PFRP

Pelagic Fisheries Research Program

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Introduction

The last PFRP Newsletter (October–December 1999) featured two articles on the status of tuna and billfish stocks in the Pacific. In this issue, we continue the theme with a contribution from NMFS/JIMAR researcher Marc Labelle on the status of Pacific bigeye tuna stocks. Labelle uses a method very similar to the one used by Michael Hinton to analyze the status of blue marlin. Also in this issue, PFRP Program Manager John Sibert contributes his personal observations on the most recent round of negotiations for a comprehensive tuna conservation and management treaty in the Pacific.

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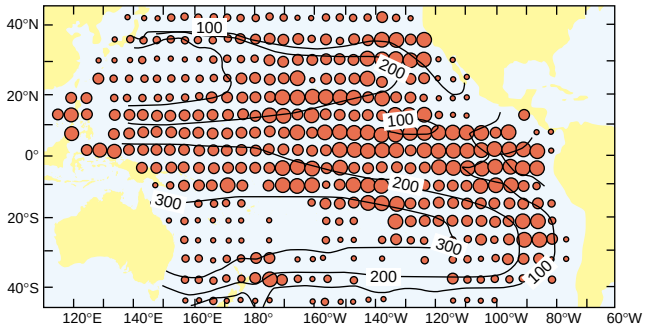

Figure 1. Annual depth distribution of the 15°C isotherm and nominal bigeye CPUE for the Japanese longline fleet from 1986 to 1995 (Hampton et al. 1998).

More Data Required to Assess Bigeye Tuna Population

This is a companion article to "Pacific Blue Marlin Stock is Healthy, Says New Analysis," which appeared in PFRP Volume 4, Number 4. In this article, researcher Marc Labelle discusses the data and methods behind the prevailing hypothesis on bigeye tuna population and identifies steps that could be taken to improve the reliability and accuracy of the hypothesis.

Fishery monitoring programs generally aim to provide time series of catch and effort by area and period. The corresponding trend in catch-per-unit effort (CPUE) is often considered an index of abundance and used to calibrate models that perform sequential population analyses (SPA). From a statistical point of view, CPUE is a ratio that can be determined using "estimators."

Estimating CPUE

The suitability of various estimators depends on several factors, including

- intended use;
- the level of variation in effort and catch and the correlation between these two variables;
- the weight given to each observation pair, and
- the relative incidence of zero catches.

In some cases, the available data sets do not fall in any particular category, and several estimators appear to be equally suitable. Labelle et al. (1997) faced this scenario and used several estimators to compute CPUE trends for the bluefin tuna purse seine fishery in the Mediterranean. The authors obtained substantially different trends and concluded that complementary surveys would be required to identify the most reliable estimator.

Even when there is agreement among scientists on the choice of a particular estimator, fishing methods and gears change over time, so the time series of catch and effort must be adjusted before proceeding with the analysis. Generalized linear models (GLMs, McCullagh & Nelder 1989) and additive models (GAMs, Hastie and Tibshirani 1990) are used to account for the effects of certain factors and produce "standardized" CPUE trends that are, in principle, more representative of actual abundance. In longline fisheries, Olsen and Laevastu (1983) identified 32 factors that can affect CPUE. Typical logbooks do not keep track of so many details, and long time series of data with high contrast are needed to statistically dissociate the effects of several factors. Thus, for many fisheries, only a partial standardization may be achieved by this method.

The Effect of Fishing Habits

The apparent relation between CPUE trends and abundance is also affected by the spatial distribution of fishing effort. When

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More Data Required (continued from page 1)

fishing activities are not conducted over the entire range of the species harvested, CPUE trends may not reflect overall abundance. Geostatistical methods such as kriging can be used to predict densities in unfished areas (see Pelletier and Parma 1994), at least in cases where the underlying assumptions of the interpolation method are met (Hilborn and Walters, 1992). This helps deal with problems linked to the horizontal distribution of effort, but further adjustments may be needed when the vertical distribution of effort does not match that of the species harvested.

