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Population Dynamics of Bigeye and Yellowfin tuna in Hawai‘i’s Fishery[1]

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*Around the Hawaiian Islands, a variety of small and medium-scale fisheries target bigeye (*Thunnus obsesus*) and yellowfin tuna (*T. albacares*) associated with offshore seamounts and weather monitoring buoys, an inshore network of fish aggregating devices (FADs), and natural aggregation sites (Itano and Holland, 2000). These fisheries, conducted from longline, troll and handline, and to a lesser extent from pole-and-line vessels, provide an important source of revenue for the state (Boggs and Ito, 1993; Ito and Machado, 1999). The small-gear fleet (essentially the trolling and handline vessels) supports recreational and subsistence fisheries for both residents and the tourist industry (Pooley, 1993; Hamilton and Huffman, 1997).*

An important sector within Hawai‘i’s small-scale commercial fisheries is the offshore handline fishery, which targets mixed-species aggregations found in association with NOAA offshore weather monitoring buoys and seamounts (Itano and Holland, 2000). Most of the catch and effort in this fishery, which currently lands roughly 500 t per year, concentrates on the Cross Seamount and takes mostly juvenile and sub-adult yellowfin and bigeye tunas. Concerns have been raised as to whether the fishery intercepts too many juveniles that might otherwise recruit to inshore fisheries or to the offshore longline fishery (Holland et al., 1999). There is also concern among handline fisherman exploiting the Seamount that further increases in fishing effort could over-exploit offshore tuna resources, and/or reduce the economic viability of their fishery. Moreover, yellowfin and bigeye around Hawai‘i are part of the wider Pacific Ocean stock that is being exploited by various coastal and high-seas fisheries (Hampton and Fournier 2001b; Hampton and Fournier, 2001a). Therefore, the overall health of the Pacific-wide stock is important for the viability of local fisheries. In these concerns, the Cross Seamount fishery exemplifies resource allocation and sustainability issues that are increasingly frequent in all oceans.

[1]This article is excerpted from the original paper, “Dynamics of bigeye and yellowfin tuna in Hawaii’s pelagic fisheries: analysis of tagging data using a bulk transfer model incorporating size-specific attrition,” which was published in the NMFS Fishery Bulletin, Vol. 101, No. 2: 215-228 (April, 2003). Go to http://fishbull.noaa.gov/fcontent.htm to access the complete paper.

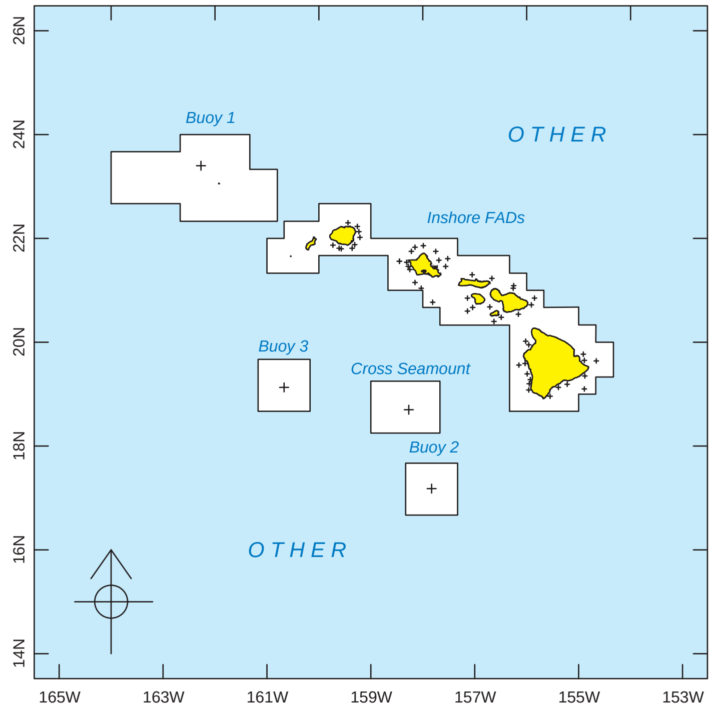

Figure 1. The study area around the Hawaiian archipelago, showing the boundaries of the sites used in the model; individual crosses indicate the geographic location of FADs.

The Tagging Project

Conventional tagging of bigeye and yellowfin commenced in 1995 to advance understanding of the dynamics of tuna aggregations in the Hawaiian Islands, and to provide management guidance. Although initially focused on the Cross Seamount, the Hawai‘i Tuna Tagging Project (HTTP) expanded its scope to tag fish throughout the archipelago, and has tagged and released more than 17,000 bigeye and yellowfin of roughly equal numbers during a five-and-a-half-year period.

Previous analyses of the data suggested that recruitment (transfer) rates from the Cross Seamount to inshore areas were low, and concluded that fishing effort on the Seamount was not having an

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adverse impact on inshore trolling and handlining, or offshore longlining in local tuna fisheries (Sibert et al., 2000). The data also suggested that bigeye on the Seamount had a higher mean residence time than yellowfin (Holland et al., 1999; Sibert et al., 2000).

However, those analyses were made while tagging was still in progress, using a small set of recapture data. Many more tag releases and recoveries have taken place since then, permitting a more complete view of movement and residence times. The work presented here includes releases and recoveries up to June 2001. A size- and site-specific tag attrition model was developed to analyze the data and provide information on transfer and exploitation rates, which are important for management of the resource as well as for subsequent fishery assessments. The approach used in this research may prove useful in other areas in which resource allocation issues need to be addressed.

Materials and Analytical Methods

This analysis includes recaptures of tagged bigeye and yellowfin tuna released in the Hawai'i pelagic fishery between August 1995 and November 2000, specifically, in the area from 163°W to 152°W, and 14°N to 24°N (Figure 1). We examined 12,848 tag releases from within the area, of which 7,541 (59%) were bigeye and 5,307 (41%) were yellowfin. Releases were made primarily at the Cross Seamount, located about 290 km south of O'ahu, at 18°42'N, 158°16'W. Releases were also made at NOAA Weather Buoys 51001, 51002, and 51003 (identified as Buoy 1, Buoy 2 and Buoy 3 in Figure 1) and at inshore areas immediately surrounding the main Hawaiian Islands. Additional details on the tagging program and fisheries are given in Itano and Holland (2000). As of June 2001, 1,131 bigeye (14.9%) and 983 yellowfin tuna (18.5%) were recovered; a summary of releases and recaptures with the information used in this analysis is given in Table 1.

The method used to analyze the data is an extension of a tag-attrition model commonly used in analysis of tuna tagging data (Kleiber et al.,1987; Hampton, 1991a). We developed a site- and size-specific model to describe the dynamics of the tagged population in the study area by combining Sibert et al.'s (2000) site-specific model with Hampton's (2000) size-specific model. The model essentially deals with the basic processes: natural mortality (M), fishing mortality (F) and transfers (T) between the various components (or compartments from the model's perspective) in the fisheries. Fishing and natural mortality were estimated over three size classes: bigeye 29-55cm, 56 -70cm and > 70 cm and yellowfin 20-45cm, 45-55cm and > 56cm. The transfer rates, however, were aggregated and therefore estimated over the entire sizes. The tag-release and recaptures allowed us to aggregate the data into 5 sites for bigeye and 6 sites for yellowfin tuna. These are shown in Figure 1.

Results

Several variants of the attrition model were evaluated, including attrition estimated over a single size class, and common fishing mortality rates among the offshore sites (Buoy 1, Buoy 2, Buoy 3 and the Cross Seamount; see Figure 1). Conveniently, the number of parameters to be estimated in the tag-attrition model can be used to identify the structurally different models. For example, $M_3F_{3,5}T_{13}$ is the model in which M is estimated over 3 size classes, and F over 3 size classes at 5 sites, with 13 transfer coefficients for the observed exchanges.

Table 1. Summary of tag releases and recaptures by site and species, with usable information. Geographic areas of the sites are given in Figure 1.

