Pacific Bigeye Tuna Research Coordination Workshop
November 9-10, 1998
East-West Center
Honolulu, Hawaii

Report of workshop

I. Introduction

The workshop was called to order by Dr. Sibert, who served as workshop coordinator and chairman. David Itano and A.D. Lewis were appointed as workshop rapporteurs. Introductions were made after which the group was referred to the previously circulated document "Bigeye Tuna: Five-year Research Plan - A Prospectus for Coordinated International Research" (v. Draft 11/04/98). The Chairman indicated the document was far from complete and suggested that the introduction be refined to include better estimates of current surface and sub-surface bigeye catches and a more accurate estimate of the value of the fishery. A major section of the prospectus that the workshop would attempt to complete would contain regional research plans for the different areas of the Pacific Ocean represented at the workshop. It was noted that some regions are well advanced in the planning or implementation of field research on bigeye tuna while others are very much in a conceptual or planning phase. The chairman stressed the importance of producing a workable prospectus in the near future with the major portion of the work to be completed during the week, then finished by correspondence as soon as possible.

Dr. Miyabe emphasized the importance of using tagging data to obtain better estimates of size and age specific natural mortality for bigeye, including the importance of tagging larger numbers of small bigeye to meet this objective.

II. Discussions on proposals for regional field work in:
A. Australian Coral Sea

Dr. Hampton of the SPC/OFP outlined plans for a small-scale archival tagging project in conjunction with CSIRO (Hobart). It is proposed to deploy 80 data logging tags manufactured by Wildlife Computers on medium sized (80 – 100 cm) bigeye in the Australian Coral Sea during December 1998. Australian flag longline vessels will be used to longline and handline bigeye tuna found in feeding aggregations of lanternfish (Myctophidae) that normally occur in the northwestern Coral Sea during this time of year. Cooperating fishing vessels have made their platforms, crews and fish available at no cost to the project. **The workshop participants recommended that archival tagged bigeye be double tagged with conventional dart tags which will also be used to conduct opportunistic tagging of other species, i.e. yellowfin, skipjack, etc.**

The South Pacific Commission (SPC) tagged approximately 3,800 medium sized bigeye in this area during the early 1990s with over 200 recaptures to date. Recaptures of medium-large bigeye in the area of release continue to occur, seven years after release, and the recaptured tuna are still not as large as the largest year classes taken by the fishery. These recaptures suggest that bigeye may be longer lived and slower growing than commonly perceived. Fishing effort in this area has increased significantly in recent years, suggesting that a return rate of 10% can be expected from the proposed archival tagging project. The CSIRO plans to match the SPC-funded 1998 tagging with 100 additional archival tags to be released during the 1999 fishing season.

B. Hawaii

Dr. Holland and David Itano described current and proposed plans for bigeye tagging and research in the Hawaii region. The Pelagic Fisheries Research Program (PFRP) funded a small scale tagging project for bigeye and yellowfin on the Cross Seamount, located within the Hawaii EEZ approximately 150 miles south of Oahu. This project, designed to address interaction and aggregation issues, was expanded to the Hawaii Tuna Tagging Project which will tag yellowfin and bigeye throughout the entire Hawaii EEZ for a two year period, with tag releases having begun during March 1998. Total releases to date for both projects exceed 11,000, of which 58% are bigeye. The overall recapture rate stands at 10.9%, with 1100 recaptures made by domestic handline, longline, pole and line and troll vessels. The recapture rates for bigeye and yellowfin are 8.7% and 13.6% respectively. Most of the releases and recaptures have been made on the Cross Seamount and inshore FADs. A variety of commercial and sport vessels are being used as tagging platforms at the Cross Seamount, around the main Hawaiian Islands, the northwest Hawaiian Islands and near Midway Atoll. The project has been targeting aggregation points such as seamounts, isolated islands and anchored FADs to maximize bigeye releases. An ancillary project funded by the Hawaii State FAD program, but an integral part of the HTTP will begin in November 1988, targeting the tagging of small yellowfin and bigeye (20 - 35 cm) found in association with Hawaii State anchored FADs.

A proposal has been submitted to the PFRP, looking at the comparative feeding ecology of bigeye and yellowfin tuna found on inshore FADs, offshore FADs, seamounts and open water areas. This project, if funded will collaborate with the Hawaii Tuna Tagging Project to obtain gut samples from tuna found in different association types.

Dr. Laurs described the status of bigeye related research being conducted by the Honolulu Laboratory of the National Marine Fisheries Service (NMFS). Bigeye tuna represent one of the two highest dollar value pelagic resources landed by Hawaii based fishermen (with swordfish), due to the importance of the species to longline landings of sashimi quality product. The Honolulu Lab has committed 80 archival tags to bigeye, with 24 deployed to date and one recapture under a PFRP-sponsored project. Conventional tagging of longline caught bigeye continues on an opportunistic basis from the NMFS R/V *Townsend Cromwell* which also conducts *in situ* fisheries oceanography in the Hawaii EEZ and adjacent seas.