Longline fishing depth has been shown to be an important source of CPUE variation in several studies (Hanamoto 1987, Boggs 1992). Lines deployed deeper are more effective in catching certain species such as bigeye tuna. This is thought to be due to a preference of bigeye tuna for 10-15°C water (Hanamoto 1987; Holland et al. 1990; Boggs 1992; Brill 1994), since high nominal CPUE values tend to occur where the 15°C isotherm is within 200 m from the surface (Fig. 1).

Since the mid-1970s, Japanese longliners progressively moved from shallow sets (4–6 hooks/basket) reaching depths of 90–150 m, to deeper sets (>10 hooks/basket) reaching 100–250 m (Suzuki et al. 1977; Hanamoto 1987). It has been hypothesized that this increased the effectiveness of longline gear in targeting bigeye tuna. Consequently, the depth distribution of the species and the gear should be accounted for if longline CPUE is to serve as an index of bigeye abundance.

The Role of Statistics

Hinton and Nakano (1996) described a procedure to standardize longline CPUE using data on effort distribution, fish habitat preferences and environmental conditions. Basically, the degree of overlap between the fish and the depth distributions of the hooks serves to compute an index of "effective effort." In strata where fish spend most of their time away from the hooks, effective effort is a small fraction of the number of hooks deployed. By contrast, in cases where they overlap totally, the probability of contact between fish and hooks is highest, and effective effort is a function of all hooks deployed in that stratum.

Hampton et al. (1998) used this procedure to compute indices of abundance for bigeye tuna throughout the Pacific Ocean from 1962 to 1996. The authors used the results of fishing depth studies with time-depth recorders (TDR), and records of the number of hooks/basket by fleet/period to estimate the proportion of hooks per 100 m depth zone in each stratum (max. 600 m). Sonic tracking results and published data on the temperature and oxygen preferences of bigeye were used to compute indices of habitat preference (Figs. 2-4).

Two indices of temperature preferences were generated: the first based on the best available information and a second depicting less restrictive preferences. Sea temperature and dissolved oxygen data were extracted from the World Ocean Atlas climatological databases (Levitus and Boyer 1994a, b) and used to characterize the habitat conditions in each stratum. For every depth zone within a stratum, the product of the bigeye temperature and oxygen-preference indices is computed based on the prevailing conditions. The scores obtained are normalized (sum to 1.0) to obtain six fractions, which can be considered to represent the proportion of time bigeye spend in each depth zone. These figures, and those on hook-depth distribution, are then used to compute effective effort by stratum and an overall index for each year (Fig. 4).

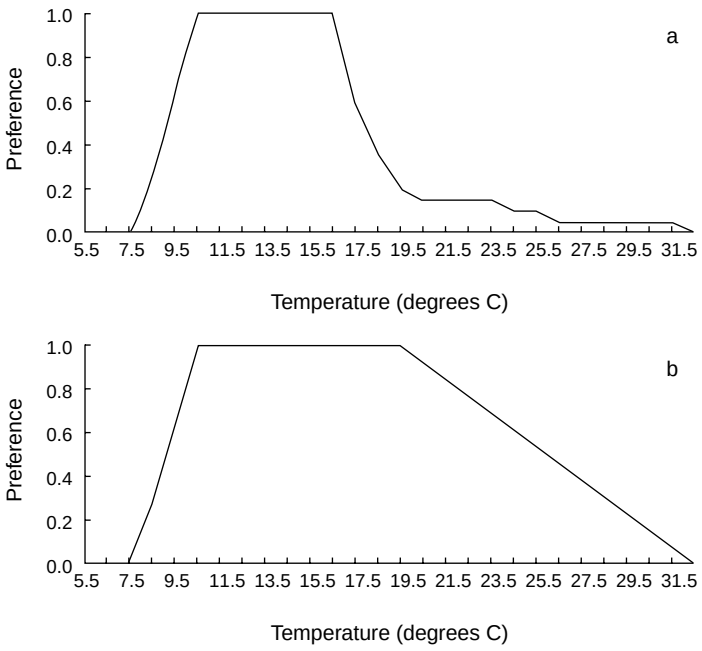

Figure 2. Alternative hypotheses regarding temperature preferences of bigeye tuna: (a) based on sonic tracking (Holland et al. 1990) and longline TDR observations (Boggs 1992), and (b) alternate hypothesis assuming a stronger preference for water temperatures >20°C (Hampton et al. 1998).