Site	Release	Recapture
Bigeye Tuna		
Buoy 2	1493	317
Buoy 3	326	29
Cross Seamount	5371	653
Inshore Areas	160	50
Other	0	48
Total	**7350**	**1097**
Yellowfin tuna		
Buoy 1	247	20
Buoy 2	260	40
Buoy 3	59	9
Cross Seamount	3423	635
Inshore Areas	1239	254
Other	0	12
Total	**5228**	**970**
Grand Total	**12578**	**2067**

For both species, the model in which the attrition is partitioned over size classes demonstrated significant improvement ($P > 0.999$ using a likelihood ratio test) over the reduced models: $M_3F_{3,5}T_{13}$ versus $M_1F_{1,5}T_{13}$ for bigeye, and $M_3F_{3,6}T_{17}$ versus $M_1F_{1,6}T_{17}$ for yellowfin. Similarly, the models with site-specific fishing mortalities described the data significantly better ($P > 0.999$) than models in which a common fishing mortality was estimated for all offshore aggregations. The observed and predicted tag returns by time-at-liberty and by initial size classes of release provide good descriptions of the data. The graphs for the Cross Seamount fishery are shown in Figures 2 and 3. Agreement between observed and predicted number of tags by site is reasonably good, particularly for sites where large numbers of recoveries were made (Tables 2 and 3).

The transfer coefficient estimates for movements between the various areas ranged from virtually zero to 0.05 day^{-1} (Tables 4 and 5). For bigeye, the transfer rate estimates from Buoy 2, Buoy 3 and the Cross Seamount to the longline fishery were higher than the rates from those sites to inshore areas (Tables 3 and 4). For yellowfin, the pattern was similar except for the additional high transfer estimate from Buoy 1 to the longline area. These differences between transfer rates (from offshore sites to inshore site vs. offshore sites to longline area) in both species were statistically sig-

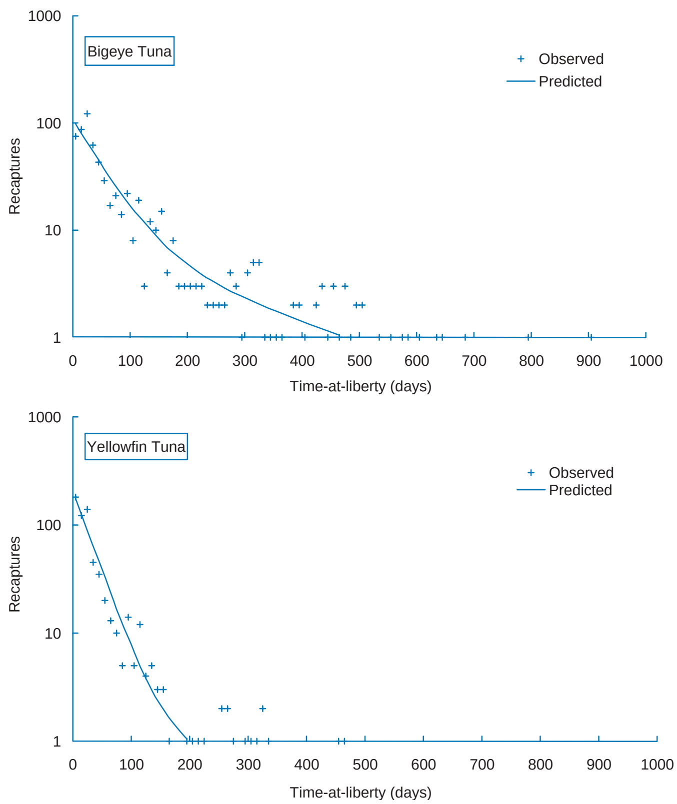

Figure 2. Observed (crosses) and predicted (continuous lines) tag returns by time-at-liberty from the Cross Seamount for bigeye and yellowfin tuna.

nificant (taken to mean if the 95% CI ranges do not overlap); this shows the importance of emigration into the longline fishery compared with emigration into the inshore area. The transfer rate for yellowfin moving from inshore to the Cross Seamount was virtually zero, while transfer from inshore to the longline area was very low (0.00703 day^{-1}). There was no observed transfer of bigeye from inshore areas to the longline fishery, and a very low estimated transfer rate to the Seamount (0.00375 day^{-1}).

Estimates of the natural mortality rate for both species were highest in the smallest size classes. The estimates decreased gradually for both species, except that for yellowfin there was a slight increase in the largest size class, yielding a ‘U’ shaped curve (Figure 4). The estimates for bigeye were 0.00576, 0.00372 and 0.00181 day^{-1} (2.102, 1.356 and 0.660 yr^{-1}) for 29-55, 56-70 and ≥71cm respectively, while for yellowfin they were 0.01425, 0.00221 and 0.00361 day^{-1} (5.203, 0.806 and 1.316 yr^{-1}) for 20-45, 46-55 and ≥56 cm respectively (Figure 4 and Table 6). These estimates are within the range of the values estimated by Hampton (2000) from analysis conducted for fisheries in other regions of the Pacific.

Fishing mortality estimates are highly variable both within the three size classes and between the sites (Figure 5). At the Cross Seamount, *F* was nearly the same for bigeye tuna over the three size classes (≈ 0.0026 day^{-1}), but for yellowfin tuna, *F* at the Seamount was higher for the medium size than for the smaller and larger size

Table 2. Bigeye tuna: observed and predicted tag transfers from the $M_3F_{3,5}T_{13}$, n = 31 model; the rows (From) are tag release sites and columns (To) are recapture sites.

To From	All	B2	B3	Cross	Inshore	Other
Observed						
All	1097	317	29	653	50	48
B2	321	294	5	18	3	1
B3	40	2	19	11	1	7
Cross	711	21	5	623	22	40
Inshore	25	0	0	1	24	0
Other	0	0	0	0	0	0
Predicted						
All	1115.8	332.0	29.7	652.7	50.9	50.5
B2	342.4	296.2	5.2	22.6	7.9	10.6
B3	36.8	0.7	18.5	12.6	2.0	3.1
Cross	715.3	34.3	5.9	604.7	34.1	36.1
Inshore	21.3	0.7	0.1	12.8	6.9	0.8
Other	0.0	0.0	0.0	0.0	0.0	0.0

Table 3. Yellowfin tuna: observed and predicted tag transfers from the $M_3F_{3,6}T_{17}$, n = 38 model; the rows (From) are tag release sites and columns (To) are recapture sites.

To From	All	B1	B2	B3	Cross	Inshore	Other
Observed							
All	970	20	40	9	635	254	12
B1	36	19	0	0	5	9	13
B2	47	0	32	1	7	6	1
B3	13	0	2	8	2	1	0
Cross	667	0	5	0	618	38	6
Inshore	207	1	1	0	3	200	2
Other	0	0	0	0	0	0	0
Predicted							
All	978.9	20.2	40.6	8.7	634.5	258.8	16.1
B1	33.5	18.6	0.5	0.0	5.0	8.1	1.3
B2	46.4	0.1	17.4	4.0	16.9	7.7	0.4
B3	7.8	0.0	0.6	1.1	3.9	2.0	0.1
Cross	677.1	0.4	20.7	3.2	606.5	34.3	11.9
Inshore	214.1	1.0	1.4	0.4	2.3	206.6	2.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0

classes (i.e., 0.0027, 0.0115 and 0.0067 day^{-1}).

The total attrition rate, *Z*, by size *k* and by site *i* can be calculated from $Z_{ik} = M_k + F_{ik} + \sum T_{ij}$, from which the averages for the size class or site may be obtained. Alternatively, these could be estimated from a model in which *Z* is kept constant over the size classes. While there were large variations in the estimates for different

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Population Dynamics (continued from page 3)

Table 4. Bigeye tuna estimated transfer coefficients (day^{-1}) from the full model $M_3F_{3,5}T_{13}$, n = 31; the rows (From) are tag release sites and the columns (To) are recapture sites. Elements with asterisks indicate transfers that were not observed; the diagonal elements (dashed) were not defined in the model.

	To				
From	B2	B3	Cross	Inshore	Other
B2	—-	0.00245	0.00113	0.00752	0.02707
B3	0.00000	—-	0.01111	0.01073	0.03927
Cross	0.00045	0.00026	—-	0.00464	0.01057
Inshore	**	**	0.00375	—-	**
Other	**	**	**	**	—-

Table 5. Yellowfin tuna estimated transfer coefficients (day^{-1}) from the full model $M_3F_{3,6}T_{17}$, n = 38. The rows (From) are tag release sites and the columns (To) are recapture sites. Elements with asterisks indicate transfers that were not observed; the diagonal elements (dashed) were not defined in the model.

	To					
From	B1	B2	B3	Cross	Inshore	Other
B1	—-	**	**	0.00648	0.01055	0.04935
B2	**	—-	0.04301	0.00217	0.00000	0.00024
B3	**	0.00036	—-	0.00205	0.00101	**
Cross	**	0.00226	**	—-	0.00136	0.02051
Inshore	0.00042	0.00069	**	0.00000	—-	0.00703
Other	**	**	**	**	**	—-

sites, the estimates were not appreciably different for each of the three size classes at any particular site. At the Seamount, the gross attrition rate for yellowfin of 0.038 day^{-1} was roughly twice that for bigeye (0.022 day^{-1}); this was estimated from a model in which M was estimated for a single size class. However, the average gross attrition for the entire geographic range of the model was not much different for the two species (0.033 day^{-1} for bigeye and 0.034 day^{-1} for yellowfin). Similar results were obtained in a preliminary analysis of the early recaptures (Holland et al., 1999). In other words, there are consistent indications that yellowfin and bigeye behave differently at the Seamount.