The study of pelagic fish habitat and ecology in relation to offshore fisheries has been a major initiative of the Honolulu Lab in recent years, through direct field work, remote sensing and validation, bigeye habitat studies and large-scale ecosystem research and modeling. Dr. Polovina is leading these efforts and explained the encouraging use of satellite altimetry data to detect current eddies, seamounts and vertical temperature structure, such as shoaling of the thermocline. He further emphasized the interesting and unique nature of the Hawaiian archipelago to the physical oceanography of the north central Pacific region. The NMFS has submitted a proposal to the Pelagic Fisheries Research Program to examine longline catch rates in response to physical oceanographic structure as determined by an oceanographic buoy moored in an area of productive bigeye habitat. The moored buoy, equipped with temperature and current sensors within the top 500 m of the water column will also be very useful to ground truth satellite derived data. This will also provide information relative to longline fishing in the open ocean, shear associated with eddies, etc. Dr. Brill provided a brief overview of the unique physiology of bigeye tuna, as the analogue of a yellowfin tuna evolved to expand its three dimensional range. He further noted the difficulty of maintaining bigeye in aquaria and hence the focus on biochemical and physiological rather than tank studies of the species.

The workshop participants agreed upon the importance of using remote and in situ monitoring of the environment in conjunction with archival tags to discern how bigeye react to their physical environment. Satellite derived estimates of primary productivity from water color was also mentioned as a potential tool for understanding bigeye habitat and defining areas of higher productivity.

C. Eastern Pacific Ocean (EPO)

Dr. Allen explained the primary interest of the Inter-American Tropical Tuna Commission (IATTC) in regard to EPO bigeye resources centered on interaction issues between EPO longline fisheries for large, high value fish and a recently developed FAD based purse seine that takes significant quantities of juvenile bigeye. The importance of obtaining better age specific estimates of natural mortality was stressed, as yield assessments and interaction estimates rely significantly upon these parameters. An additional concern of the IATTC has to do with the possibility of longer range and long-term interaction issues related to EPO bigeye resources. The IATTC has imposed a limit of 45,000 mt of bigeye from the EPO surface fishery, which if exceeded would shut down purse-seining on floating objects. The possibility of mitigating purse seine landings of juvenile bigeye by modified fishing techniques exploiting a differential depth stratification compared to skipjack and yellowfin, as well as escape/sorting grids was discussed. These possibilities indicate the potential application of behavioral studies to management goals.

The IATTC intends to mount a large-scale tagging project, focused on conventional tagging of bigeye found in aggregation with floating objects, but no firm plans are currently in place pending the identification of a funding source. However, there is a distinct possibility of conducting a pilot tagging project in 1999 to tag bigeye, yellowfin and skipjack in the area of the EPO purse seine fishing grounds where there is concentrated fishing using FADs . The objectives of this project are to estimate movements, interaction between surface and sub-surface fisheries, and rates of natural mortality in bigeye, but the opportunity would be used to gain a better understanding of the relationship between southern (south of 5°N) and northern groups of yellowfin in the EPO. There is also an interest to deploy archival tags in the southern region in conjunction with conventional tags. The intention of the IATTC is to realize an ongoing bigeye tagging project in the EPO region over the next several years.

Kurt Schaefer outlined plans for the IATTC to begin life history research on EPO bigeye, which will include studies on the age, growth and reproductive biology of the species in different geographic regions of IATTC jurisdiction. He stressed the importance of conducting similar studies throughout the Pacific due to the possibility of regional differences in reproductive parameters or growth characteristics. Otoliths and vertebrae will be sampled from 30 - 180 cm FL bigeye with chemical marking of tagged fish for age validation purposes. Size and age specific reproductive characteristics from surface and sub-surface fisheries will be determined using histological analyses of gonad material. Spatio-temporal distributions in spawning, length at maturity, spawning frequency, batch fecundity and sex ratios will be determined.

Dr. Gunn made a general request for any sources of archived bigeye otoliths, particularly of any fish sampled between 1960 and 1974 due to their utility for age validation from bomb radio carbon chronometry analysis. He felt that bigeye reach greater ages than commonly believed, possibly in excess of 20 years, but this remains to be confirmed.

The Chairman asked if there were other research organizations in the IATTC region that should be included in the bigeye research group. Dr. Allen indicated that the Ecuadorian government plans to re-start their at-sea observer program which would be collecting some data on bigeye in addition to other pelagic species but did not feel they would be conducting a great deal of bigeye specific research.

