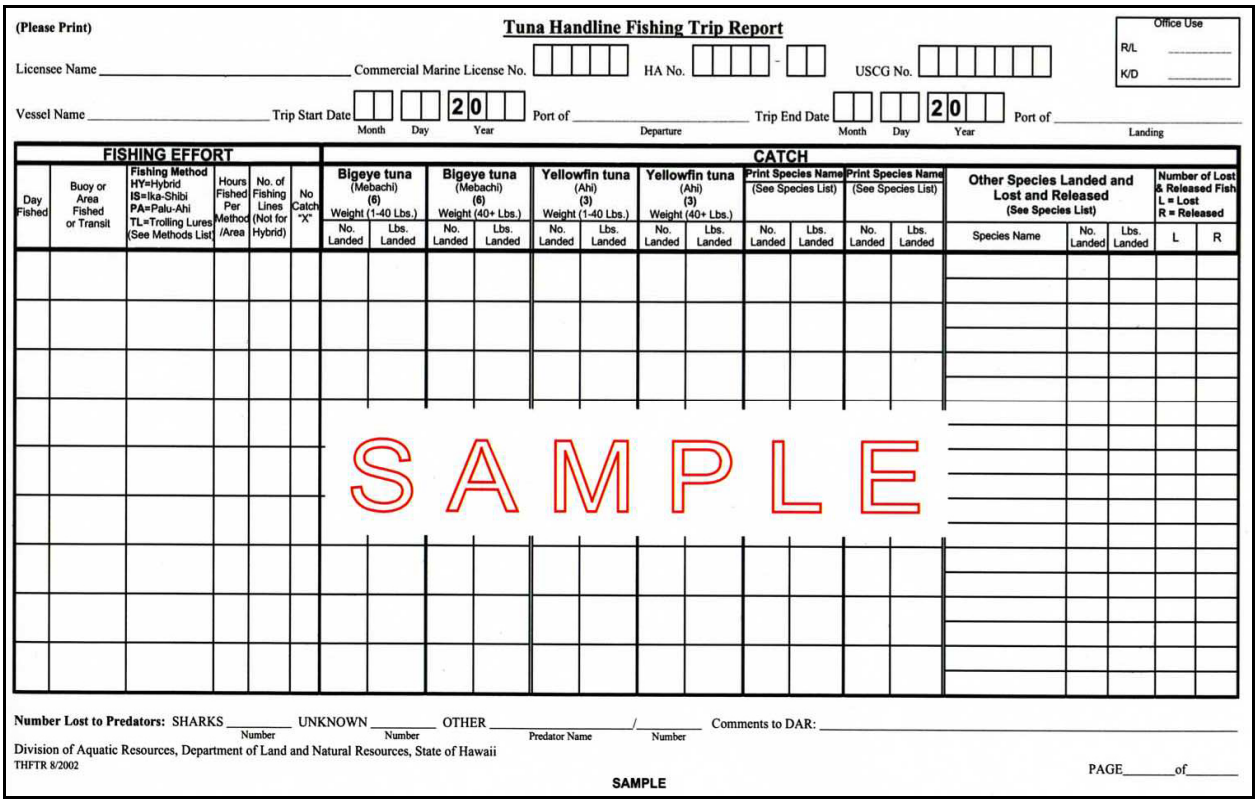
Appendix A: Current HDAR Handline Trip Reporting Form and Instructions



(Please Print)

Tuna Handline Fishing Trip Report

Office Use
R/L
K/D

Licensee Name _____ Commercial Marine License No. ____ HA No. ____ - ____ USCG No. ____

Vessel Name _____ Trip Start Date Month ____ Day ____ Year 20__ Port of _____ Departure Trip End Date Month ____ Day ____ Year 20__ Port of _____ Landing