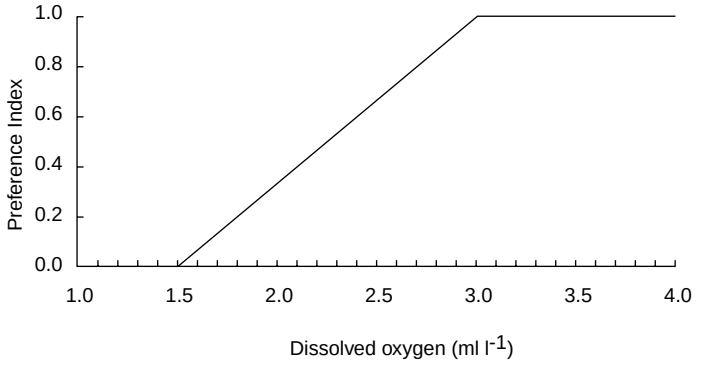

Figure 3. Dissolved oxygen preference of bigeye tuna, based on various physiological observations (Hampton et al. 1998).

Applying Statistical Findings

For the Western and Central Pacific Ocean (WCPO), the standardized CPUE index trend is strongly dependent on which temperature preference hypothesis is selected. One possible interpretation is that under hypothesis 1, changes in longline deployment patterns lead to greater gear efficiency in the WCPO because

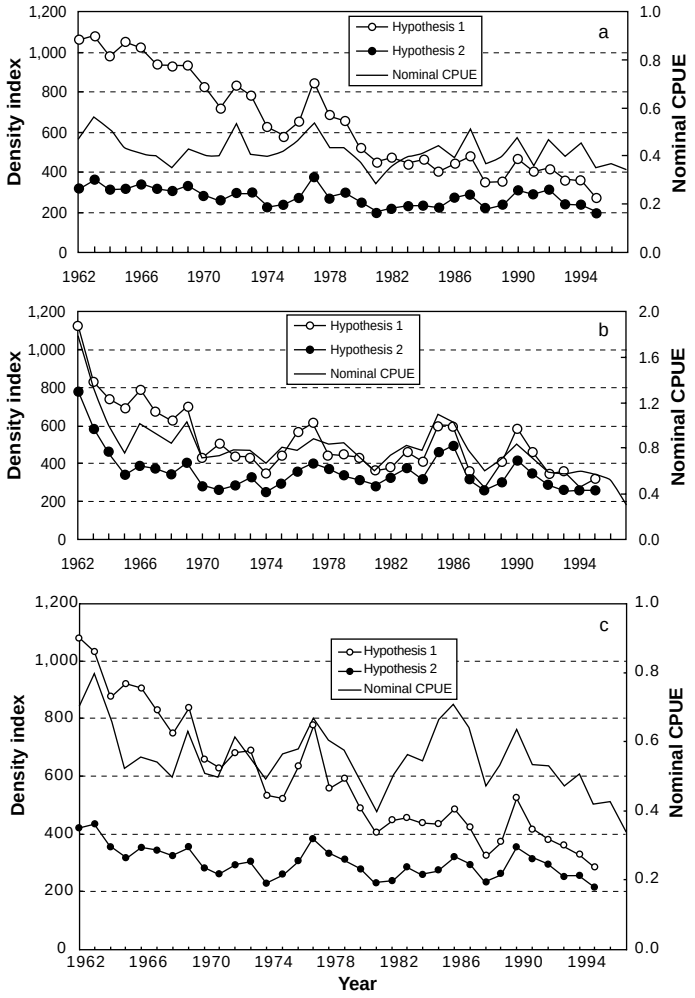

Figure 4. Standardized CPUE for the two temperature preference hypotheses and nominal CPUE for (a) the western and central Pacific, (b) the eastern Pacific, and (c) the entire Pacific Ocean (Hampton et al. 1998).

of better targeting of optimal bigeye habitat. Under hypothesis 2, little or no change in the effectiveness of longline effort is predicted because of the less specific temperature preference assumed for bigeye tuna. For the Eastern Pacific Ocean (EPO), both density indices and nominal CPUE show similar trends. This may reflect the importance of dissolved oxygen, since the low concentrations that limit the distribution of bigeye are sufficiently shallow in some areas to reduce the effectiveness of deep sets. Also, the change from conventional to deep longline sets may have had a smaller relative impact on gear efficiency due to the shallower optimal temperature layer in that region.