D. French Polynesia

Stephen Yen and Dr. Laurent Dagorn described the results of the joint EVAAM (SMA) / IFREMER / ORSTOM research program ECOTAP on pelagic resources of the French Polynesian zone that utilized the research vessel *Alis*. Two years of field work were conducted, involving pelagic longlining, echo sounding, sonic tracking of tuna and pelagic trawling. The project conducted research on bigeye behavior and habitat, and longline characteristics in relation to catch rates. In May - July of 1999, the ECOTAP program will conclude, leaving the future of this type of research in question. However, cooperation between research and local fisheries has been excellent, and results of direct relevance to local fishermen have been obtained. Mr. Yen mentioned that the legacy of ECOTAP is a willingness and interest of local commercial vessels to work with research and the mechanisms and staff to facilitate this type of collaboration. The workshop participants fully supported further studies on the pelagic resources of this region, especially bigeye, with the Chairman noting the strategic geographical location of French Polynesia for basin-wide research coverage.

E. Western North Pacific

Dr. Miyabe described the status of tuna research capabilities of his organization. Field research on tropical tuna conducted by the National Research Institute of Far Seas Fisheries is carried out on dedicated research cruises and during some observer trips on commercial tuna vessels. A small to medium size longline research vessel will be chartered for at least three-year period. Western Pacific operations by this vessel will begin in April 1999, concentrating bigeye, yellowfin, albacore and swordfish research. It is possible that bigeye could be tagged during these cruises. Prefectural longline training vessels that will be operating near Hawaiian waters during the beginning of 1999 are another possibility for collaborative research. There is a strong possibility that these longline vessels could encounter tags from the Hawaii Tuna Tagging Project, and Dr. Miyabe agreed to translate the HTTP poster, which will increase awareness of tags with the Japanese fleet.

A large and well equipped government research vessel (RV Shoyo Maru), currently scheduled to work in the Indian Ocean in early 1999, will become available for pelagic research in the Pacific during the late 1999. She will be capable of longline and gillnet operations, acoustic tagging of large fish and will be equipped with a full array of sophisticated marine electronics. Possibly starting in September, a research cruise by this research boat will be conducted in the central and eastern Pacific. As the details of this cruise become more concrete, they will be circulated to the interested people.

F. Western Equatorial Pacific (WEP)

Dr Tony Lewis noted the previous involvement of SPC in conventional tagging of bigeye in the western equatorial Pacific (WEP). Of the 6,800 bigeye tagged during the Regional Tuna Tagging Project (RTTP, 1989-1992), 35% were released in the WEP (65% in the Coral Sea – see earlier), and a further 3,500 in the Philippines. Overall return rates were 8% and 25% respectively. These experiments have provided useful information on movements, age and growth and estimates of natural mortality for bigeye of various sizes. The OFP currently has no plans to undertake further conventional tagging of bigeye, and it was observed that opportunities to routinely tag and release large numbers of bigeye were generally quite limited. The recent increase in the use of drifting FADs in the WEP fishery, which takes significant quantities of small-medium sized bigeye with the use of deeper nets, may offer some potential for bigeye tagging in this area provided technical and handling problems could be overcome (see later discussion of tagging platforms).

Apart from the planned Coral Sea archival tagging, a proposal had been lodged with the United States Tuna Foundation (USTF) for 300 archival tags to be deployed in as yet undetermined areas, but likely to include the WEP area adjacent to the main longlining area in the central Pacific. The success of this proposal remains uncertain. It is possible that renewed EU funding during 1999 may be adequate to support further archival tagging work.

The continued involvement of the OFP in other areas relevant to bigeye research, such as age and growth studies, environmental determinants of tuna production, observer and port sampling work, and stock assessment was noted.

III. Tagging issues - both conventional and archival

A. Archival tags

1. Field data examples

Dr. Brill and Mike Musyl presented vertical and horizontal movement data derived from the recapture of a 131 cm bigeye that had been tagged in the dorsal musculature with a Northwest Marine Technology (NMT) device. The fish was tagged and recovered off Kona, Hawaii in the spring and summer of 1998 after four months at liberty. The fish exhibited classic vertical distribution profiles of deep diving during the day and shallow swimming at night with regular vertical excursions throughout the day. Dr. Brill speculated that the rapid vertical excursions from great depths were thermoregulatory in nature. Geolocations interpolated from the data indicated that the fish remained within the general vicinity west of the island of Hawaii and south of Oahu, but accuracy was considered to be reliable only to within 2 degrees (approximately 120 nm radius). An important shortcoming of the device was apparent as the fish normally dove to depths in excess of the ability of the light sensor to detect day length information. Fortunately, the fish exhibited extremely regular diving behavior at apparent sunrise and sunset periods that were used to calculate nominal day and night periods.