FISHING EFFORT						CATCH															
Day Fished	Buoy or Area Fished or Transit	Fishing Method HY=Hybrid IS=Ika-Shibi PA=Palu-Ahi TL=Trolling Lures (See Methods List)	Hours Fished Per Method /Area	No. of Fishing Lines (Not for Hybrid)	No Catch "X"	Bigeye tuna (Mebachi) (6) Weight (1-40 Lbs.)		Bigeye tuna (Mebachi) (6) Weight (40+ Lbs.)		Yellowfin tuna (Ahi) (3) Weight (1-40 Lbs.)		Yellowfin tuna (Ahi) (3) Weight (40+ Lbs.)		Print Species Name (See Species List)		Print Species Name (See Species List)		Other Species Landed and Lost and Released (See Species List)			Number of Lost & Released Fish L = Lost R = Released	
						No. Landed	Lbs. Landed	No. Landed	Lbs. Landed	No. Landed	Lbs. Landed	No. Landed	Lbs. Landed	No. Landed	Lbs. Landed	No. Landed	Lbs. Landed	Species Name	No. Landed	Lbs. Landed	L	R

SAMPLE

Number Lost to Predators: SHARKS _____ Number UNKNOWN _____ Number OTHER _____ Predator Name / _____ Number Comments to DAR: _____

Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii
THFTR 8/2002

PAGE_____of_____

SAMPLE

TUNA HANDLINE FISHING TRIP REPORT INSTRUCTIONS

Header

1. **"Licensee Name" -** Print your full name as it appears on your commercial marine license.
2. **"Commercial Marine License No." -** Enter your commercial marine license number in the boxes.
3. **"HA No." -** Enter the State of Hawaii certificate number if the vessel is registered with the State Division of Boating & Ocean Recreation.
4. **"USCG No." -** Enter the U.S. Coast Guard document number here if the vessel is registered with the U.S. Coast Guard.
5. **"Vessel Name" -** Print the vessel name as registered with the State Division of Boating & Ocean Recreation or U.S. Coast Guard. If you do not have a vessel name, leave this line blank.
6. **"Trip Start Date" -** Enter trip start date in boxes (Month/Day/Year). Trip start date is the day you left port. **A trip report consists of multiple (3 or more) days of fishing.**
7. **"Port of Departure" –** Print the port or launch ramp where you departed from. Enter port of departure even if you did not catch anything.
8. **"Trip End Date" -** Enter trip end date in boxes (Month/Day/Year). Trip end date is the day you returned to port.
9. **"Port of Landing" –** Print the name of the port or launch ramp where you land your catch: e.g., Honokohau Harbor and Kewalo Basin, etc. Complete this section even if you did not catch anything.

Fishing Effort

1. **"Day Fished" -** Enter day of month fished (e.g., 1, 2…12…31), and **use a separate line for each day fished**. Enter day fished even if you did not catch anything and complete this section.
2. **"Buoy or Area Fished or Transit" –** Print only one buoy identification letter(s) or enter one area code fished per line. **Use a separate line when buoy or area fished changes.** Refer to Commercial Fisheries Statistical Charts A-H. Enter buoy or area fished, even if you did not catch anything. When transiting and trolling to or from a destination, enter the word **Transit**. Transit is when a vessel is traveling from a port of departure to the first fishing area, or from one area to another, or when returning to a port of landing while **Trolling**. If the vessel stops to fish, or if fish are landed while underway; the buoy or area whichever is applicable must be reported like a normal fishing activity.

Fishing Effort Continued

3. **"Fishing Method" -** Print code or method **"HY" = Hybrid, "IS" = Ika-shibi, "PA" = Palu-ahi, "TL" = Trolling lures** or print other fishing method used. **Use another line when fishing method changes** (see methods list).
4. **"Hours Fished Per Method/Area" -** Enter number of hours fished (fishing gear soak time).
5. **"No. of Fishing Lines" -** Enter number of fishing lines used (not for Hybrid method).
6. **"No Catch X" -** Enter an **X** in this box if you fished and did not catch anything.