The rate of loss from the system is measured by the attrition rate, but a more intuitive measure may be calculated from "half-life" ($\ln(2)/Z_{ik}$), which is a proxy for population residence (Holland et al., 1999). Essentially, half-life is the time required to reduce a population by half. The half-life of about 18 days for yellowfin at the Seamount was roughly half that for bigeye (31 days). Although the half-life across the size classes for yellowfin was similar, the half-life for the larger class of bigeye was significantly longer than it was for the smallest class (Table 6).

Table 7 shows the ratios of the attrition components to the total gross attrition for both species on the Seamount; roughly 70% of the total loss is due to emigration. Fishing mortality accounted for about 12% in each of the three size classes of bigeye, whereas yellowfin *F* estimates were 7%, 30% and 20% respectively. The contribution of natural mortality to overall attrition in the smaller size classes was substantial: 24% for bigeye and 35% for yellowfin. In the larger size classes, the contributions ranged from 6 to 16%.

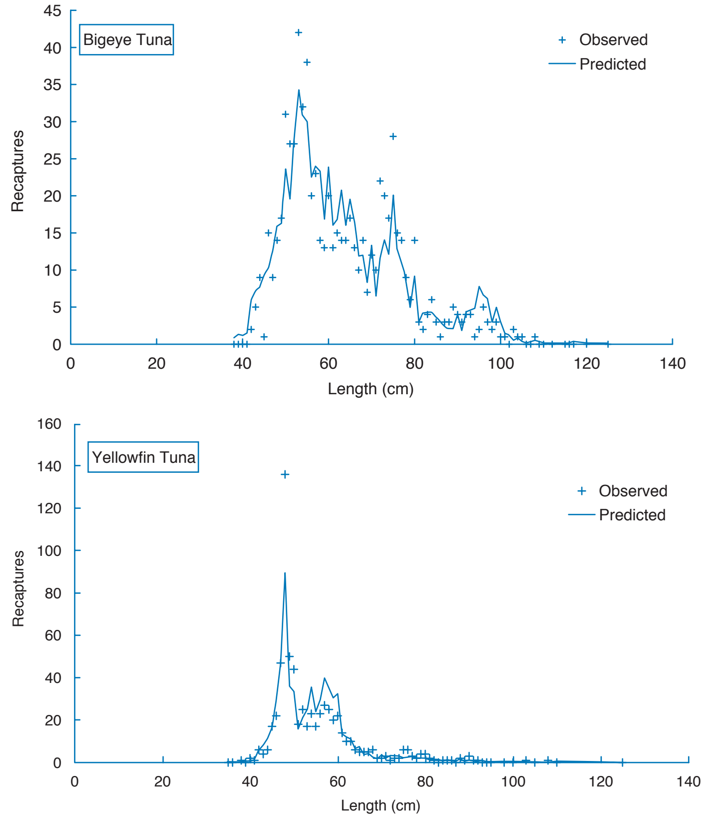

Figure 3. Observed (crosses) and predicted (continuous lines) tag returns by initial release size class from the Cross Seamount for bigeye and yellowfin tuna.

Discussion

The size- and site-specific attrition model described in this paper is new, and potentially applicable to other fish species for which release and recapture data meet the model requirements. Essentially, what is required are the sizes and geographic positions of releases and recaptures. However, one difficulty was encountered relating to the quantity of release data that was available for analysis. Since releases were stratified over 1-cm size-class cohorts to reliably track their growth over time, larger numbers of releases would be required to have reasonable numbers in the cohorts. We thus assumed that all tags were released at some arbitrary time zero.

Attempts to estimate size-specific transfer rates were unsuccessful due to poor convergence of the numerical estimation procedure; the rates were poorly defined in the data sets because of the low number of recaptures in the relevant strata. However, it is trivial to incorporate size-specific transfer rates in the model, and use the same procedure to estimate the transfer rates in the size classes under scrutiny.

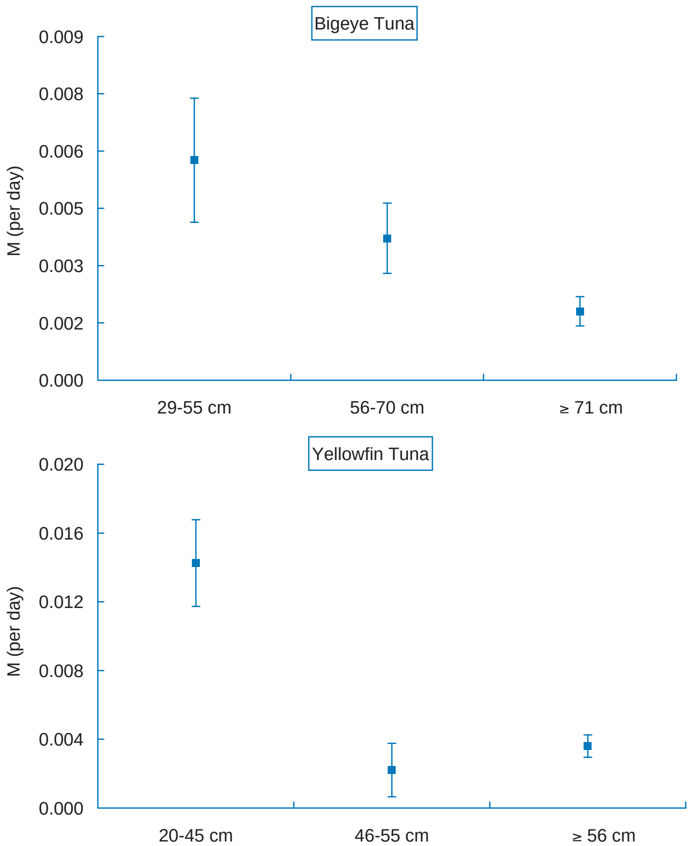

Figure 4. Estimates of natural mortality rates by size classes for bigeye and yellowfin tuna; error bars are one standard deviation across the mean value.

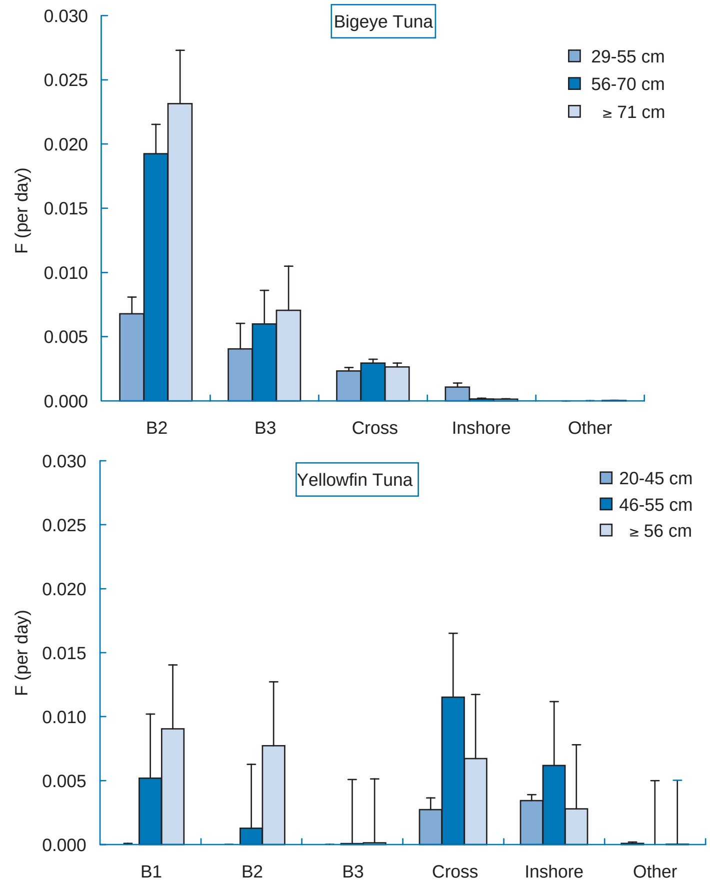

Figure 5. Estimates of fishing mortality rate by size-class and by site for bigeye and yellowfin tuna; error bars are one standard deviation from the mean value.