Dr. Gunn presented data from southern bluefin tuna tagged in South Australia with Wildlife Computer archival tags. The bluefin exhibited very different vertical behavior compared to the Hawaiian bigeye. The fish remained at depth for long periods and body temperature showed less variation. Due to the internal placement of the tag, feeding behavior of the fish was detectable due to chemical warming of the gut cavity during digestion. Regular and very characteristic ascents and descents at dawn and dusk were evident. However, Dr. Gunn warned that a great deal of individual variation in behaviour was observed, and that it is would be dangerous to assume a standard behavioural pattern for southern bluefin. Estimation of longitude from the data was generally feasible, but latitude estimation was dependent on time being spent at the surface. Temperature/depth profiles could be useful in this regard.

Some discussion ensued on the use of archival tags. Participants noted that whilst the value of the vertical movement/depth data was clear, the horizontal movement data may only be useful addressing questions of movement on larger scales. The success of pop-up tags as a fishery-independent source of geolocation information in several situations was noted.

2. Suitability of archival tags

A discussion ensued on the relative merits of conventional and archival tags in tagging programs. The larger sample sizes possible with conventional tags are desirable for many reasons but archival tags can deliver large quantities of repetitive data that argue that a single archival tag is worth many conventional tags. Archival tags are obviously useful for behavioral data but are also valuable for obtaining annual movement cycles and displacement data from areas where there is no fishing effort. Archival tags are also useful to discern stock relationships that could have implications for regional management. **The ideal situation was agreed to exist when conventional and archival tagging projects are implemented concurrently, possibly within the same time/area strata.**

Given the technical problems experienced with some archival tags (light and depth sensors), the workshop participants agreed that the group should develop specific criteria for bigeye-specific archival tags to present to the tag manufacturing companies and maintain a standardized approach for coordinated Pacific-wide bigeye research. Careful testing and calibration of tags would be an integral part of this coordinated effort.

3. Attachment issues

Dr. Brill described the NMFS experience with the use of various methods of tag attachment. He recommended that Northwest Marine Technology tags be inserted in the dorsal musculature rather than sewn into the body cavity. He recommended that tags sewn into the dorsal musculature should be used on fish greater than approximately 85 cm FL while fish as small as 65 cm can be tagged with Wildlife Computer tags placed in the body cavity. Based on extensive experience with southern bluefin tuna, Dr. Gunn opted for internal placement of Wildlife Computer tags, recommending that the body wall be cut open and a small tear made in the peritoneum, allowing the tag to be pushed inside the cavity. This internal placement had the advantage of allowing visceral temperature to be recorded if this was considered desirable. With both methods, minimizing stress on the fish was of critical importance.

Dr. Brill described the harpoon style attachment of acoustic and popup tags for giant Atlantic bluefin using a modified tag head, and also the T-hammer style applicator. Large fish are leadered beside the vessel, tagged in the water and the circle hooks extracted backwards allowing easy cutting of the leader for release. It was felt that the harpoon method may be preferable for purse seine caught fish, and the T-hammer approach for longline-caught fish.

Characteristics of existing (30 days of limited data) and future pop-up tags were discussed, with the main constraints to further development likely to be power requirements for transmission, and unit cost.

4. Applicability of archival tag data to stock assessment and management

Dr. Hampton spoke on the use of archival tag data for stock assessment and fisheries management. He listed the main benefits of archival tags for use in describing or defining the following aspects of stock assessment:

a) Stock distribution/mixing
   - horizontal movement characteristics
   - differences between seamount/land associated, FAD- associated, and open ocean fish

b) Use in basin-scale simulation models

- specific hypotheses of environmental effects on tuna aggregation/movement

c) Interpretation of longline CPUE
- vertical behavior of fishing gear in relation to temperature, DO and setting characteristics of longliners

Workshop participants noted that archival tags were very useful for the documentation of annual cycles of movement and seasonal or long distance movement/migration, particularly when lack of fishing effort from remote areas precludes the possibility of tag recaptures. The possibility of a fish moving to regions where fishing effort or fleets are markedly different also has important implications for anticipated tag recapture and reporting rates.

B. Practical tagging issues - Conventional and archival

1. Deployment strategies

The chairman suggested that a tagging experiment design study should be described in the prospectus and conducted to estimate release numbers and areas before large-scale fieldwork (especially conventional tagging) begins. The design will be influenced by the questions being asked, and in general it will be better to have more release locations rather than large numbers of fish in a few locations. Field operations that have begun or are soon to start can be used to refine and ground truth the tag design study. The large scale of the design study would require basin scale catch and effort database. A large database of this type is currently being compiled by the SPC, IATTC, and NRIFSF for use in a large-scale modeling exercise. It was suggested that a basin scale design study would be appropriate if regional objectives and criteria were adequately addressed. Dr. Hampton suggested that tag release strategies should be related to the expected level of tag returns, since the analysis of tagging data will be driven by recapture rates. Large scale experiments may have global goals but with many regional implications.