Conclusions

The results indicate that fishing patterns and bigeye habitat preferences should be taken into account to properly interpret CPUE trends. The prevailing hypothesis indicates the overall population size has declined continuously since 1962; this trend is also accompanied by an apparent geographical compression of the habitat range. However, it would be premature at this stage to infer too much about bigeye stock status from this preliminary analysis; more precise information on habitat preferences is required to produce reliable indices. Archival tagging of bigeye tuna would provide very valuable information on this issue. Further monitoring on fishing patterns and better models of longline depth profiles could help improve the predictions. Also, the standardization procedure should be tailored to account for other factors that are known to influence longline CPUE.

Finally, efforts should be made to determine if the predicted density patterns are supported by empirical observations. Systematic fishing surveys using a standard gear configuration should be conducted for such purposes. Unfortunately, there seems to be a perennial shortage of funding to conduct large-scale field studies on tuna. Hopefully, the new tuna fishery management commission, to be created shortly, will recognize the complexity of bigeye stock-assessment, and help provide the resources required to reduce much of the current uncertainty concerning its stock status.

Further Reading

Hampton J., K. Bigelow, and M. Labelle. 1998. Summary of current information on the biology, fisheries and stock assessment of bigeye tuna (*Thunnus obesus*) in the Pacific Ocean, with recommendations for data requirements and future research. Secretariat of the Pacific Community. Oceanic Fisheries Programme Tech. Rep. 36. 46p.

Hinton, M.G., and H. Nakano. 1996. Standardizing catch and effort statistics using physiological, ecological and behavioral constraints and environmental data, with an application to blue marlin (*Makaira nigricans*) catch and effort data from the Japanese longline fisheries in the Pacific. IATTC Bull. 21(4): 117–200.

Labelle, M., T. Hock, B. Liorzou and J.L. Bigot. 1997. Indices of bluefin tuna (*Thunnus thynnus thynnus*) abundance derived from sale records of French purse seine catches in the Mediterranean Sea. Aquat. Living. Resour. 10: 329–342.

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Reflections on MHLC5

It was my privilege, as a member of the United States delegation, to participate in the fifth session of the Multilateral High-level Conference on the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific (MHLC); the session was held September 5–16, 1999 in Honolulu. In my view, participation by scientists in the MHLC is critical if we expect to conclude in June 2000 with a practical and scientifically supported management commission. Unfortunately, many interested scientists with expertise in highly migratory fish stocks in the Pacific, were unable to participate in MHLC5, and I thought that those who were absent might be interested in what transpired. The following opinions and observations are mine alone—not those of the United States delegation—and I offer them in the spirit of wider dialogue.

Participation by Scientists

There were 28 official delegations listed, but French Polynesia was absent, so in fact there were 27 participating delegations. Of these, only 11 delegations included one or more members of the Standing Committee on Tuna and Billfish (SCTB), the only body with a credible claim to Pacific-wide scientific expertise on highly migratory fish stocks. The Chair of the SCTB was particularly noticeable by his absence, either as an observer or member of a national delegation. It seems to me that delegations without scientists, particularly without SCTB members, are at a great disadvantage when technical issues are discussed; it's a bit like going to a shootout without your guns. A sprinkling of observers from several organizations was present, including the Secretariat of the Pacific Community (SPC), the Forum Fisheries Agency (FFA), and the Inter-American Tropical Tuna Commission (IATTC). Generally, observers speak only when spoken to in plenary, although the IATTC circulated a paper with the permission of the Chair. While some SCTB members addressed the plenary on behalf of their national delegations, most SCTB members contributed their expertise by intervening in delegation meetings, whispering in the ears of heads of delegation, building consensus during breaks, or assisting the Chair with late-night drafting duties.

