PFRP

Pelagic Fisheries Research Program

Volume 3, Number 3 July 1998

Keeping Our Eye on Bigeye

Recent changes in the way bigeye tuna are harvested throughout the Pacific have emphasized information gaps concerning this species. Tagging is an important means of obtaining vital information on movement, mortality and exploitation rates of tunas. Researchers in Hawai'i have stepped up tagging activities on bigeye using both state-of-the-art electronic technology and tried-and-true conventional tags. This newsletter issue outlines what is being tagged in Hawaiian waters.

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Archival Tags—A Worthy Reward for a Wealth of Information

State-of-the-art electronic technology is making it possible to follow the movements of individual tuna for months—even years. The method—which has successfully tracked bluefin tuna (*Thunnus thynnus*) in the Atlantic and southern bluefin tuna (*T. maccoyii*) in the Indian Ocean—consists of inserting so-called "archival tags" into captured fish. Once the fish are released, the tags "wake up" every 128 seconds, 675 times per day, to record pressure, light intensity and internal and external temperatures. At midnight of each day, the tags use these recordings to calculate a geographical position for that day. Anecdotal data suggests that these calculated positions can be fairly accurate. With information stored in the tag, researchers can reconstruct in detail not

(continued on page 2)

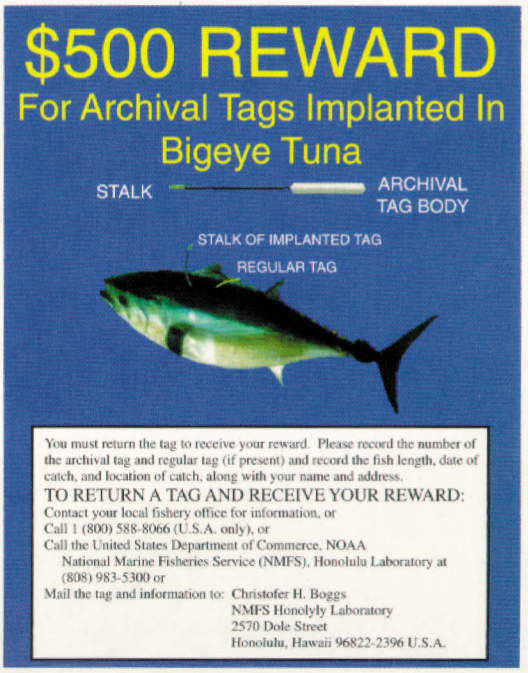

Figure 1. Bigeye tuna archival tag reward poster.

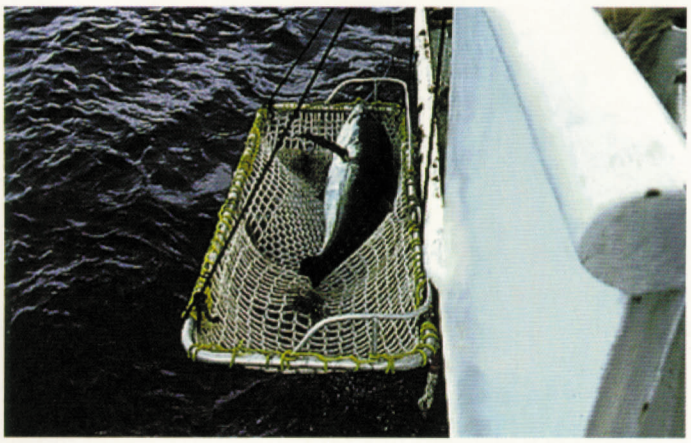

Figure 2. A sling is used to hoist a live, longline-caught bigeye tuna aboard the *Townsend Cromwell*.

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Archival tags (continued from page 1)

Figure 3. The sling is brought on deck, and the tuna is lowered onto a foam pad. A wet cloth placed over the fish's eye calms the tuna while the hook is removed. On deck handling requires about 1 minute for tagging after which the fish is released.