The subject of access to significant quantities of exploitable bigeye was discussed. Apparently, the large feeding aggregations of bigeye in the Australian Coral Sea are a unique situation, and few opportunities to routinely tag large numbers of medium sized fish exist in other areas of the Pacific. However, the Cross Seamount in Hawaii is a reliable release point for large numbers of small to medium sized fish and it is possible that bigeye can be targeted on other seamounts in the north and South Pacific. Further targeting of bigeye can also be accomplished through the extensive use of both anchored and drifting FADs. It is clear that some innovative and experimental methods will have to be employed to target bigeye for a large-scale conventional tagging project. However, the smaller numbers of large fish necessary for archival tagging can easily be met using commercial or research longline and handline vessels.

Itano suggested that large-scale tagging of bigeye is really dependent on funding levels, making it very difficult to estimate how many fish can be tagged without a better understanding of budget levels. For example, it is probable that a distant-water class baitboat operating in the Coral Sea, Cross Seamount or on drifting FAD arrays in the eastern Pacific could tag very large numbers of bigeye. However, the full charter of this style vessel would be relatively expensive. Dependency on vessels of opportunity or small troll and handline vessels would limit the tag release numbers significantly.

The possibility of tagging fish from purse seine vessels was discussed. The IATTC has invested a great deal of time on tagging tropical tuna from purse seiners. Differential return rates of purse seine tagged tuna versus pole and line tagged fish strongly suggest a high post-tagging mortality on fish tagged from purse seiners. However, tagging from purse seine vessels making log/FAD sets may be the only way

to tag significant quantities of bigeye from the equatorial regions unless a large, dedicated pole and line tagging vessel can be funded. Efficient purse seine tagging operations would however require considerable methodological development.

The workshop was directed to develop a list of areas where it is known that quantities of bigeye can be caught and tagged, and a list of areas where it would be desirable to tag large quantities of fish to address specific management objectives. The following table of potential sites was compiled by David Itano from a variety of sources.

Table 1. Possible locations where bigeye may be available for tagging.

Name	Location	Size of fish	Seasonality	Comments
Moro Gulf / Celebes Sea	S. Philippines to N. Indonesia	20 – 55 cm	All year	Anchored FAD aggregations
Coral Sea	Australian Coral Sea, 14° – 18° N, 145° – 148°E	55 – 115 cm	October – December	Seasonal feeding aggregations
Solomon Islands	South Pacific	25 – 65 cm	Unknown	Anchored FAD aggregations
Western Equatorial Pacific	10°N - 10°S, 130°E – 150°W	35 – 90 cm	All year	Drifting object, FAD and anchored FAD aggregations
Cross Seamount	18°40'N, 158°10'W	35 – 110	All year, peak October – May	Seamount aggregation
NOAA Weather Buoys	Outer Hawaii EEZ	35 – 110 cm	All year	Anchored FAD aggregations
Capricorn Seamount	Outer Tonga EEZ, 18°40'S, 172°10'W	35 – 145 cm	All year, peak November - May	Seamount aggregation
Eastern Pacific Ocean	5°N - 10°S, 95°W - <150°W	40 – 115 cm	All year	Drifting object and drifting FAD aggregations

2. Tagging platforms

There is little doubt that pole and line gear is the best gear type for tagging and releasing large quantities of tuna in good condition. Such a vessel should have adequate size to achieve an at-sea autonomy of several weeks and be able to carry large quantities of live bait in temperature controlled and filtered baitwells. A vessel type built low to the water would facilitate the landing of larger fish and the use of handline gear in an efficient manner. Dr. Miyabe agreed to investigate the availability of Japanese prefectural pole and line training vessels that could be used for large scale tagging operations. However, he cautioned that such a vessel would probably be restricted to operations within the western Pacific.

The idea of a dedicated tagging platform that could service many different tagging projects in the Pacific was discussed. **The workshop participants agreed that a dedicated tagging platform would be an essential and highly desirable resource for collaborative bigeye research on a Pacific-wide basis.** Such a vessel would become a highly specialized and experienced tagging and field research unit available to several different regions. It is anticipated that a regional tagging vessel would operate concurrently with other tagging platforms operating in other regions of the Pacific. An additional benefit of a dedicated tagging vessel would be the ability to tag other species, such as yellowfin, albacore and bluefin tuna with minimal additional cost and conduct in situ oceanographic sampling. Some provisional operational and charter costs were suggested for several vessel types.