Two of the primary objectives of the HTTP were to improve understanding of the dynamics of tuna aggregations at the Cross Seamount, and to determine the importance of Seamount-associated fish to nearby longline and inshore fisheries. This discussion therefore focuses on the Seamount fishery and its potential interaction with other fisheries. Previous analyses using fewer data have estimated gross attrition rates and residence times (Holland et al., 1999) as well as transfer and attrition rates (Sibert et al., 2000). But by using the more recent and complete data and including size-specific attrition to improve the tag-attrition model, we have been able to provide a more detailed picture of fishery dynamics and interactions.

Attrition and Transfer Rates

The natural mortality rate is a critical parameter in stock assessment models, and size- or age-specific estimates would greatly improve stock assessment efforts. Unfortunately, natural mortality is not linked to a well defined *in situ* process, and M is always estimated indirectly (e.g., Fournier et al., 1998). In tag-attrition models, M is the "residual attrition" that cannot be accounted for by processes specified in the model. In our model, M would also include permanent emigration beyond the model area. Hampton (2000) estimated natural mortality rates from tagging data for a large number of size classes from a "single fishery" model. We have shown here that the attrition component can also be partitioned into size classes in a bulk transfer model. The relatively low number of recoveries from most of the sites did not allow us to estimate attrition over a larger number of size classes. However, our estimates of M are consistent with Hampton's (2000) estimates for both species within the size ranges considered.

The relatively low estimates of transfer rates for both species from the Cross Seamount to inshore areas support earlier findings (Sibert et al., 2000). However, the relatively high transfer rates estimated for both species from the Seamount and offshore buoys to the longline fishery (and by inference to the Pacific-wide fishery) suggest that fish associated with these structures contribute substantially to the longline catch. Furthermore, the longline fishery considered in our model is an open compartment with no boundaries. Any recoveries outside the bounded compartments are considered as emigrants from the perspective of inshore and offshore

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Table 6. Estimates of size-specific attrition components (day^{-1}) and residence times (days) at the Cross Seamount, with standard deviations of the estimates (in parentheses). Note the different size classes for the two species; also note that the size-independent transfer rates make the emigration component constant for all the size classes.

		Bigeye tuna		
Component	From	29–55cm	56–70cm	≥71cm
M	All	0.0058 (0.0016)	0.0037 (0.0009)	0.0018 (0.0004)
F	Cross	0.0023 (0.0003)	0.0029 (0.0003)	0.0026 (0.0003)
Emigration	Cross	0.0159 (0.0017)	0.0159 (0.0017)	0.0159 (0.0017)
Resid.Time	Cross	28.9 (2.6)	30.7 (206)	34.0 (3.1)
		Yellowfin tuna		
		20–45cm	46–55cm	≥ 56cm
M	All	0.0143 (0.0025)	0.0022 (0.0016)	0.0036 (0.0006)
F	Cross	0.0027 (0.0009)	0.0115 (0.0019)	0.0067 (0.0007)
Emigration	Cross	0.0241 (0.0019)	0.0241 (0.0019)	0.0241 (0.0019)
Resid.Time	Cross	16.9 (1.3)	18.3 (1.1)	20.1 (1.4)

Table 7. Attrition component ratio (scaled by total attrition) by size classes at the Cross Seamount for bigeye and yellowfin tuna; *E* is the emigration rate.

Size Class	M/Z	F/Z	E/Z
	Bigeye tuna		
29–55cm	0.24	0.10	0.66
56–70cm	0.16	0.13	0.71
≥ 71cm	0.09	0.13	0.78
	Yellowfin tuna		
20–45cm	0.35	0.07	0.59
46–55cm	0.06	0.30	0.64
≥ 56cm	0.10	0.20	0.70

fisheries. In the likely scenario of higher under-reporting of recoveries from non-Hawai‘i-based fisheries, our estimate of transfer rates from inshore and offshore sites to the longline fishery will be lower.

At first glance, the higher transfer rates from the offshore locations to the longline fishery could be explained by the fact that these locations are contained within the geographical area of the longline fishery. However, analysis of the time at liberty for fish released at Cross Seamount indicates that they first become vulnerable within the inshore FAD areas before recruiting to the longline fishery. For instance, bigeye released at the Seamount were caught after 238 ± 156 (median 254) days in the inshore fisheries, while in the longline fishery they were caught after 542 ± 297 (median 509) days. For yellowfin, however, there was little difference: 154 ± 134 (median 88) days in the inshore fisheries, and 157 ± 112 (median 89) days in the longline fishery. These interspecific differences could be due in part to the different vulnerability of the two species to the gears used in the inshore and longline fisheries. Inshore fisheries generally target surface-swimming fish, thereby favoring the exploitation of smaller yellowfin, whereas longline gear targets deep-swimming adults. Implicit in these results are size-specific vulnerabilities in the inshore and longline fisheries. Similar to the inshore fisheries, the Seamount fishery targets surface-swimming fish and therefore “favors” small to medium sized tuna.

The gross attrition rate for any given spatial component Z_i in our model includes size-dependent M and F and size-independent T (emigration rate). At the Seamount, the actual estimates of all three components were generally lower for bigeye than for yellowfin, thereby making the estimated residence times for bigeye twice as long as for yellowfin (Table 6). Our estimate of residence time for bigeye agrees closely with earlier estimates (Holland et al., 1999; Sibert et al., 2000). More recently, Musyl et al. (2003) found similar results from archival tagging data based on geolocation and vertical movement patterns. They estimated a bigeye residence time of 25 ± 12 days at the Seamount, and this value is consistent with the estimates derived in this study using conventional tagging data.

Leaving M aside, it is not entirely clear why the yellowfin emigration rate from the Seamount is higher, while at the same time yellowfin appear to be more vulnerable in the fishery than bigeye. The yellowfin’s greater vulnerability could be explained in part by their shallower swimming depths, which bring them into more frequent contact with handline and troll gear. However, bigeye constitute the greatest proportion of commercial catches by weight from the Seamount (Itano and Holland, 2000), and Sibert et al. (2000) suggested that this apparent discrepancy could be due a much higher biomass of bigeye than yellowfin on the Seamount, coupled with longer residence times.

Residence Times

The apparent longer residence times for bigeye at the Seamount could be due to longer periods of continuous residence, and/or a greater tendency to revisit over time. It is possible that bigeye may gain a trophic advantage by extended association with seamounts (Fonteneau, 1991; Brill and Lutcavage, 2001). The behavior of bigeye associated with Cross Seamount, inferred from archival tag data (Musyl et al., 2003), indicates that their vertical movements are akin to their characteristic open-water behavior. That is, they move within the surface mixed layer at night, but remain deep during the day except for brief upward excursions (Holland et al., 1990; Dagorn and Josse, 2000). However, Musyl et al. (2003) note the irregular and sometimes more extended day-night transitions of the putative Seamount-associated bigeye. This modified day-and-night behavior at Cross Seamount could indicate that they are exploiting a food source that may not be available to or preferred by sympatric yellowfin. Unfortunately, no observations are currently available of similar vertical movement by yellowfin at the Seamount. Preliminary investigation of the feeding habits of bigeye and yellowfin at the Seamount and offshore weather buoys suggests feeding ecology is very different between the two species even at immature sizes (Grubbs et al., 2001). They suggest that separation in vertical distribution may be maintained during feeding; bigeye may target prey in the deep-scattering layer while yellowfin feed primarily on mixed-layer prey.

Estimates of horizontal movement patterns of bigeye equipped with archival tags suggest that almost all bigeye released from the Seamount stayed in close proximity to the Seamount and the main Hawaiian island chain (Sibert et al., 2003). The relatively high transfer rates between the Seamount and NOAA weather buoys, and the similar magnitude of transfer rates between the Seamount and inshore areas, suggests that the apparently lower emigration rate of bigeye is due to returnees contributing to the recapture attrition curve. Given the estimated *F* at the Seamount for the two species in this study, the number of bigeye residing at Cross Seamount has to be at least an order of magnitude greater than the number of yellowfin to match the observed fishery catch statistics.