Catch

1. **"No. Landed" -** Enter number landed under each listed species weight range column.
2. **"Lbs. Landed" -** Enter number of pounds landed under each listed species weight range column.
3. **"Print Species Name" –** Print name of species (see species list) landed in the blank box and enter **"No. Landed"** and **"Lbs. Landed".**
4. **"Other Species Landed and Lost and Released" –** If species is not listed in the boxes, print species name in **"Species Name"** column and enter **"No. Landed"** and **"Lbs. Landed".**
5. **"L" –** For lost fish, print species name and enter number lost to predation in the **L** column. If species lost is unknown, print **unknown** for species name and enter number lost. **Lost** refers to fish that were lost to any type of predation, i.e. sharks, porpoise, etc. **Do not include lost fish with number or pounds landed.**
6. **"R" –** For released fish, print species name and enter number released in the **R** column. **Released** refers to fish that were landed and intentionally released dead or alive, or tagged-and released. **Do not include released fish with number or pounds landed.**

Bottom of Page

1. **"Number Lost to Predators" –** To the best of your knowledge, enter number of fish lost to **Sharks**, or if predator cannot be identified use **Unknown**. If predator can be identified, print predator name next to **Other**, and enter number of losses.
2. **"Comments to DAR" –** Print comments in this section, and use a blank sheet of paper if more space is needed.
3. **"PAGE__of__." –** Enter the page number, and total number of pages. (Example: Page 1 of 2, Page 2 of 2, if a total of two fishing report forms were submitted.)

Appendix B: David Itano's Article on Deep-Set Short Gear

HAWAIIAN-STYLE SMALL-SCALE DEEP SETTING LONGLINE TECHNIQUE USED ON SEAMOUNTS

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Introduction

In general, longline fisheries for pelagic species within the Western and Central Pacific Ocean (WCPO) deploy either shallow-set or deep-set gear. So called "regular" longline gear has been estimated to hang at depths of 50–120 m while deep longline gear covered a wider range from 50–300 m — deploying four to six hooks between floats (per basket) for shallow sets and an average of 13 hooks per basket for deep sets (Suzuki and Warashina 1977). Deep longlining was introduced to the WCPO in the 1970s and is widely practiced by the major fleets to target deep-swimming bigeye and albacore tuna (Sakagawa et al. 1987). Modern tuna longline vessels may deploy more than 30 hooks per basket, and utilise a "line shooter" to set additional mainline between floats to sink the line even deeper. In contrast, typical swordfish style longline sets are very shallow with only four or five hooks per basket, and do not use a line shooter. For a detailed description of pelagic longline gear see Beverly et al. (2003) and Swenarton and Beverly (2004).

One problem with shallow-set longline gear is that it places the hooks within the upper mixed layer of the ocean, bringing the gear into conflict and potential interaction with surface fisheries; that is, subsistence, recreational and small-scale handline and troll fisheries, as well as large-scale purse-seine fisheries. Shallow-set gear also produces significantly higher interaction rates with protected or ecologically sensitive bycatch species that are easily overharvested, such as marine turtles, seabirds, marine mammals, oceanic sharks, manta rays and whale sharks. Shallow-set gear also competes with important sport and recreational species prized by surface fisheries, such as marlins, spearfish, sailfish, wahoo and mahi mahi (or dolphinfish).

In response, deep-set longline gear has been actively promoted as one means to improve targeting, while decreasing the likelihood of interactions with protected species. The importance of reducing interaction rates with protected species cannot be overemphasised. In recent years, longline fisheries have been significantly curtailed and even closed in attempts to mitigate interaction rates with marine turtles and marine mammals.

Possible solution to reducing bycatch and improving targeting

What is now considered conventional deep-set bigeye tuna longline gear uses a line shooter setting around 25–30 or more hooks per basket on mainlines stretching over 30–50 or more nautical miles (nm) of open ocean. However, hooks are still placed from floatline to floatline within each basket, producing a wide range of actual hook depths within a set. Interaction rates with bycatch species of the upper mixed layer still occur. Also, current speed and shear often shallow a set considerably, raising deep longline gear to shallow-set depths.