Geography & Boundaries

Geographic issues occupied much of the attention of the MHLC5; these included sub-regional panels, high-seas pockets (dubbed "coconut holes"), and the area of competence of the proposed convention. The area of competence was debated more than once, with various delegations expressing their preferences for different boundaries. Multiple alternatives were offered for the northern boundary: 50°N, 45°N, 42°N, 40°N 35°N, 30°N, 25°N, and probably others that I can't recall. The eastern boundary also moved around a bit, and the western boundary disappeared and reappeared several times. The exercise approached a *reductio ad absurdum*, and it became obvious, at least to me, that articulation of geographic boundaries that are both biologically sensible and politically acceptable is an impossible task. It is difficult to predict how this issue will play out, but there is some sympathy for adopting a strategy similar to that adopted by the IATTC—to declare that the area of competency is the central and western Pacific (i.e., no explicit boundaries), but in the case of a regulatory measure applied to conserve a stock, to define the regulatory area with precise geographic boundaries. In the current draft text, only the eastern and southern boundaries are explicitly delimited.

The boundaries issue is one that could either simplify or complicate the scientific work of Commission scientists. If the Commission boundaries do not include the complete distribution of the fishery, it becomes difficult to obtain data. We witnessed this problem at SCTB12 when we were unable to review data for northern albacore because it falls under the aegis of another body, the Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC). This could have resulted in a misleading impression of the distributions of the northern albacore population, and of fisheries on it (cf. Working Paper MHLC1). It is already clear that careful coordination of research and management between the MHLC Commission and the IATTC will be necessary on many issues. If boundary issues are not resolved in a satisfactory manner, three-sided cooperation on other issues may also be required (assuming the ISC actually becomes a reality). It sounds like extra work and extra costs to me.

Tim Lawson

John Sibert (C) with Robin Allen (L), IATTC, and Tony Lewis, SPC, at MHLC5, held in Honolulu, September 1999; fewer than half of the delegations at the conference had scientists to advise them.

If northern boundaries are too far south, the northern range of some important species will be excluded from the MHLC commission. In addition to northern albacore and northern bluefin, significant exclusions would include skipjack, yellowfin, swordfish, and some marlins, all species for which there are important or potentially important fisheries in both equatorial regions and high latitudes. Such an exclusion would probably require a separate body to manage the northern stocks. Is anyone willing to duplicate the effort of negotiating the MHLC Convention in order to transform the ISC into a real management organization? It sounds like even more extra work and even more extra cost to me.

Regions & Representation

Some delegations proposed sub-regional panels (specifically, a northern panel) to advise the Commission on unique problems that may occur in some areas. As you might imagine, this proposal only added to the confusion because the boundaries of the sub-regional panels also were not clear. If the broader definition of the convention area ultimately is adopted, it seems clear to me that sub-regional panels will be inevitable. Some countries will be more interested than others in management measures to conserve southern albacore. The same holds true for fisheries in the northern part of the range with regard to management measures applied to equatorial skipjack fisheries.

The draft conventions give "special attention" to management measures in coconut holes. This issue is very important to several island states because it's possible that fishing in the holes might adversely impact populations in adjacent EEZs. Enforcement and catch reporting were mentioned as concerns, but no consideration was given to other, more creative ways in which these pockets might help achieve the conservation and management goals of the Commission. For instance, fishing in these areas might somehow be restricted to help maintain ecosystem integrity or protect a portion of the population. An even more radical suggestion would be to use revenues from licensing of fishing in the coconut holes to help finance commission operations.

Geographic issues should be amenable to empirical study. At SCTB12, scientists began to discuss the size of an area that would have to be controlled to achieve a specific management goal. I'm certain we will hear the results of more studies on these questions at SCTB13.

Quota Allocation

Quota allocation was discussed immediately after a divisive and inconclusive discussion about decision making. It should not be surprising, therefore, that the discussion about allocation did not fare well; the tenor of the discussion can be summed up by the expression "What's mine (within my EEZ) is mine and what's yours (high seas) is negotiable."

In my view, discussion of quota allocation is premature in the extreme; allocation presupposes that the preferred management method will be to compute a total allowable catch (TAC) for the convention area and then divide the TAC among participants. One delegation pointed out that there are several other fisheries management methods (area closures, seasonal closures, limited entry) that have not been extensively discussed in the context of the MHLC. It is obvious that, if the desire is there, a TAC can be established in an orderly fashion without going through the painful exercise of allocation. So why make trouble and spend precious time now discussing allocation?