Implications

The overall picture emerging from the analysis is similar to the earlier findings of Sibert et al. (2000). At any given time, the resident population (or standing stock) of yellowfin on the Seamount is considerably smaller than the bigeye population. However, during their brief stopovers on the Seamount, yellowfin are highly vulnerable to the area's offshore handline/troll fishery. Yellowfin associate with the Seamount but leave quite rapidly, and most never return. In contrast, the longer apparent residency, or persistence, of bigeye at the Seamount may be due to longer periods of association and a tendency to return over time. Even though they tend to leave the Seamount (perhaps permanently when they grow to larger sizes), they appear to remain near Hawai'i for at least two to three years. Some of them become vulnerable in the inshore area, but if not captured, they later become vulnerable to the offshore longline fishery. This situation is very similar to the aggregation of bigeye in the Coral Sea of northwestern Australia (Hampton and Gunn, 1998), where bigeye appear to have a lower attrition rate than yellowfin. Hampton and Gunn (1998) argued that although both species gradually disperse from the Coral Sea, large numbers of bigeye remain resident for some time and become vulnerable in the fishery. More recently, archival tagging on drifting FADs in the Eastern Pacific Ocean has shown that bigeye remain resident in the general area of release for at least about a year (Schaefer and Fuller, 2002).

In our study, virtually all (99.4%) of bigeye recoveries were made within the model area. These observations suggest some degree of regional fidelity during the bigeye's exploited phase (medium size), with a low level of mixing for these immature size classes in the Central and Western Pacific region. However, it appears that larger bigeye are not resident in Hawaiian waters, as spawning adults do not recruit to the local longline or handline fisheries. It is likely that, as these fish mature, they move to warmer waters to the south of Hawai'i where bigeye spawning is known to occur (Nikaido et. al, 1991).

The extent of catch interaction between the Cross Seamount fishery and nearby inshore and longline fisheries does not appear to be of great management concern at current rates of exploitation. However, given that these rates are considered moderate (10–30%), and the Seamount aggregations are highly vulnerable to low-cost gear types, we suggest monitoring of any further increase in fishing effort at the Seamount. This note of caution has been reinforced by increased concern over recent bigeye and yellowfin stocks examined in recent assessments from the Western and Central Pacific (Hampton and Fournier 2001b; Hampton and Fournier, 2001a). These assessments suggest declining adult biomass, declining recruitment, and greatly increased fishing mortality for juveniles in the equatorial region, which is probably the main source of recruitment to the Cross Seamount and other Hawai'i-based fisheries.

Conclusions

To adequately refine our estimates of fishery interaction and transfer rates, it will be necessary to conduct additional strategic tagging experiments involving the release of tuna that comprise the full geographic and size ranges landed in the fisheries. Comparative studies of yellowfin and bigeye using electronic tags would also help to understand differences in how the two species partition their habitat. However, current size-based estimates of natural and fishing mortality rates, together with transfer rates and other ancillary information, still remain useful to conduct a yield-per-recruit analysis to investigate various scenarios arising from an increase or decrease in fishing effort and its effects on fishery components. The results of this analysis will also be useful in refining stock assessment models that are currently being developed for the species.

References

The list of complete references cited in this article can be seen at the NMFS Fishery Bulletin web site (see footnote 1), or at the PFRP web site, at the Journal Articles link in the Publications List.

PFRP

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The Hazards of Tying One On[1]

Chris Harvey-Clark

With regard to external tags, especially for pelagic fish but also turtles, current problems with reliable long-term instrumentation include outright loss of tags through tissue reaction or insufficient mechanical anchoring, premature release of tags due to hardware or software malfunctions, and biofouling, or accumulation of marine invertebrates and algae around a tag, which can also cause premature release.

Tag performance can also be compromised by poor battery performance that results in intermittent signals, and by tech problems that result in inaccurate reports of latitude, or data that are nonsensical or at inappropriate resolutions. The extent of all these problems is indicated by lower than expected tag return rates, or by verified failures owing to rejection or technology glitches.

Location Location Location—and Other Considerations

Part of the difficulty with successful tagging is that current systems for anchoring large external objects do not take into account biocompatibility. This includes:

- the choice of an implantation site on the animal;
- the effect of drag and wear at the point of attachment;
- use of materials that are not surgical or biocompatible (i.e., materials with properties that irritate tissue or delay wound-healing); and,
- galvanic corrosion of incompatible metals used in anchors, connecting cables, etc.

As if that weren't enough, researchers also must contend with "the food-chain eventuality:" tags that are damaged, detached or even consumed by predators of the tagged fish.

The location of an incision for implantation of internal tags has a direct influence on the rate of loss. An incision made in the lateral body wall is less prone to abrasion and damage than one made in a midventral site, leading to lower rates of expulsion. Tag placement studies also have shown that hydrodynamics are important. In sharks, for instance, spaghetti tags placed in front of dorsal fins shed at an average rate of 18%, vs. 6% when placed between the first and second dorsal fins (Francis, 1989). In addition, anchoring tags in "hard tissue" may work better than in soft tissue like muscle; according to Xiao et al. (1999), the loss of dart tags is 50% lower when tags are placed in the dorsal fin cartilage vs. the musculature of the sharks *G.galeus* and *M.antarcticus.*

Tag performance also varies according to material composition, tag type and weight. Peperel (1990) found that stainless steel tags last longer than nylon Floy tags; however, it's now known that plastic tags are the longest lived, surviving for up to 27.8 years in the case of the rototag. Tag longevity is also affected by the type of tag used. Dart tags have higher shed rates than fin tags (Davies and Joubert, 1967; Xiao et al., 1999), and in one species (the whale shark), speargun points lasted longer than Floy tags (Eckert and Stewart, 2001). Because large tags are more prone to expulsion, the maximum size usually recommended for an internal tag is 2% of body weight.

Implantation, Wound Closure and Healing

Tags that are implanted subcutaneously into muscle tend to be treated like foreign bodies, undergoing a splinter-like migration through tissues. This is especially true of tags that are subject to constant motion from contracting muscle tissue, or from pulling forces exerted by tags attached via external cables to implanted anchors. Similarly, tags implanted inside the coelomic cavity of fish are subject to physical loss by expulsion through incision wounds; this can be prevented in many cases through the use of catheter tunnelling or a gridiron surgical technique. The latter entails separating tissue layers in different planes to prevent each layer from overlying another. In some species such as the channel catfish, another phenomenon accounts for the loss of internally implanted tags: the gut is capable of enveloping and incorporating foreign materials into the intestinal lumen, from which the materials are passed in a fashion similar to stool. Anchoring internal tags using a "stay suture" can prevent this.

Among the suture materials available to close wounds are silk (not recommended; see Table 2) and polypropylene. Working with warm-water teleost fish, Wagner, Stevens and Byrne (2000) found that the highest wound-breaking strength, up to 6 weeks post-surgery, is provided by monofilament line. Braided silk sutures and vertical mattress suture patterns caused significantly more inflammation than absorbable monofilament (polydioxanone) woven into simple interrupted patterns. In addition, they found that dummy radio transmitters compound the inflammatory effect silk has on healing incisions.

Other options for closing incisions include wound clips and surgical adhesives. Wound clips, however, are associated with higher infection rates in mammals, and do not work well in many teleosts because of the delicacy of their scales; the exception was larger, leather-skinned teleosts like sturgeon. The jury is still out on use of surgical adhesives, but Nemetz and MacMillan (1988) found that cyanoacrylate worked well in young channel catfish, allowing rapid healing; they claimed compete healing in 14 days at 25° C (350 degree-days). However, adhesions occurred in 60% of cases.

The next consideration for internal tags is healing of closed incisions. Wagner, Stevens and Harvey-Clark (1999) studied wound healing in rainbow trout that had surgical sites prepared with a povidone-iodine antiseptic; they found that cleaning the sites with the antiseptic had no effect on the rate of healing or bacterial colonisation—and that in fact, accurate apposition of wound edges was the most critical factor contributing to good wound healing.

[1]This article is adapted from the notes to "Tying One On," presented at the Marine Species Telemetry Conference, University of Hawai'i, Honolulu, December 2002 (© 2002).

The Science Vacuum in Aquatic Species Surgery

Pain and distress are poorly understood in fish species, yet the possible effects on welfare of the animals are substantial, including aversion, fear, stress, pain and suffering. Given this situation, there are a number of ethical as well as practical considerations that should be kept in mind in the course of research that requires direct contact with animals.

As a point of departure, we reprise the animal-handling principles espoused by the American Society of Ichthyologists and Herpetologists:

- avoid or minimize distress to animals;
- use sedation or general anesthesia whenever animals suffer more than slight distress; and,
- euthanize animals at the termination of a procedure if they are suffering unrelievable severe or chronic distress.

The Society recommends further that if distress in the course of research cannot be alleviated by any of the methods described above, it should be justified for scientific reasons in writing by the principal investigator.

Causes of distress in fish that are subject to research include experimental factors such as marking and sampling methods, in addition to anesthesia and surgery. Coincident environmental stressors include confinement or restriction of movement; type and duration of restraint; type and rate of feeding; the extent and nature of handling (including netting and transport); and the nature of veterinary care.