This paper reports on a longline system, developed in Hawaii, that attempts to increase the targeting of deep swimming species while minimising the potential for interaction with surface oriented bycatch species. It is similar to a system developed independently by Steve Beverly, Fisheries Development Officer at SPC, and trialled in Mooloolaba, Australia (see *Fisheries Newsletter* # 109). Both of these techniques were reported at the last Standing Committee on Tuna and Billfish, SCTB 17, held in Majuro, Republic of the Marshall Islands in August 2004.

http://www.spc.int/OceanFish/html/SCTB/SCTB17/FTWG-7a.pdf

Background

The Hawaii-based pelagic longline fleet operates within a limited framework, allowing for 164 transferable vessel permits for vessels less than 101 feet in overall length. Vessels are monitored by vessel monitoring system (VMS) and a federal logbook reporting system. Hawaii-based longline vessels targeting bigeye tuna set 20–40 hooks per basket on floatlines set approximately 0.8 km (0.4 nm) apart, achieving hook depths of around 91–366 m (300–1200 ft) (NMFS 2001). The majority of protected species interactions occur with swordfish targeting gear, setting only four to five hooks per basket, but interactions still occur with the deep-set gears.

However, pelagic longline gear less than 1 nm (1.85 km) in length is permitted under federal regulations to be deployed by any Hawaii commercial fishing vessel outside the permitting and regulatory framework that monitors the main longline fishery. This report discusses the development of a small-scale longline system that targets either bigeye tuna (*Thunnus obe-*

sus) or the lustrous pomfret (*Eumegistus illustris*). While this system may have limited value for large scale-fisheries, the concept may be applied to larger scales or find a direct application in WCPO's small-scale or artisanal longline fisheries.

Fishing grounds

This system was developed to target bigeye tuna and pomfrets, which are concentrated in dense aggregations over the summit of the Cross Seamount, approximately 290 km south of Honolulu, Hawaii. This particular seamount is unique among the many Hawaiian seamounts, as it rises sharply from 4000 metres to 330 metres, which is apparently the right depth for both species. The seamount summit aggregates commercial concentrations of bigeye and yellowfin tuna, forming the base for a local handline fishery. The seamount is also a primary tag and release location for Hawaii-based tuna tagging experiments (Itano and Holland 2000). Handline vessels targeting bigeye tuna over the seamount normally take small to medium sized bigeye around 7–20 kg in weight. However, larger fish are found over or near the seamount that have been targeted by Hawaii-based longline vessels.

Development of the fishing method

Hawaiian longline vessels have fished the area of the Cross Seamount for several decades, targeting large bigeye tuna on the outer seamount slopes. The offshore handline fishery developed afterwards, peaking in the late 1980s and early 1990s (Itano 1998). During the 1990s, some conventional longline vessels began to set gear directly over the seamount summit, causing gear interactions and heated conflicts with the handline fleet. A commonly seen strategy was for a longline vessel to set gear in an "S" pattern upcurrent of the seamount, hauling the gear after it had passed over the area. Although these boats caught some bigeye tuna of a similar small size as the handline vessels, they also took larger fish that were apparently unavailable to the handline boats.

In response to these observations, some handline boats began to experiment with vertical longline gear to deploy baited hooks all the way down to the seamount summit. These gears were very similar to those described by Preston et al. (1998), consisting of a single vertical line, buoyed at the top and weighted at the bottom, with branchlines snapped on from top to bottom. Catch rates of larger bigeye tuna (30–60 kg) encouraged further experimentation that continues to the present. The use of vertical longline gear gave way to the use of short sets of deep-set horizontal gear as described below.

Deep-set fishing gear

An informal observer trip was conducted by the author to the Cross Seamount from 7–14 July 2004 to observe the fishing method. Fishing took place on F/V *Double D* (Fig. 1), which was designed and built by its captain, Joe Dettling (Fig. 2). Fishing continued on the seamount for six

Figure 1. F/V *Double D*
Figure 2. Captain Joe Dettling hauling the line on F/V *Double D*, while a crew member lands a tuna

consecutive days. The primary gear type was horizontal longline sets of less than 1 nm in length. Joe explained that this gear can be quickly adjusted and set in any number of configurations and depths, but is generally set to target either bigeye tuna or pomfret. The bigeye gear is set at mid depth over the seamount summit while the pomfret gear is set deeper, just above the seamount itself. It should be noted that there are currently at least two vessels deploying this style of gear on the seamount. It is believed that both vessels use very similar gear but the descriptions here apply directly to Joe's boat only.