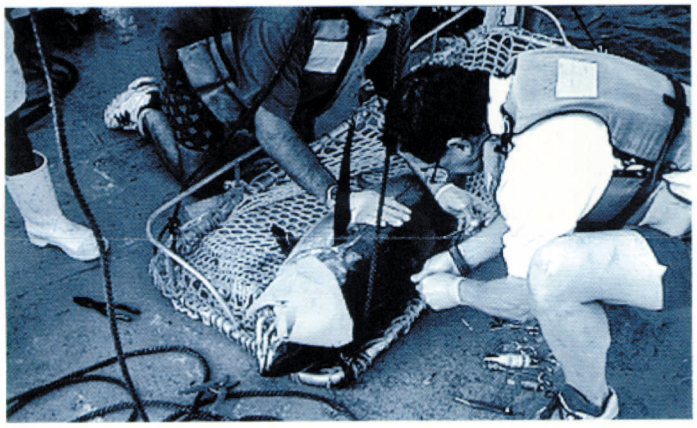

Figure 4. Richard Brill inserts an archival tag into the fish's dorsal muscle (the sensor stalk is visible below his left hand) and then closes the incision with a suture. Mike Musyl inserts a conventional tag behind the archival tag.

only the fish's migrations but also their vertical movements. The trick to the success of the operation, however, is to retrieve the tags when the fish are recaptured.

To entice fishermen to cooperate in returning archival tags being used in a recently begun project to track bigeye tuna (*T. obseus*) around the Hawaiian Islands, researchers Mike Musyl and Richard Brill of the Pelagic Fisheries Research Program (PFRP) at the University of Hawai'i at Mānoa and Christofer Boggs of the National Marine Fisheries Service (NMFS), Honolulu Laboratory, are offering a generous monetary reward—$500 per returned tag (Figure 1).

Currently, 24 bigeye tuna have been tagged and released in the joint research project. Operations were carried out March–April 1998 aboard the National Oceanographic and Atmospheric Administration (NOAA) research vessel *Townsend Cromwell.* The two dozen bigeye were caught and released on the Kona (western) coast of the island of Hawai'i. This area was chosen because high mountains in the center of the island provide a lee, allowing easier handling of fish for tag and release (Figures 2–4).

Northwest Marine Technologies archival tags were placed in the longline-caught bigeye, which ranged in size from 87-131 cm fork length. Two of the smaller fish had the tags placed in the body cavity. The remainder had the tags placed into the dorsal musculature immediately adjacent to the first dorsal fin. Intramuscular placement of the tags was chosen because studies conducted at the NMFS Kewalo Research Facility on juvenile yellowfin tuna showed that this technique was highly suitable. Moreover, experience on the cruise showed that intramuscular implantation could be accomplished more quickly and with less risk of serious injury to bigger fish than placement in the body cavity.

Traditionally, movement patterns of tuna have been studied through catch statistics, tag and release studies and the trackings of individual fish carrying ultrasonic (usually depth sensitive) transmitters. Although all three methods can be effective, all three have limitations. Analysis of catch statistics requires the ability to differentiate changes in abundance from changes in specific fishing gear vulnerability. Tag and release studies provide no direct data on movement routes between release and recapture positions, which may be extensive. Ultrasonic telemetry can provide very detailed data on vertical and horizontal movements, but the length of observation is limited by the battery life of the transmitter or the endurance of the tracking party, which is usually no more than 60 hours.

Research into bigeye tuna is spurred by the continually increasing harvest of the species since the 1970s to satisfy the demand for high quality sashimi in Japan and in sophisticated markets worldwide—a demand that cannot be satisfied by the limited supply of bluefin tuna, the premier sashimi species. By the early 1990s, fishery biologists suspected that the bigeye tuna stock in the Pacific was almost fully exploited. At this same time, purse-seine fishing methods—altered to avoid capturing dolphins—began catching large quantities of juvenile bigeye tuna aggregated under floating objects.