To address the challenge of mortality caused by handling or tagging, researchers must be sensitive to the possibility of capture myopathy,[1] which is influenced by the amount of time fish are handled. Handling time and even water temperature should be measured and linked with outcomes to provide data that can guide procedural modifications so that survival rates increase.

Fish and Stress

Some effects of stress on fish caused by experimentation include changes in motility, gastric secretion, heart rate and blood pressure, as well as secretion of catecholamines and steroids; human activity in the lab or environment can affect any such factor being measured. Following is a limited physiological basis for and against the ability of fish to feel pain and suffering:

- fish lack the spinothalamic pathway in the spinal cord, as well as mammalian nociceptors for mechanical and heat-type pain reception (Stephens 1996);
- sensory-discriminative pathways connect to the brainstem in fish, vs. the cortex in mammals;
- fish experience non-reflexive behavioral reactions to shock, and produce endogenous opioid substances in response to pain/fear;
- elasmobranch fish lack lamina 1 of the dorsal horn of the spinal column, but pain-associated neuropeptides such as Substance P have been identified in the horn region of some elasmobranch fish; and,
- goldfish (*Carassius auratus*) undergo a graded increase in electrical shock sensitivity upon administration of morphine.

*A stress- and exercise-induced pathological condition of muscle tissues or muscle.

In summary, though surgical skin preparation techniques are known to be effective in mammals, the techniques seem to have little or no effect on wound healing in teleosts, which takes 300 to 400 degree-days (Stevens et al. held fish for 42 days at 9.3° C, or 390 degree-days). This is not too different from skin healing in humans, which typically takes 273 to 390 degree-days. Wound healing in sharks is almost completely undescribed.

Materials and Anchoring Issues

As noted above, the physical properties of tags and implants have a significant bearing on performance and tissue compatibility; these properties include surface texture (rough versus smooth), tendency to cause inflammation, and "interface capability," which is enhanced with certain biomaterials, especially those that incorporate porous technology to encourage cell in-growth. Available biomaterials include plastics, silicones, epoxies and select metals; see Table 1 for a summary of characteristics.

A scrupulously selected tag or implant can still perform poorly, or fail altogether, if it is not optimally secured to the animal. Anchoring technology therefore considers the size, shape and composition of an anchor, the design of its attachment mechanism, and the possibility of juxtaposed incompatible materials (especially cables made from different metals, which can produce electrogalvanic action that causes chronic inflammation). Anchors should be made from highly compatible, low-irritation materials, and should be configured to minimize sharp edges, which tend to enhance loss. In addition, constant tension or movement at the attachment point tends to cause wound breakdown, so researchers should place tags at the point(s) of least drag, and avoid locations or attachment methods that allow movement or micro-movement to cause inflammation and wound breakdown.

(continued on page 10)

Table 1. Biomaterials Characteristics

Medical-grade silicone	good for implantation, but can stimulate formation of granuloma, and cause inflammation if contaminated with impurities.
Epoxies	exhibit poor biocompatibility, and in the United States have a maximum approved duration of 24 hours in contact with human tissues; even medical-grade epoxies such as Eptek 301 are considered USP Class VI materials (i.e. they are not very biocompatible)
Ultra-high molecular weight polyethylene	used in the wear surfaces of joint replacements— it is easily machined and its wear particles are minimally reactive.
Urethane-based materials	these materials are brittle, but coating technologies exist (such as hydromeric coatings) that enhance biocompatibility
Polymethyl methacrylate	a bone cement that must age to nullify the toxicity of a component monomer
Stainless steel	subject to pitting and other corrosion, as well as oxide film-formation that robs local O_2 supplies
Titanium*	superior to stainless steel (titanium oxide is more stable)
Cobalt-chromium	similar in performance to titanium

** In the case of titanium, advanced coating technologies are available to promote cell in-growth, but in dental applications this is most useful for the first 6 months, after which graft strength is similar in smooth finished implants.*

Antibiotics and Infections

Antibiotics and/or antimicrobials may be employed prophylactically as infection controls, but there is a dearth of information on the species of organisms that colonize surgical wounds in fish, and their antimicrobial sensitivities in the aquatic environment. In any case, researchers performing surgery on fish should seek to minimize the use of antibiotics due to their multisystemic effects and the development of resistant bacteria stimulated by widespread misuse of such compounds. The need for antibiotics can be reduced by employing adequate surgical technique, and exercising care in conduct of sterile surgical procedures to avoid introduction of contaminants into the surgical field or the incision.

In addition, researchers should avoid empirical use of antibiotics (i.e., do not choose or employ antibiotics on the basis of anecdotal information), and give due consideration to the bacterial species cultured, as well as pharmacokinetics data[2] and information on antimicrobial drug sensitivity. For this reason, it is recommended that veterinary advice be sought on a rational basis for antimicrobial usage if there are significant problems seen with wound infections.

Pathophysiology of Surgery in Fish

Skin tissues in fish are thinner on the head than the trunk, are relatively rigid, and can allow up to 40% leakage from an intramuscular injection. Also, fish skin is osmotically active, conducting, for example, 50% of calcium uptake in rainbow trout, and 65% of chloride loss in shanny.

With regard to gills and respiration, the flow of water and blood are counter-current over the gills (oral to aboral); therefore, water flow when using anesthetic apparatus should be via the mouth, not the opercular flap, which will gas exchange. And fish should be moved in a forward direction only during resuscitation, not back and forth.

Underlying such specific considerations is the fact that surgery in fish, as in any animal, operates on the same general principles:

- time is trauma—keep surgical times as short as feasible;
- antibiotics should be administered before surgery, not after, using the rational basis mentioned above;
- tissues should be handled gently; and all surface and subcutaneous “dead spaces” should be closed to forestall infection;
- hemostasis, or control of blood loss, is critical; and,
- postoperative environmental conditions, particularly water temperature and nutrition, are important to successful recuperation.

In addition, use of aseptic techniques during surgery can protect the surgeon and the fish from potential infection by colonizing bacteria— but the efficacy of such techniques with fish is controversial (Wagner, Stevens and Byrne, 2000).

Problems with asepsis range from issues of simple practicality to concerns about the negative effects that aggressive surgical preparation can have on the mucous skin-defense system of fish. Aseptic surgical preparation and maintenance of a clean or even sterile operating field requires that researchers use caps, gowns, masks and sterile gloves, install draping to enclose the operating field, and allow only sterile materials into the field. Such steps are often if not always impractical in the unpredictable, sometimes turbulent conditions aboard ships at sea. They also require purchase, transport and field use of protective materials and sterilizing equipment such as autoclaves or hot-glass-bead sterilizers. Finally,

[2]The details of absorption, distribution, metabolism and excretion of antibiotics.

aseptic scrub techniques themselves can damage scales, disrupt mucus layers and biofilms, expose dermis and blood vessels, and devitalize underlying tissues—a tendency that can be mitigated only by forgoing sterile preparations, or substantially reducing their intensity.

On the other hand, asepsis can prevent zoonosis (transmission of diseases, including Streptococcus Iniae and septicemia, from fish to man), and prevent bacterial colonization of surgical wounds in fish. The latter incites complications such as:

- generalized infection and delayed or prevented healing;
- inflammation of the wound field;
- a need for antibiotics;
- decreased food intake and alteration of various physiological parameters;
- colonization of implants themselves; and,
- septicemia or death.

The bottom line in aseptic technique for surgery on fish is to tailor asepsis to the species. Tough-skinned species like sharks and sturgeon can undergo vigorous skin preparation, while many teleosts with scales cannot. Disruption of mucous coatings should be minimized. Care should be taken to clean and sterilize instruments between animals to minimize infection and avoid the inadvertent transmission of disease. Finally, the surgeon should use barrier methods when practical to minimize wound contamination with sea or fresh water, skin mucous and debris, or other foreign materials.

Disinfectants

Several disinfectants are available that can kill pathogenic bacteria, fungi and viruses. The efficacy of these disinfectants can be defined as a function of potency and contact time, but it should be recalled that organic matter compromises or voids the activity of

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Upcoming Events

CCSBT Meetings

- June 2003
  Assessment Planning Meeting (if needed),
  Canberra, Australia
- August 25–29, 2003
  4th Meeting of the Stock Assessment Group (SAG4),
  Christchurch, New Zealand
- September 1–4, 2003
  8th Meeting of the Scientific Committee (SC8),
  Christchurch, New Zealand
- October 7–10, 2003
  10th Annual Meeting of the Commission (CCSBT10),
  Wellington, New Zealand
- *5th meeting of the Ecologically Related Species Working Group*, Wellington, New Zealand (TBA)

With regard to the preceding meetings: if examination of fishery indicators suggest that a full stock assessment is required, then SAG4 and SC8 will be postponed until October, and CCSBT10 until December. Go to http://www.ccsbt.org/docs/meeting.html for details.