Bigeye longline set

The gear is very simple, consisting of a small, hydraulically driven longline reel with a fairlead mechanism, 3.6-mm monofilament mainline, flag buoys, hard plastic floats, 5-kg weights, with stainless steel longline snaps that are rigged with 2.0-mm diameter monofilament leaders that are 2 m long, ending in a tuna circle, or Japan style longline tuna hooks. Exact details of setting times and depth will not be given, as requested by the fisherman.

Setting takes place before dawn to take advantage of what is considered the peak biting time for bigeye in this area. The set consists of approximately 100 leaders snapped on the mainline using one or two floats. Figure 3 shows a tuna set with one set of floats, producing two baskets of 50 hooks each. The setting procedure for this configuration would be as follows:

1. Position vessel upcurrent of target area.
2. Deploy flag buoy #1 and pay out mainline to desired target depth.
3. Attach 5-kg weight.
4. Snap on baited branchlines, closely spaced, approximately 8–10 metres apart.
5. Attach hard buoy float.
6. Snap on more baited branchlines.
7. Attach a 5-kg weight.
8. Pay out additional mainline.
9. Attach and deploy flag buoy #2.

This procedure, depending on how many floats are used, will produce what are essentially two or three large "baskets" of gear held down by lead weights. An additional floatline can add additional depth to the set but is not normally used on the seamount due to the possibility of hooking the seamount summit. The line is normally retrieved after a short soak of two hours or so, or when the distance between floats indicates the lines are loading up with catch.

Pomfret longline set

There are several species of pomfrets (Bramidae), known locally by the generic term "monchong", that are taken as incidental catch in the Hawaii-based longline fishery. The most common species taken in open water is the bigscale pomfret (*Taractichthys steindachneri*). The larger lustrous pomfret (*Eumegistus illustris*) appears to be a seamount and deep-slope associated species and is more sought-after by the fish buyers due to its higher meat yield ratios. After the fisherman had developed the deep-set longline technique to target large bigeye tuna, it became apparent that large quantities of *E. illustris* were also found over the seamount summit. By modifying the gear slightly, Joe found that the gear could effectively target this species of monchong while also taking medium and large bigeye.

The gear is essentially the same as described for bigeye tuna fishing. However, two or more sub-surface floats are used instead of surface hard floats. These sub-surface floats are only slightly positive in buoyancy; their purpose is to keep the deeper set gear from fouling the seamount summit while maintaining the gear at depth. Another important modification to the monchong gear is the addition of more branchlines spaced very closely, and the use of smaller circle hooks. Normally, a monchong targeting set will deploy 200 hooks in the same