3. Tag recovery and reward issues

The workshop participants could not reach a consensus on the necessity or desirability of standardizing archival tag rewards between programs and what the reward should be. The most common reward stated by participants for archival tags was $500 in the local currency, although Japanese government agencies do not condone the awarding of cash rewards to fishermen.

For conventional tagging projects, it was agreed that each region should handle tag publicity, recovery and reward mechanisms and the thorough collection of tag recapture data, as each region is best able to deal with their local conditions and fishing communities. The workshop participants discussed the concept of a centralized collection point for tag recapture data and generally agreed that some centralization of processing may be desirable. However, workshop participants were uncomfortable with the idea of a separate entity collecting and pooling all data for analysis. **Due to the short period of the workshop and variety of complicated issues related to this concept, no resolution could be reached. It was agreed that further discussion on the fate of regional bigeye tagging data would continue via correspondence.**

In the area of tag publicity and returns, Dr. Miyabe was asked to investigate the possibility of placing a tag return advertisement in the newspaper that is routinely faxed to all distant-water Japanese fishing vessels.

The importance of widespread, thorough and ongoing publicity and information exchange in several languages was stressed to maximize tag reporting rates. It was suggested that a full time tag publicity and information agent could be desirable for a tagging program of this magnitude. The generally low costs of rewards in the overall project cost, and the significant manpower requirements for proper publicity and information exchange and storage were noted.

4. Data archiving, quality control and access

The workshop participants agreed that tag release and return data should be collected and verified on the local, or regional level and possibly collected at a centralized location for processing. However, it was noted that there may be many problems and conflicts with access to data from special interests and other groups. The workshop participants agreed that a resolution to this problem could not be made during the short period of the workshop but that issues related to data access and sharing should be discussed further and listed for future reference.

The workshop participants recommended that data processing should be a budget line item in all regional or individual tagging proposals submitted for funding.

November 11, 1998 (Day 2)

C. Technical concerns

An electronics supplier fielded technical questions about the current state of the art in electronic tags. The current light sensors can discern light levels down to a depth of approximately 400 m, and it was unlikely that this performance could be further improved. Problems with moonlight levels and amplification algorithms remained to be resolved. Light at these levels is almost certainly omni-directional meaning that tag placement on the ventral side of fish would not hinder light detection.

The main interest in accurate light detection by archival tags was in providing data for geolocation algorithms. The severe light sensing limitations were mitigated in the Hawaii example by assuming that the recaptured bigeye exhibited very regular ascent/diving behavior at civil twilight and sunrise. Dr. Boggs proposed that regular diving behavior calibrated to the last few days before recapture at a known position could be a more reliable positioning mechanism as opposed to relying on light sensor data. Running averages of day lengths may also be useful. Dr. Gunn suggested that some calibration of light levels at the time of diving should be carried out to quantify the relationship between diving and absolute light levels. The possibility of using moonlight and time of moon set for geo-positioning was discussed and may be useful. It was concluded that incorporation of light sensors in archival tags, despite constraints, was a desirable if not necessary design feature. Dr. Gunn indicated that the light sensing capabilities of the two leading suppliers of archival tags were comparable.

The need for calibration of tags (light, temperature, and depth) before deployment and after recovery was noted. Archival tag manufacturers routinely undertake extensive levels of quality control and post-manufacture testing. This adds considerably to unit cost, but reduces the risk of post-deployment failure. The thorough quality control and product testing by two of the manufacturing companies was noted with appreciation.

In discussing the use of pop-up tags, the possibility that these might be able to detect the death of a fish was raised, although the difficulty of distinguishing tag failure and fish death or predation was noted. Sinking rates of dead and/or dying fish, tail beat frequency etc might be worthy of further investigation in this regard. Popup tags are also subject to crushing and loss at depth (800 m), and because of their visibility may potentially subject the fish to greater predation, although use of appropriate colors may reduce this risk.

In considering the possibility that electronic tags might be used to provide estimates of natural mortality, and that pop-up tags in particular provide a fishery-independent method of recovery, the workshop participants generally felt that archival tags were not appropriate for estimation of natural mortality, and that the use of conventional tags remained preferable.

A note of caution was sounded about possible influence of electronic tag carriage on behavior. While a valid concern, it was noted that archival tag return rates at least have generally been unaffected for marine animals when the tag weight is less than 10% of body weight, and 4% in avian situations.

It was concluded that the use of the Iridium global telephone network in association with pop-up tags may occur in the near future, but the much greater power requirements for transmission to such systems is a major technical power.