SCTB Meetings

- July 7–8, 2003
  Working Group Meetings,
  Mooloolaba, Queensland, Australia
- July 9–16, 2003
  16th Meeting of the Standing Committee on Tuna and Billfish, Mooloolaba, Queensland, Australia
- July 17–18, 2003
  SCG/WCPFC Meeting (tentative)

Western Pacific Regional Fisheries Management Council Meetings

- May 7–8, 2003
  83rd SSC Meeting, Honolulu, Hawaii
- June 9–13, 2003
  118th Council Meeting, Honolulu, Hawaii

Dates are tentative and subject to change. For details, go to http://www.wpcouncil.org/events.htm

Table 2. Absorbable vs. Non-absorbable Sutures

Absorbable Sutures*		Non-Absorbable Sutures	
Types/Uses	**Characteristics**	**Types/Uses**	**Characteristics**
Polydioxanone PDS (best overall absorbable)	• strong & easy to handle, with low tissue reactivity • absorbed slowly by hydrolysis (58% strength at 4 weeks) • useful in infected fields due to strength	**monofilament nylon, polypropylene, polyethylene** (best all-around materials). useful in infected/ contaminated fields; fine calibers are used in microsurgery	• hard to handle, with poor knot-holding ability • nonreactive and strong, with low tissue drag • loses polyamide radicals, inhibits infection
Synthetic multifilaments (Polyglycolic Acid: DEXON,VICRYL)	• easy to handle, with moderate to low tissue inflammation • absorbed by hydrolysis (80% decrease in diameter by 4 weeks) • coated with polymer to impart monofilament characteristics	**monofilament stainless steel wire**	• strong, inert and non-reactive, but poor flex durability
		stainless steel wound clips	• allow very fast closure with applicator gun • low tissue reactivity • poor tissue apposition in fish
surgical catgut (NOT for use in fish, or skin)	• natural multifilament suture (from submucosa of sheep intestine) • weak; elastic, and inflammatory (absorbs water and swells; knots loosen) • absorbed by phagocytosis	**silk** (not recommended, esp. in infected areas)	• multifilament composition allows wicking of bacteria • fragments/breaks easily, and has high tissue reactivity

** Absorbable sutures are designed for internal use, such as suturing hollow organs like the stomach, and closing subcutaneous wounds from which sutures cannot be removed. Note, however, that the rate of absorption of such sutures is affected by infection and wound contamination; also, some materials are inflammatory and promote adhesion formation, and some (catgut) are not reabsorbed in fish.*

many disinfectants, so precleaning using soaps is required before disinfection.

Chlorine (sodium hypochlorite 1–2%, and binary chlorine dioxide agents are reliable and cheap disinfectants whose residues can be rinsed away, but they are also caustic, highly toxic, and degrade plastics. Tamed iodine compounds such as betadine and wescodyne are gentle by comparison, but stain and lose efficacy readily if contaminated with dirt or other organic materials. Other options include quaternary ammonium compounds such as roccal and hibitane; formalin-based compounds such as formacide; and 2% weight-volume glutaraldehyde-based compounds such as Cidex, which are generally used for instrument disinfection. Contact with tissue is to be avoided for the majority of these disinfectants, and instruments sterilized in them should be rinsed with a sterile water or saline solution prior to contact with tissues.

Sutures and Faster Healing

Fish have little redundant skin or submucosal tissue, and skin healing after surgery is optimal at each species' preferred temperature. However, certain surgical techniques can minimize physical disruption and speed healing. Researchers should consider scales when choosing the location for an incision, planning incisions to go around, not through, scales, especially in large-scaled fish. Vertically oriented incisions, which are perpendicular to natural tension lines in skin, should be avoided, as they tend to gape open. And incisions generally should be closed in a single layer.

Sutures facilitate healing by holding tissues together until healing occurs. The properties of ideal sutures include uniform size and strength (common gauges range from 10-0 to 4); ease of handling and ability to hold knots; the ability to be sterilized; the ability to be absorbed into tissue without loss of strength; and the absence of a tendency to elicit tissue reaction. Sutures should not wick moisture and bacteria from the skin surface into tissues through capillary action— hence the use of braided and multifilament sutures such as silk should be avoided (see Table 2 for more details). Sutures are available in natural or synthetic form, can be absorbable or non-absorbable, and can be composed of multiple filaments or a single monofilament. Non-absorbable sutures are encapsulated in a sheath of fibrous tissue, while absorbable sutures are absorbed via hydrolysis or phagocytosis. Some absorbable sutures such as surgical catgut are poorly absorbed in fish and should also be avoided. "Tissue glues" such as Vetbond and Nexaband are an alternative to sutures, but are also associated with increased inflammatory responses.

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Compendium—Fisheries Research in Brief

Grad Assistant Earns Accolade

PFRP Graduate Assistant Brittany Graham earned one of two top prizes awarded recently at the annual Albert L. Tester Memorial Symposium. The Symposium is held each spring at the University of Hawai‘i to honor Tester, a former UH Senior Professor of Zoology, for his lively encouragement of student research in marine biology.

Only original research papers can be submitted, and each is judged on quality, originality and importance of research, as well as quality of public presentation. Graham captured the award out of a field of 38 fellow students for her exemplary presentation,“Pacific Salmon: A Conduit of Marine Nutrients and Organic Matter to Stream Ecosystems.” She is completing her masters thesis on the topic at Michigan State University, and while at UH, migrates between two PFRP-funded projects investigating the trophic ecology and migratory behavior of tuna in the equatorial Pacific using nitrogen and carbon stable isotopes. Congratulations Brittany!

To Change or Not to Change—Climate IS the Culprit

Attribution of recent biological trends to climate change is complicated because non-climatic influences dominate local, short-term biological changes. Any underlying signal from climate change is likely to be revealed by analyses that seek systematic trends across diverse species and geographic regions. However, debates within the Intergovernmental Panel on Climate Change (IPCC) reveal several definitions of a “systematic trend.”

A paper by Camille Parmesan and Gary Yohe explores these differences, applies diverse analyses to more than 1,700 species, and shows that recent biological trends match climate change predictions. Global meta-analyses documented range shifts averaging 6.1 km per decade towards the poles, and significant mean advancement of spring events by 2.3 days per decade.

Parmesan and Yohe define a diagnostic fingerprint of temporal and spatial “sign-switching” responses uniquely predicted by 20th century climate trends. Among appropriate long-term/large-scale/multi-species data sets, this diagnostic fingerprint was found for 279 species. This suite of analyses generates “very high confidence” (as defined by the IPCC) that climate change indeed is already affecting living systems.

adapted from Nature *Articles, 02 January 2003: Parmesan, Camille and Gary Yohe: A globally coherent fingerprint of climate change impacts across natural systems.* Nature*, 421, 37–42 (2003); doi:10.1038/nature01286. E-mail: parmesan@mail.utexas.edu*

Fish Farm Coming to Kona, Hawai‘i

Native bottomfish stocks in Hawai‘i are dwindling to the point where local fish wholesalers must import more than half of what the public consumes—but Kona Blue Water Farms (KBWF) proposes to reverse the trend by growing native species on an open-ocean farm in waters off Kona, Hawai‘i.

According to Neil Anthony Sims, Vice President and Director of Research for KBWF, the pent-up demand for bottomfish is now being met by shifting to imports and putting pressure on other stocks that are already showing signs of overfishing. KBWF plans to raise its juveniles in a land-based hatchery at the Natural Energy Laboratory of Hawai‘i, adjacent to the Kona airport, then move the fish to floating pens at its nearby offshore site. The pens will occupy about 81 subsurface acres at a depth of 150 to 200 feet, far enough offshore to minimize effects on near-shore coral reefs.

Sims says two recent developments made the operation commercially viable. First was a complete rewrite of ocean leasing legislation by the state to permit open-ocean aquaculture. Second were important advances in engineering for offshore mooring systems, with a new type of open-ocean pen that can be submerged, then pumped with air to float to the surface when necessary.

adapted from an article by Bruce Benson, High Technology Development Corporation (full article at http://www.hawaiiocean-science.org/cgi-bin/modlib.pl?id=279&$template=preArticle.html)

(continued on page 14)

A large school of *Researchae Pelagicus* exhibit uncharacteristic posing behavior at the end of their annual migration to the PFRP PI's conference in 2002. Note that none appear to be tagged (related story on page 16).