In Hawai'i, increases in local longline landings of bigeye since 1975 and a growing fishery for mostly juvenile bigeye tuna on the Cross Seamount and around NOAA weather

buoys located at the outer regions of Hawai'i's 200-mile exclusive economic zone (see page 4) have added concern about the status of the local resource. Biologists (but not fishermen) think it unlikely that local fisheries can deplete such a wide-ranging species as bigeye and suspect that locally caught bigeye tuna are part of a single, highly mobile, Pacific-wide stock exploited predominantly on the high seas beyond the Hawai'i fishery. However, the appropriate scale for the management of bigeye tuna (e.g., central Pacific versus Pacific-wide) depends on an understanding of fish movement rates between regions. How far do bigeye tuna move, and where do they go? Archival tags can be a powerful tool in answering those questions.

Data from the tags can also provide a wealth of information necessary to answer other fundamental questions concerning the ecology of bigeye tuna, including the relationship between bigeye movements and environmental factors. Understanding optimal environmental limits for the species could also lead to refined methods to monitor their abundance.

Such information is extremely valuable for efficient harvesting, precautionary management and conservation of bigeye tuna. Of course, the future success of this project relies on the recovery of tags and the deployment of additional tags. With a 5 percent recovery rate (excluding short-term recoveries) expected, at least one of the 24 tags released so far should be recovered, and a total of four recoveries are expected for the total of 80 archival tags to be deployed by the program.

Persons catching or handling bigeye tuna can identify the archival tags by the following features. The body of the NMT tag is made of stainless steel, weighs 52 grams and is 16 mm in diameter and 100 mm length. The sensor stalk is made of Teflon and measures 2 mm in diameter and 200 mm in length. The battery life of the archival tag is more than seven years. For more information on the NMT tag, visit the NMT Web site at: http://www.nmt-inc.com/.

To report a retrieved tag, call 1 (800) 588-8066 (U.S. only) or 1 (808) 983-5300. To receive the $500 reward, the tag must be returned. Please record the number of the archival tag and regular tag (if present), the fish length, date of catch, location of catch, and your name and address. Mail the tag and information to Christofer Boggs, NMFS Honolulu Laboratory, 2570 Dole Street, Honolulu, HI 96822-2396 U.S.A.

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All Things Considered, Eating Fish Is Better

As a food source, fish and shellfish are replete with benefits: high in protein, low in saturated fat and a direct source of omega-3 polyunsaturated fatty acids (important for optimal brain and retinal development, maturation of the visual cortex and motor development), docosahexaenoic acid and antioxidants (such as selenium and vitamin E). Fish consumption has also been related to reduced risk of coronary and cardiovascular diseases. Furthermore, in many remote areas, commercially available food alternatives are prohibitively expensive or inaccessible. These points appear in "Balancing Fish Consumption Benefits with Mercury Exposure" (Dec. 12, 1997, *Science*), which argues against the U.S. Environmental Protection Agency (EPA) guidelines that set the reference dose (daily amount safely consumed over a lifetime) of methylated mercury (MeHg) at 0.1 microgram per kilogram.

According to the article's authors—Grace M. Egeland and John P. Middaugh of the Alaska Department of Health and Social Services—the EPA's decision was based on concern about reducing industrial emissions of mercury. However, because states use the reference dose to develop fish consumption advisories, it "could result in fish consumption advisories for sport and subsistence fish consumers when average fish tissue concentrations are as low as 0.2 ppm." In comparison, the U.S. Food and Drug Administration allows commercial sale of fish with Hg tissue concentrations up to 1 ppm; "the federal program for Women, Infants and Children provides food vouchers for tuna (which contains, on average, 0.2 ppm Hg) to participants because of its superior nutritional value"; and the intake guidelines for MeHg set by the World Health Organization is five times that set by the EPA, the authors note.

In toxic doses, MeHg causes neurological and developmental disorders in humans, the authors acknowledge. But, they contend, a reasonable approach would be to weigh the benefits of eating fish and shellfish along with risks of MeHg intake. They ask state public health workers using the EPA reference dose to develop fish consumption advisories to consider all of the factors: "the uncertainties of the risks, the potential health benefits of fish consumption, the competing risks associated with other available food sources, the potential medical impact of dietary and lifestyle changes on a population, and the social and economic ramifications of restrictive fish and seafood consumption advisories."