D. Commercial issues

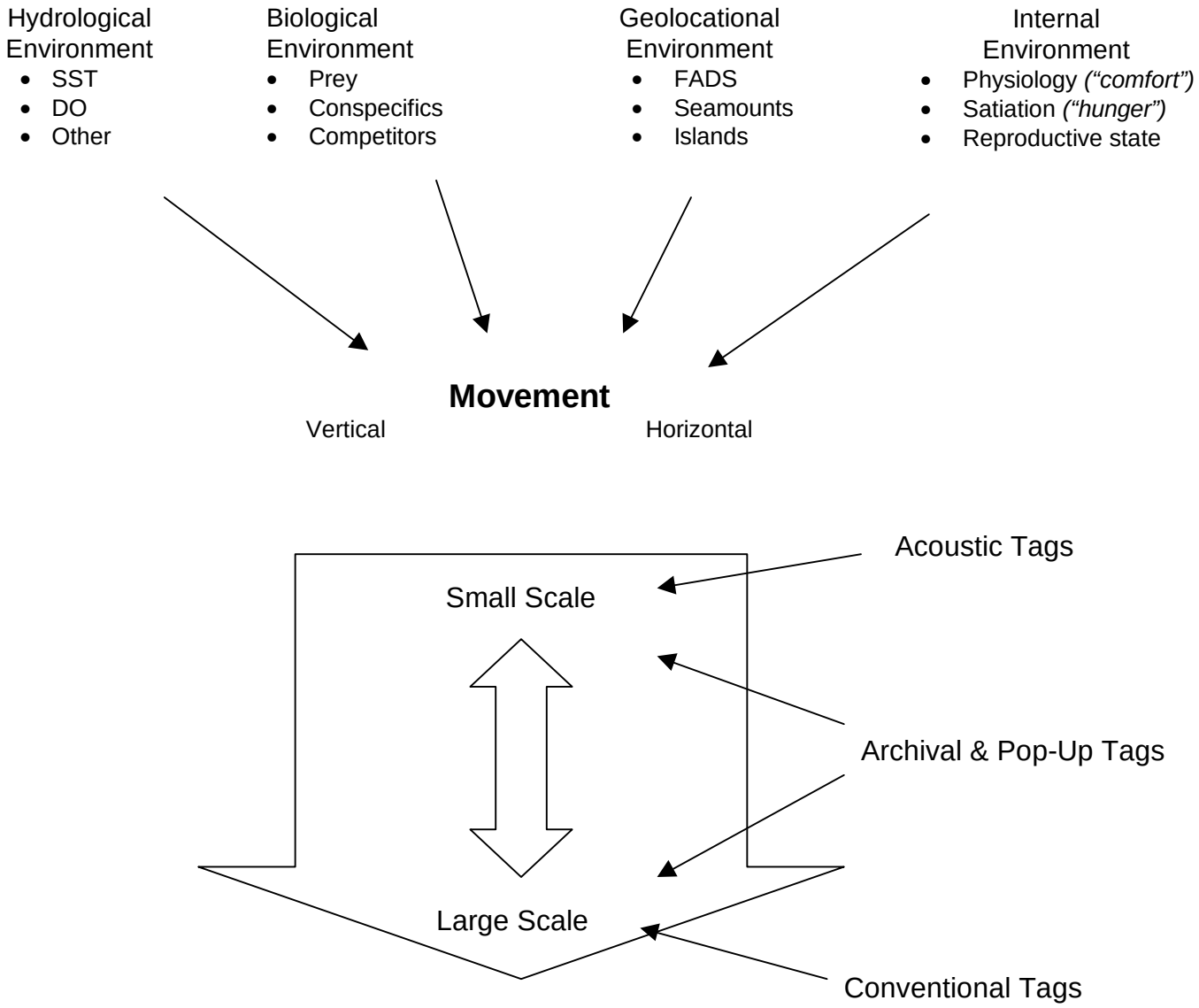
The importance of archival tag design incorporating species or objective specific needs was again emphasized. Dr. Gunn advised that the current generation of archival tags, currently worth approximately $1200 each, were as good a tag as likely to be available for some time and that new model tags may not be available for some years. Delivery times of current model tags are adequate. **Participants felt there was great merit in the standardized purchase and use of the same type of tag, even to the extent of a central acquisition point.** There remains much scope for the development of better archival tag software, and participating research organizations were encouraged to engage in research and development related research.

IV. Research priorities

Dr. Dagorn, in noting that many of the suggested applications of archival tagging data to stock assessment (see earlier) involved behavioural information, described his ideas on the potential influence of the environment, aggregation, internal state and the biological environment on bigeye vertical and horizontal movements . Dr. Dagorn provided a useful synthesized view of tuna behavior movement at different scales and identified some appropriate research methods.