Species List

Some of us had hoped for a generic species list such as "fish caught by tuna boats." The current draft MHLC convention defines "highly migratory fish stocks" as those listed in annex 1 of the United Nations Convention on the Law of the Sea (excluding sauries) and "other species of fish" that the commission wants to include. Non-target and Associated and Dependent Species (NTADS) are generally included in the articles on application of the precautionary approach. So it would seem that there is sufficient scope to address management measures for incidental- and by-catch species such as mahimahi, opah, sharks, turtles, and sea birds if necessary.

Scientific Advice

The draft treaty calls for creation of a scientific committee and authorizes the commission to "engage the services of scientific

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Upcoming Events

February 7–11, 2000

Symposium on Tagging and Tracking Marine Fish with Electronic Devices
East-West Center; Honolulu, HI
fax (808) 522-8223
e-mail jsibert@soest.hawaii.edu, or
dlau@soest.hawaii.edu

February 14–17, 2000

International Pelagic Shark Workshop
Pacific Grove, CA
Contact Ocean Wildlife Campaign

March 23–26, 2000

Conference in Regards to Interannual, Decadel, and Interdecadal Scales of Variability in the Pacific from the Tropics North to the Arctic
Scripps Institution of Oceanography, La Jolla, CA
c/o Institute of Ocean Sciences
P.O. Box 6000, Sidney, B.C., Canada V8BL 4B2
Tel (1-250) 363-6366 or (1-250) 363-6827
e-mail picse.ios.bc.ca
http./.pices.ios.bc.ca

April 11–19, 2000

MHLC6
Hawaii Convention Center, Honolulu, HI
e-mail barbara.hanchard@ffa.int

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Reflections on MHLC5 (continued from page 5)

experts," but as far as I can tell, scientific advice has received only cursory attention. It might be possible for the SCTB to take on some of the functions envisaged for a scientific committee, and for the SPC's Ocean Fisheries Program (OFP) to be engaged to supply scientific services. At present, the OFP reports to the Pacific Community (PC) and its members. Many parties to the MHLC are not PC members and feel uncomfortable depending on an organization in which they do not participate. Similarly, PC members may feel that their priorities will not be well addressed if the OFP is preoccupied with issues related to the MHLC Commission. Finally, it must be asked how current OFP funding sources would view such "diversions" of research assets.

Many other issues of interest to scientists were discussed or at least mentioned. Of the remaining outstanding issues, I think boundaries, scientific advice and management methods are among the most critical. MHLC Chair Satya Nandan remarked informally that it is unlikely scientists will get everything they want. In my opinion, scientists should make every effort to ensure that they get what they need.

A copy of the MHLC5 Report, with the current draft convention, is available at http://www.soest.hawaii.edu/PFRP/pfrp1.html. MHLC6 is tentatively scheduled for April 2000 in Honolulu. I intend to participate, and I hope to see more of my scientific colleagues accompanying national delegations.

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Fisherman Rewarded for Return of Archival Tag

Thanks to commercial fisherman Keoni Erickson, the PFRP/NMFS archival tagging project has recorded an early notch in its data belt. Erickson on November 29 hauled in a 30-lb, 86-cm bigeye tuna near Cross Seamount off Kona and on seeing its spaghetti tag, iced the fish and brought it in whole. NMFS researchers Mike Musyl and Rich Brill met Erickson at Kewalo Basin to remove the archival tag, which had accumulated 8 days worth of temperature and depth profiles and navigation information. The cooperative tuna had been tagged and released over the Seamount on November 20 by Musyl and Tom Kazama and crew, aboard the NOAA research vessel *Townsend Cromwell*. The goal of the tagging project is to understand harvest impacts and interactions among Pacific fisheries by obtaining data on tuna migration patterns and on the effect of environmental factors on distribution and catchability. Twelve other tags were deployed with the first and are awaiting discovery by other lucky fishermen.

Dave Itano

Keoni Erickson (R), skipper of the hand-liner Moana Kai, accepts a t-shirt and $500 reward from NMFS Fisheries Biologist Rich Brill (C) for bringing in an archivally tagged bigeye tuna; at left is Biologist Mike Musyl, who had tagged and released the tuna only 9 days earlier.

PFRP Pelagic Fisheries Research Program

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