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Tracking Hawai'i's Tuna

Hawai'i's sashimi could be Mexico's ceviche, literally. One of the unusual recoveries of a tuna tagging project at Cross Seamount, 150 miles southwest of Kona, Hawai'i, is a yellowfin tuna recaptured by a purse seiner seven months later off of Ensenada, Mexico. The majority of the nearly 300 tuna recaptured by the project to date, however, were caught near the point of release. These findings of the Hawai'i Seamount Tuna Tagging project will be analyzed along with the results of the ongoing Hawai'i Tuna Tagging Project to provide an understanding of the movement of Hawai'i's bigeye and yellowfin tuna, including the role of fish aggregation devices (FADs), *ko'a* (traditional fishing grounds), banks and seasonal effects. The two tuna tagging projects are underway with funding provided by the Pelagic Fisheries Research Program (PFRP) with a National Oceanographic and Atmospheric Administration (NOAA) cooperative agreement and with essential recapture information provided by fishermen and those in the fishing industry.

Hawai'i Seamount Tagging Project

The Hawai'i Seamount Tagging Project—under the direction of principal investigator Kim Holland of the University of Hawai'i at Mānoa's Hawai'i Institute of Marine Biology—is examining tuna around Cross Seamount and offshore weather buoys in the outer regions of Hawai'i's exclusive economic zone (Figure 1). Located about equidistant from Honolulu and Kona, the seamount is chartered to a depth of 330 meters and is the primary fishing ground of the Hawai'i-based offshore handline fishery. Weather buoys 1, 2, 3 and 4, which are set and maintained by NOAA, are also exploited by the handline vessels. These buoys have in effect become highly productive fish aggregators and can account for large catches of yellowfin and bigeye tuna and other pelagic species. Longline vessels also operate in waters adjacent to the buoys and at times directly over Cross Seamount.

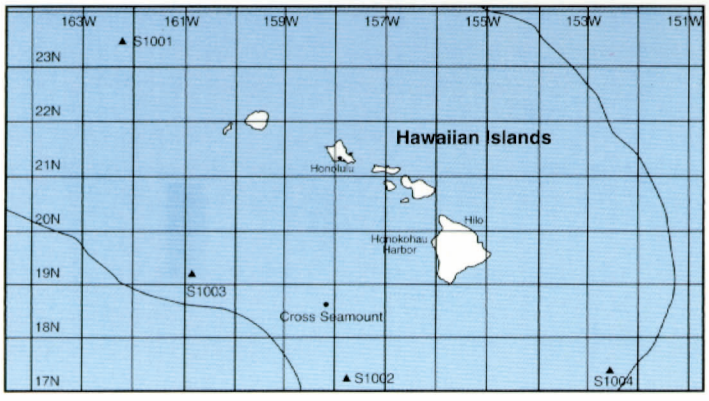

Figure 1: Hawai'i Offshore Handline Fishery Grounds include Cross Seamount and NOAA weather buoys 1, 2, 3 and 4.

The objectives of the project are to investigate retention rates of tuna on the Cross Seamount, movement and exploitation patterns of tuna in relation to domestic fisheries and interaction between surface and longline fishing gear. The tagging project also supports a collaborative biological investigation of the Inter-American Tropical Tuna Commission that is an age validation study for bigeye tuna.

During the project, 3,399 bigeye and 1,460 yellowfin tuna were tagged and released, with the majority of the releases made at Cross Seamount and weather buoy 2 (Table 1). Selected tuna were injected with a harmless dye that deposits an invisible layer on all bony structures at the time of injection. The dye layer is visible under UV light, allowing scientists to ascertain whether growth lines evident in the bones after tagging correspond to daily growth rings, like the annual growth rings in a tree trunk. The work is necessary before accurate age estimates of bigeye tuna can be made, which are crucial for effective management of the stocks.