Do you know where your baseline is?

Are global populations of marine life notably reduced, and/or are they still in decline today? In many cases, yes. Relative to what? Well, that depends on your baseline.

This concept is hardly new to natural scientists, but it's just been Hollywood-ized in a slightly preachy new web site championed by Los Angeles filmmaker Randy Olson. Olson is also a USC faculty member in marine biology, and his site enjoys sponsorship by the Scripps Institution of Oceanography (La Jolla), the USC Wrigley Institute for Environmental Studies, and several notable conservation groups. Two coral reef ecologists and a kelp forest ecologist were among the core group of consultants who helped create the site (http://www.shiftingbaselines.org).

What's their point? Basically, that a scientist's choice of a baseline in any study of change is critical to the time-relative accuracy of the study's conclusions. In Olson's words, "If we know the baseline for a degraded ecosystem, we can work to restore it. But if the baseline shifted before we had a chance to chart it, then we can end up accepting a degraded state as normal— or even as an improvement."

This phenomena is presented as a problem that distorts the"truth" of ocean science research, which scientists are described as loathe to tell anyway, because "No one likes to be the bearer of bad news." To this end Olson and his team have gathered (and manipulated) images, and added commentary that is personal (mostly) and scientific (slightly), to a site named "Shifting Baselines: the truth about ocean decline."

The site is way thin on science, but it does at least recommend that we all "watch for the upcoming reports of the Pew Oceans Commission and the U.S. Oceans Commission this year." Which begs the question: what baselines will the commissions have chosen to frame the conclusions they reach?

Articles of Interest From the Canadian Journal of Fisheries and Aquatic Sciences

(http://pubs.nrc-cnrc.gc.ca/cgi-bin/rp/rp2_vols_e?cjfas):

Volume 60, Number 3, March 2003
Catchability and the spatial distribution of fishing vessels. (Are Salthaug and Sondre Aanes; pages 259–268)

Volume 60, Number 2, February 2003
The importance of habitat quality for marine reserve-fishery linkages. (Lynda D. Rodwell, Edward B. Barbier, Callum M. Roberts, and Tim R. McClanahan; pages 171–181)

Volume 60, Number 1, January 2003
Which community indicators can measure the impact of fishing? A review and proposals. (Marie-Joëlle Rochet and Verena M. Trenkel; pages 86–99)

Vol. 59, Number 12, December 2002
The potential use of environmental information to manage squid stocks. (D.J. Agnew, J.R. Beddington, and S.L. Hill; pages 1851–1857)

Global fish abundance estimation from regular sampling: the geostatistical transitive method. (Nicolas Bez; pages 1921–1931)

Dynamic geography of small pelagic fish populations in the California Current System on the regime timescale (1931–1997). (Rubén Rodríguez-Sánchez, Daniel Lluch-Belda, Héctor Villalobos, and Sofia Ortega-García; pages 1980–1988)

Volume 59, Number 11, November 2002
Reconstructing ecosystem dynamics in the Central Pacific Ocean, 1952–1998. I. Estimating population biomass and recruitment of tunas and billfishes. (Sean P. Cox, Steven J.D. Martell, Carl J. Walters, Timothy E. Essington, James F. Kitchell, Christofer Boggs, and Isaac Kaplan. Pages 1724–1735)

Reconstructing ecosystem dynamics in the central Pacific Ocean, 1952–1998. II. A preliminary assessment of the trophic impacts of fishing and effects on tuna dynamics. (Sean P. Cox, Timothy E. Essington, James F. Kitchell, Steven J.D. Martell, Carl J. Walters, Christofer Boggs, and Isaac Kaplan; pages 1736–1747)

Key principles for understanding fish bycatch discard mortality. (Michael W. Davis; pages 1834–1843)

A small school of *Researchae Pelagicus* pause at a local feeding site during their annual migration to the PFRP PI's conference in 2001. Note that none appear to be tagged.

Volume 59, Number 9, September 2002
Marine ecosystem assessment in a fisheries management context. (Jason S. Link, Jon K.T. Brodziak, Steve F. Edwards, William J. Overholtz, David Mountain, Jack W. Jossi, Tim D. Smith, and Michael J. Fogarty; pages 1429–1440)

Articles of Interest from the Fishery Bulletin, National Marine Fisheries Service
(http://fishbull.noaa.gov/fcontent.htm):

Volume 101, Number 1; January 2003
Estimating long-term growth-rate changes of southern bluefin tuna (Thunnus maccoyii) *from two periods of tag-return data.* (Hearn, William S., and Thomas Polacheck; pages 58–74)

A general framework for integrating environmental time series into stock assessment models: model description, simulation testing, and example. (Maunder, Mark N., and George M. Watters; pages 89–99)

Dive-depth distribution of loggerhead (Caretta caretta) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacific: Might deep longline sets catch fewer turtles? (Polovina, Jeffrey J., Evan Howell, Denise M. Parker, and George H. Balazs; pages 189–193)

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Bycatch of billfishes by the European tuna purse-seine fishery in the Atlantic Ocean. (Gaertner, Daniel, Frédéric Ménard, Carol Develter, and Javier Ariz; pages 683–689)

Movements, behavior, and habitat selection of bigeye tuna (Thunnus obesus) *in the Eastern Equatorial Pacific, ascertained through archival tags.* (Schaefer, Kurt M., and Daniel W. Fuller; pages 765–788)

Age and growth of the swordfish (Xiphias gladius L.) *in the waters around Taiwan determined from anal-fin rays.* (Sun, Chi-Lu, Sheng-Ping Wang, and Su-Zan Yeh; pages 822–835)

Necropsy findings in sea turtles taken as bycatch in the North Pacific longline fishery. (Work, Thierry M., and George H. Balazs; pages 876–880)

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Vertical and horizontal movements of southern bluefin tuna (Thunnus maccoyii) *in the Great Australian Bight observed with ultrasonic telemetry.* (Davis, Tim L. O., and Clive A. Stanley; pages 448–465)

Nuclear and mitochondrial DNA markers for specific identification of istiophorid and xiphiid billfishes. (McDowell, Jan R., and John E. Graves. Pages 537–544)

Volume 100, Number 2; April 2002
Horizontal and vertical movements of juvenile bluefin tuna (Thunnus thynnus) *in relation to oceanographic conditions of the western North Atlantic, determined with ultrasonic telemetry.* (Brill, Richard, Molly Lutcavage, Greg Metzger, Peter Bushnell, Michael Arendt, Jon Lucy, Cheryl Watson, and David Foley; pages 155–167)

Differences in diet of Atlantic bluefin tuna (Thunnus thynnus) *at five seasonal feeding grounds on the New England continental shelf.* (Chase, Bradford C; pages 168–180)

Food habits and consumption rates of common dolphinfish (Coryphaena hippurus) *in the eastern Pacific Ocean.* (Olson, Robert J., and Felipe Galván-Magaña; pages 279–298)

First record of a yellowfin tuna (Thunnus albacares) *from the stomach of a longnose lancetfish* (Alepisaurus ferox). (Romanov, Evgeny V., and Veniamin V. Zamorov; pages 386–389)

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Age and growth of Hawaiian sea turtles (Chelonia mydas)*: an analysis based on skeletochronology.* (Zug, George R., George H. Balazs, Jerry A. Wetherall, Denise M. Parker, and Shawn K. K. Murakawa; pages 117–127)

An evaluation of pop-up satellite tags for estimating post-release survival of blue marlin (Makaira nigricans) *from a recreational fishery.* (Graves, John E., Brian E. Luckhurst, and Eric D. Prince; pages 134–142)

Tag and Track Yourself, Buddy!

Wanna empathize with a tagged marlin? Then attend this year's National Supercomputing Conference, where you can be fitted with a transmitter that identifies you by research specialization and allows you to be tracked as you navigate purposely from vendor's booth to product demonstration to feeding site to (presumably) restroom, all in the company of similarly outfitted wildlife (uh… colleagues).

This quirky perk was bestowed upon willing attendees at last year's mainframe extravaganza, held in November in Baltimore, Maryland. The idea, according to conference chair Dan Reed (Director of the National Center for Supercomputing Applications), was to help wandering supergeeks figure out where colleagues with similar interests were hanging out. Screens throughout the conference center summarized the details, as did a website accessible through a wireless network.

In what may have been a concession to convenience, the tags apparently were clipped to delegates' collars, rather than being surgically implanted.

PSAT anyone?

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