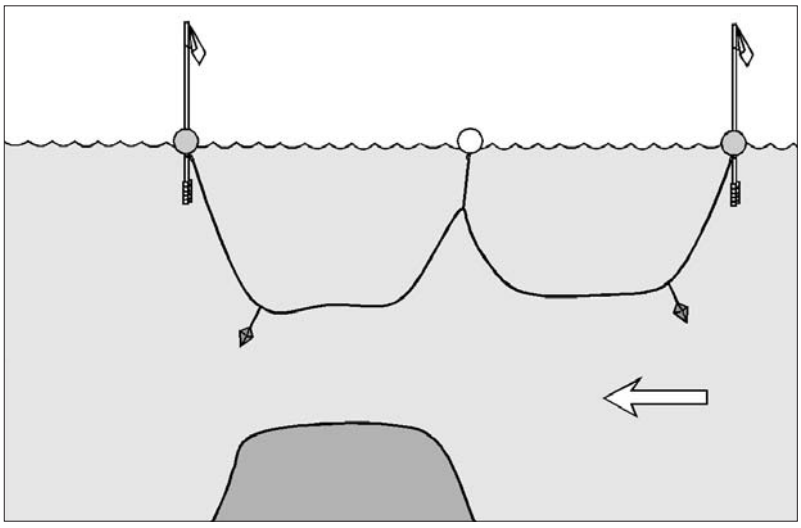

Figure 3. Bigeye targeting set upcurrent of seamount

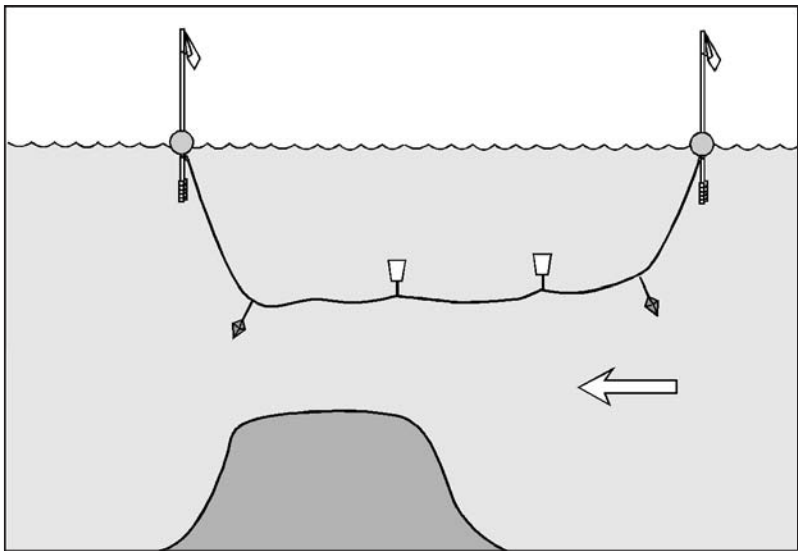

Figure 4. A monchong targeting set upcurrent of seamount

length of mainline. Figure 4 shows a typical monchong set of 200 hooks on less than 1 nm of mainline.

Catch and effort data

Catch records for the first seven months of 2004 were examined for 12 tuna targeted trips and compared with what was considered a typical monchong targeted trip from January 2003. All fishing took place on the Cross Seamount with anywhere from two to seven days of fishing per trip. Normally, four or five sets were made per day with an average of 95 hooks per set. Table 1 lists the number and CPUE of bigeye, yellowfin and monchong caught per trip. Mean catch for all 12 trips was 9.1 bigeye, 1.9 yellowfin and 1.4 monchong retained per 100 hooks set. The monchong targeting trip differed considerably for bigeye and monchong, with 2.2 bigeye, 2.0 yellowfin and 8.2 monchong taken per 100 hooks set.

These figures appear very productive, but it should be noted that the average sizes of the tuna are considerably smaller than those taken by the federally regulated longline fishery. The mean size of bigeye and yellowfin in this example was 26.9 lbs (12.2 kg) and 18.1 lbs (8.2 kg), respectively (Table 2). However, on some trips, yellowfin of a good size contributed significantly to catches; for example, the last two trips landed 68 and 46 yellowfin per trip with average weights of 34.2 (15.5 kg) and 35.6 lbs (16.2 kg), respectively.

The monchong targeting trip indicates a CPUE of 8.2 fish per 100 hooks with an average size of 11.8 lbs (5.1 kg). This size appears to be quite average or a bit low compared with the 12-trip average weight of 12.4 lbs (5.6 kg) taken on the tuna targeting trips. Reports by the fishermen indicate that some monchong targeting sets have very high catch rates of more than 80 fish per 100 hooks.

Discussion

The development of this style of gear is an example of a specialised case of targeting aggregated, structure associated tuna and seamount associated species. However, the system demonstrates a simple method to concentrate hooks within a narrow depth range with greater accuracy than is possible with conventional deep-set longline gear. The key components of the system are heavy weights after the surface floats and the use of slightly buoyant sub-surface floats interspersed with hooks within the “basket”.

A key element to the system aside from the close targeting of concentrated schools is the timing of the set. By setting before dawn, the gear takes advantage of the shallow night-time behavior of bigeye tuna and the higher biting response that is presumed to take place during the early morning hours. In this manner, the gear not only targets concentrated schools, but