	Bigeye		Yellowfin	
Location	Dyed	Non-Dyed	Dyed	Non-Dyed
Cross Seamount	567	1,360	1	867
Buoy 2	474	316	2	321
Buoy 3	0	428	0	85
Buoy 4	0	199	0	98
Other Buoy	0	55	0	86
Total	1,041	2,358	3	1,457
SPP Total	3,399		1,460	
Grand Total	4,859			

Table 1. Hawai'i Seamount Tuna Tagging Releases by location for regular tagged and dye-injected bigeye and yellowfin tuna.

As of March 1998, 5.4 percent of the bigeye and 8.4 percent of the tagged yellowfin had been recaptured (Table 2). Most of the recaptures have been made at the point of release (90.4 percent of the bigeye; 87.0 percent, yellowfin) or have indicated some movement between the seamount and offshore

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Cost-Earnings Study of the Hawaii-Based Domestic Longline Fleet, by Marcia Hamilton, Rita Curtis and Michael Travis, SOEST 96-03, JIMAR 96-300.

Social Aspects of Pacific Pelagic Fisheries, Phase I: The Hawai'i Troll and Handline Fishery, by Marc Miller, SOEST 96-04, JIMAR 96-302.

The Contribution of Tuna Fishing and Transshipment to the Economies of American Samoa, the Commonwealth of the Northern Mariana Islands, and Guam, by Michael Hamnett and William Sam Pintz, SOEST 96-05, JIMAR 96-303.

Quality and Product Differentiation as Price Determinants in the Marketing of Fresh Pacific Tuna and Marlin, by Paul Bartram, Peter Garrod, and John Kaneko, SOEST 96-06, JIMAR 96-304.

Sociology of Hawaii Charter Boat Fishing, by Julie Walker, SOEST 97-02, JIMAR 97-309.

Design of Tag-Recapture Experiments for Estimating Yellowfin Tuna Stock Dynamics, Mortality, and Fishery Interactions, by Peter Bills and John Sibert, SOEST 97-05, JIMAR 97-313.

Cost-Earnings Study of Hawaii's Small Boat Fishery, 1995–1996, by Marcia Hamilton and Stephen Huffman, SOEST 97-06, JIMAR 97-314.

Cellular Automaton Models for Fish Schools: Merging Social Behavior and Hydrodynamics, by Sabine Stöcker, SOEST 98-02, JIMAR 98-316.

An Analysis of Auction Prices of Tuna in Hawaii: Hedonic Prices, Grading, and Aggregation, by K.E. McConnell, I.E. Strand, and R.E. Curtis, SOEST 98-03, JIMAR 98-317.

Upcoming Events

July 8–11
Ninth International Conference of the International Institute of Fisheries Economics and Trade
Tromso, Norway; IIFET Secretariat, Oregon State University, 1 (541) 737-1416, e-mail ann.l.shriver@orst.edu

September 23–26
45th Annual Eastern Pacific Ocean Conference
Mt. Hood, Oregon; Center for Coastal and Land-Margin Research, Oregon Graduate Institute, 1 (503) 690-1372, fax 1 (503) 690-1273, e-mail djay@ccalmr.ogi.edu, or EPOC Secretary, National Marine Fisheries Service, Hatfield Marine Science Center, 1 (541) 867-0201, fax 1 (541) 867-0389

September 30–October 3
16th Lowell Wakefield Fisheries Symposium on Ecosystem Considerations in Fisheries Management and 1998 Joint Meeting of the American Fisheries Society Western Division, Alaska Chapter, and North Pacific International Chapter
Anchorage, Alaska; Alaska Sea Grant, 1 (907) 474-6701, fax 1 (907) 474-6285, e-mail fnbrb@uaf.edu

October 5–7
Fifth International Conference on Remote Sensing for Marine and Coastal Environments
San Diego, California; ERIM Marine Conferences, 1 (313) 994-1200 ext. 3234, fax 1 (313) 994-5123, e-mail wallman@erim-int.com