Remote Sensing
Moored Arrays
Oceanographic Stations
Fisheries Data

Tagging & Tracking
Laboratory Studies



Dr. Dagorn's contention was that small scale movements are best addressed by acoustic tags, as it was easier to relate them to environmental data, while large scale movements should be addressed by conventional and possibly archival tagging. He contended that the best tool for the interpretation of longline CPUE was acoustic tags in conjunction with on-board sensors and knowledge of longline setting characteristics. Most participants however felt that it was possible to link remotely sensed (satellite) data in particular with archival tag data and this would add greatly to its value and application. The consensus was that both acoustic and archival tags were needed for different purposes, with the latter providing the larger scale spatio-temporal perspective not possible with acoustic tags. He noted that acoustic tags provide an important bridge between sonic tracking and large-scale conventional tagging experiments. Further study on the vertical movements and habitat of tuna was recommended, particularly when verified by sonic tracking or other field methodologies. The value of feeding data provided by archival tags was generally agreed. This appears to be one of the main benefits of internal archival tags. The likely development of transponder tags in the near future, with a variety of potential applications, was flagged. Finally, it was noted that models to integrate the range of information available from archival tagging would need to be developed.

The Chairman then introduced a list of research priorities for bigeye tuna that might be addressed, in the main, via tagging. These were augmented during subsequent discussion, and are not listed in priority order (priorities were not assigned).

RESEARCH PRIORITIES FOR BIGEYE TUNA

- Movement at different scales (small, large, huge)
  Need to address the estimation of basin scale movement rates

- Natural mortality
  Age
  Other influences (e.g. food, reproduction)

- Model development
  integrate environment and movement
  integrate environment and mortality
  integrate data from conventional and archival tags

- Fishery interaction

- Inter-species differences (where implications for management)

- Aggregation /schooling/vulnerability/behaviour

- Age and growth, reproductive biology

- Archival tag geolocation algorithm development

Subsequent discussion brought out the need for a separate list of equipment or tools that would be necessary to implement or further the accomplishment of the previously listed research priorities.

EQUIPMENT OR RESEARCH TOOLS BENEFICIAL FOR REGIONAL BIGEYE RESEARCH

1. Regional tagging vessel
2. Standardized tag release and recapture projects
3. Accurate archival tag geolocation algorithms
4. Remote sensing

Table 2 provides a summary of the extent to which these research priorities are being addressed, currently and in the future. Many gaps in this coverage of research priorities are evident. While most of this research will be conducted on a regional basis, some activities will clearly benefit from global coordination. These research objectives will be incorporated into the prospectus, which will be completed by the Chairman before December, by correspondence as necessary. It is intended that the prospectus will indicate a collective will to accomplish the above research goals, thus making funding more attractive to donor parties, and could be used by all parties in support of funding requests. The demonstration of links to the management process will be helpful.

Table 2. Pacific Bigeye research matrix by organization

(T) = project completed
(+) = project in progress
(Prop) = project proposed and likely to be implemented if funding is available
(Conc) = project in conceptual phase, project supported in principal but not yet proposed or funded

Bigeye activity	CSIRO	French Polynesia	I-ATTC	NMFS	NRIFSF	OFP (SPC)	PFRP & HIMB (UH)
Movement (tagging) Sonic Archival Conventional	 **T** + Prop	 **T** - -	 Conc Conc Prop	 **T** + +	 + - +	 - + **T**	 **T** Prop +
Mortality (estimation)	-	-	Prop	-	-	**T**, +	+
Model development	**T**, +, Prop	+	**T**, +, Prop	Prop	Prop	**T**, +, Prop	+,Prop
Fishery interaction	-	-	Prop	-	-	**T**	+
Behavioral differences	-	+	Prop	-	-	-	Prop
Aggregation / schooling / vulnerability	Prop	+	Prop	-	-	Prop	+, Prop
Age and growth	+	-	+	-	+	+	+
Reproductive biology	-	-	Prop	-	-	-	Prop
Archival tag algorithm	+	-	-	+	-	-	Conc
Regional vessel	Conc	Conc	Conc	Conc	Conc	Conc	Conc

The workshop closed at 1200 hrs Tuesday November 10th. A draft record of discussion was reviewed in detail on November 11. The following persons made considerable comments on the draft. It was agreed that the record of discussion would be attached to the overall prospectus and distributed to workshop participants for review.

Post-workshop review
Marine Science Building Rm 305
University of Hawaii at Manoa
November 11, 1998

Richard Brill	NMFS
Laurent Dagorn	ORSTOM
John Gunn	CSIRO
John Hampton	OFP
David Itano	PFRP
Pierre Kleiber	NMFS
Marc Labelle	NMFS
Tony Lewis	OFP
Kurt Schaefer	IATTC
John Sibert	PFRP
Stephen Yen	SMA

Pacific Bigeye Tuna Research Coordination Workshop

November 9-10, 1998 Univerity of Hawaii, East-West Center

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