Table 1. Catch and effort data from tuna and monchong targeting longline trips

Target	End date	# Days	# Sets	Hooks/set	Hooks set	Bigeye pcs	Bigeye CPUE (#/100 hks)	Yellowfin pcs	Yellowfin CPUE (#/100 hks)	Tuna CPUE (#/100 hks)	Monchong pcs	Monchong CPUE (#/100 hks)
tuna	01/14/04	6	24	95	2280	176	7.7	107	4.7	12.4	91	4.0
tuna	01/23/04	4	22	95	2090	225	10.8	82	3.9	14.7	42	2.0
tuna	02/05/04	5	20	95	1900	196	10.3	33	1.7	12.1	12	0.6
tuna	02/15/04	5	20	95	1900	236	12.4	66	3.5	15.9	14	0.7
tuna	04/08/04	5	20	95	1900	135	7.1	18	0.9	8.1	35	1.8
tuna	04/19/04	5	20	95	1900	262	13.8	6	0.3	14.1	1	0.1
tuna	05/06/04	2	8	95	760	77	10.1	9	1.2	11.3	4	0.5
tuna	05/21/04	6	24	95	2280	224	9.8	1	0.0	9.9	59	2.6
tuna	05/28/04	2	8	95	760	42	5.5	0	0.0	5.5	24	3.2
tuna	06/15/04	7	28	95	2660	285	10.7	8	0.3	11.0	31	1.2
tuna	07/01/04	7	28	95	2660	197	7.4	68	2.6	10.0	5	0.2
tuna	07/22/04	6	24	95	2280	78	3.4	46	2.0	5.4	1	0.0
Tuna total		**60**	**246**	**95**	**23370**	**2133**	**9.1**	**444**	**1.9**	**11.0**	**319**	**1.4**
monchong	01/15/03	7	28	100	2800	62	2.2	55	2.0	4.2	**229**	**8.2**

Table 2. Catch by number and weight from tuna and monchong targeting longline trips.

Target	End date	Hooks set	Bigeye pcs	Bigeye wt (lbs)	Bigeye mean wt (lbs)	Yellowfin pcs	Yellowfin mean wt (lbs)	Monchong pcs	Monchong wt (lbs)	Monchong mean wt (lbs)
tuna	01/14/04	2280	176	3112	17.7	107	11.2	91	1067	11.7
tuna	01/23/04	2090	225	3840	17.1	82	10.6	42	501	11.9
tuna	02/05/04	1900	196	4691	23.9	33	10.9	12	164	13.7
tuna	02/15/04	1900	236	4102	17.4	66	10.5	14	193	13.8
tuna	04/08/04	1900	135	3397	25.2	18	15.7	35	455	13.0
tuna	04/19/04	1900	262	7440	28.4	6	15.3	1	12	12.0
tuna	05/06/04	760	77	2344	30.4	9	14.8	4	59	14.8
tuna	05/21/04	2280	224	7728	34.5	1	59.0	59	743	12.6
tuna	05/28/04	760	42	1504	35.8	0	NA	24	312	13.0
tuna	06/15/04	2660	285	9363	32.9	8	50.5	31	367	11.8
tuna	07/01/04	2660	197	7707	39.1	68	34.2	5	68	13.6
tuna	07/22/04	2280	78	2248	28.8	46	35.6	1	10	10.0
Tuna total		23370	2133	57476	26.9	444	18.1	319	3951	12.4
monchong	01/15/03	2800	62	2352	37.9	55	18.1	229	2701	11.8

does so at the optimal time for highest CPUE. The direct application of this methodology to fishing around FADs, both anchored and drifting may be an interesting area to explore.

While the figures for average tuna size do not appear overly impressive, the fishermen report very favourable marketing results from their deep-set short longline gear. Average prices achieved by this method are considerably higher than those received from handline and troll landings. The handline fishery also catches medium and large size bigeye on the seamount, but seldom achieves a decent price for these fish. There is an ingrained prejudice against handline caught bigeye in Hawaii due to perceived quality issues resulting in short shelf life of the product and the possibility of the "burnt tuna syndrome" caused by overheating of the muscle mass. Tuna landings from the deep-set gear described here are reported to achieve much higher prices at the Honolulu United Fishing Agency auction and are considered on a par with the landings of the larger longline vessels. This is a very important consideration locally, as the system operates on a daily auction basis, and longline vessel catch is auctioned first, followed by troll and handline landings. Even if the handline boats have good quality fish, their later position in the auction almost guarantees them lower prices.

Yellowfin of a good size contributed significantly to catches

Finally, the system is very interesting to the WCPO as it demonstrates the exploitation of a formerly unutilised resource with a stable market demand. Pomfrets are found throughout the world's oceans and may represent an alternative market species for developing areas.

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