October 14–25
PICES Seventh Annual Meeting
Fairbanks, Alaska; PICES Secretariat, 1 (250) 363-6366, fax 1 (250) 363-6827, e-mail pices@ios.bc.ca

November 4–6
Annual CalCOFI Conference
Pacific Grove, California; e-mail ghemingway@ucsd.edu or molivarria@ucsd.edu

November 16–19
Ocean Community Conference 1998
Baltimore, Maryland; 1 (800) 810-4333 or 1 (732) 562-6826, fax 1 (732) 981-1203, e-mail mts-occ98@ieee.org

November 16–19
ICES International Symposium on Confronting Uncertainty in the Evaluation & Implementation of Fisheries-Management Systems
Cape Town, South Africa; ICES Symposium, University of Cape Town, South Africa, 27-21-650-2681, fax 27-21-685-3937; e-mail ljohnsto@botzoo.uct.ac.za or dll@maths.uct.ac.za

Tracking (continued from page 4)

weather buoys. The very few recaptures made close to the main Hawaiian Islands have come mainly from FADs anchored close to the islands of Kaua'i, Moloka'i, O'ahu and Hawai'i. However, some recaptures have been taken by daytime handline gear from areas (known as *ko'a* by native Hawaiians) where tuna are known to aggregate.

	Bigeye		Yellowfin	
Location	Dyed	Non-Dyed	Dyed	Non-Dyed
Cross Seamount	44	33	0	86
Buoy 2	69	5	0	12
Buoy 4	1	2	0	5
Other Buoy	0	6	0	4
Other	2	4	1	8
Unknown	2	8	0	2
Total	118	58	1	117
SPP Total	176		118	
Grand Total	294			

Table 2: Hawai'i Seamount Tuna Tagging Recaptures by location for regular tagged and dye-injected bigeye and yellowfin tuna.

Most of the current recoveries (264) were made by offshore handline vessels. However, reports also include 13 recoveries by longline, 5 by trolling gear and 1 notable recapture by purse-seine off Ensenada, Mexico (the yellowfin had been tagged in November 1996 at Cross Seamount and was recaptured in July 1997). The gear types used to recapture the remaining 11 tuna were not reported.

Hawai'i Tuna Tagging Project

Using the structure and the results of the seamount project, the large-scale Hawai'i Tuna Tagging Project (HTTP) began field operations in March 1998. Principal Investigators Kim Holland and David Itano of the PFRP are assisted by Steve Kajiura and two field technicians operating out of Kewalo Basin in Honolulu and Honokohau Harbor in Kona. The technicians maintain close contact with the fishermen whose reporting of tag recaptures is crucial to the project's success.

In the first three months of the two-year project, nearly three thousand yellowfin and bigeye tuna were tagged off of Midway Atoll, Cross Seamount, Nihoa/Necker Islands and the Kona coast (Table 3). Except for one cooperative tagging effort with the National Marine Fisheries Service (see "Archival Tags," page 1), the fish were tagged with the assistance of local fishing vessels and their crews.

Cruise Dates	Location	YFT	BET	Total
Feb 12–13	Midway Atoll	13	0	13
Mar 6–11	Cross Seamount	171	406	577
Mar 17–21	Nihoa/Necker Islands	6	0	6
Apr 1–5	Cross Seamount	52	461	513
Apr 4–14	Kona Coast	0	23	23
Apr 6–11	Midway Atoll	342	0	342
Apr 17–21	Cross Seamount	133	772	905
May 27–30	Cross Seamount	279	212	491
Total		996	1,874	2,870

Table 3. Tagging cruises to date of the Hawai'i Tuna Tagging Project

Currently, only a few recaptured tuna have been reported by fleets operating longline or purse seine gear. However, the United Fishing Agency fish auction in Honolulu, where almost all of the local longline fish are sent, has been very helpful in reporting tagged fish. By comparison, reporting rates from the offshore handline and small scale troll fleet are believed to be very high. Tag rewards of T-shirts and caps printed with the project logo have proved to be very popular with the fishermen.

Future activities of the project include releases near the main Hawaiian Islands and to the west of Kaua'i as well as maintaining tag releases in offshore areas and near Midway Atoll. For more information on the project, connect to the PFRP Web site at www.soest.hawaii.edu/PFRP/holland_hrttp.html.

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Preparing for the Hawai'i Tuna Tagging Project

Large scale release-recapture programs initiated to provide information for fishery management—such as the Hawai'i Tuna Tagging Project (HTTP)—are both lengthy and expensive. To establish whether such a program might be useful in understanding yellowfin tuna in the exclusive economic zone (EEZ) surrounding Hawai'i, computer simulations were first carried out. Because the paths taken by released individual yellowfin tuna are not known, the simulations used a seasonal hypothesis for bulk behavioral movement of tagged yellowfin.

Principal investigators of the experiment were John Sibert, PFRP program manager, Joint Institute of Marine and Atmospheric Research, University of Hawai'i; and Christofer Boggs and Pierre Kleiber of the National Marine Fisheries Service, Honolulu Lab. The computer models were designed by Sibert and Peter Bills, from The University of Adelaide, Australia, who joined JIMAR in February 1995 to work on the project.

Based on the results of the simulations and others obtained using simple four-season hypotheses for behavioral movement, it was determined that a sensibly posed tag release-recapture experiment for the Hawaiian Islands EEZ is feasible. Release numbers necessary for success of the project were estimated to be around 500 per quarter.

To further prepare for the HTTP, the University of Hawai'i held a one-day workshop in November 1996 to discuss and design the tuna tagging project. The workshop was attended by tagging experts from the Offshore Fishery Program of the Secretariat of the Pacific Community (formerly the South Pacific Commission), the Inter-American Tropical Tuna Commission and the National Marine Fisheries Service along with members of the Hawai'i Division of Aquatic Resources, the Western Pacific Regional Fishery Management Council and the Hawai'i seafood and fishing industry. The results and recommendations of the workshop were used to draft the funding proposal for the HTTP.

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How to Assist the Hawai'i Tuna Tagging Project

The Hawai'i Tuna Tagging Project requests the assistance of the international pelagic research and fishing community in obtaining accurate tag recapture data. Here's what to look for.

Two plastic tags are in use by the program. Orange tags denote regular program releases for which the project needs the tag number, fish species, fork length (to nearest cm or 0.5 inch), date of catch, location of catch, capture gear type, and finder's name and address. Green tags indicate that the fish was injected with a dye for an age validation study. The same data and the entire head or the otoliths (ear bones) of these fish should be retained in support of the age study on bigeye tuna. Both tags have been inserted at the base of the second dorsal fin. They are about 4 inches long and 1/16 inch thick and bear the message:

> Hawaii Tagging Program
> For Reward Call 1 (800) 588-8066
> Fishermen can report tag recaptures by calling
> 1 (800) 588-8066.

The toll free telephone number will connect the caller to a program message phone when dialed from anywhere within the United States. Captured fish can also be reported at the Hawai'i numbers and addresses listed below.

> E-mail:
> <ditano@soest.hawaii.edu>
> or
> <kholland@hawaii.edu>
>
> Tel: 1 (808) 956-4108
> Fax: 1 (808) 236-7443 or
> 1 (808) 956-4104
>
> Hawai'i Institute of Marine Biology
> attn: Hawai'i Tuna Tagging Project
> P.O. Box 1346
> Kāne'ohe, Hawai'i 96744

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Assist HTTP (continued from page 7)

A reward and a letter with details of the date and place the fish was tagged, the growth rate and distance traveled are sent to individuals providing legitimate reports of tagged fish.

Fishermen with fishing vessels who would like to work with the project can also contact the above numbers to discuss compensation for trip expenses and released fish. The program is interested in working with fishermen near any Hawai'i state FAD as well as other Hawai'i locations, such an Ni'ihau, Ka'ula Rock, Penguin Banks, the Moloka'i/Lāna'i/Maui triangle, Wai'anae and the Kona district.

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