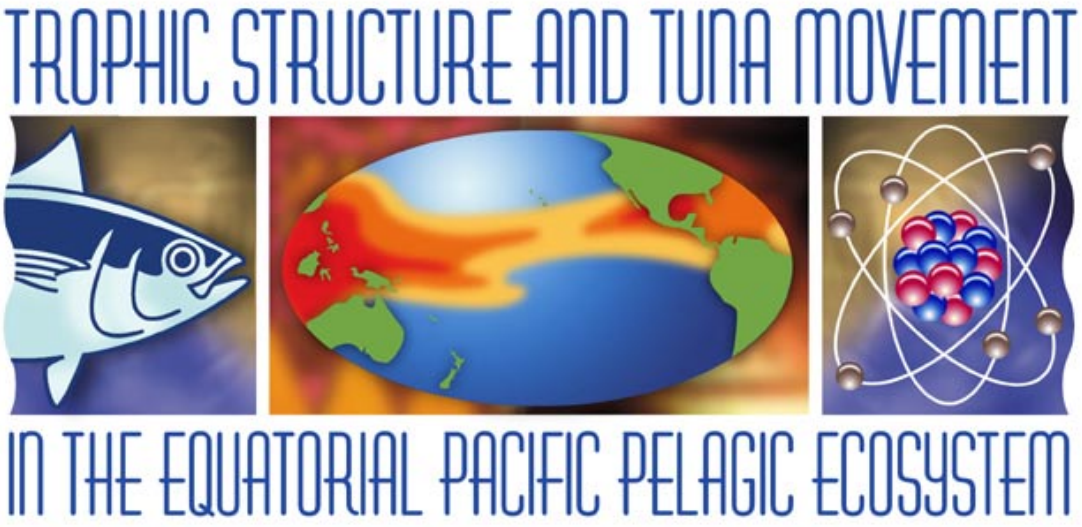

JIMAR, PFRP ANNUAL PROGRESS REPORT FOR FY 2002-2003
PROJECT # 659559

P.I. Names: Valerie Allain, Robert Olson, Felipe Galván-Magaña, and Brian Popp

Project Proposal Title: Trophic structure and tuna movement in the cold tongue-warm pool pelagic ecosystem of the equatorial pacific

Funding Agency: PFRP

1. Purpose of the project and indicative results.

Recent modeling, suggests that tuna productivity in the western and central Pacific Ocean is tied to upwelling along the equator in the central and eastern Pacific. The project proposes to test this hypothesis by combining diet analysis, stable isotopic compositions, food-web modeling, and stable isotope markers to trace tuna movements and trophic-level variation in the equatorial Pacific. The hypothesis predicts that tunas that reside near equatorial upwelling fronts feed at relatively low trophic levels. Opposite trends are expected in equatorial regions with little upwelling, such as the warm pool of the western Pacific, where tunas are expected to feed at higher trophic levels and move extensively, searching for less-abundant prey.

The main objectives of the study are:
1. to define the trophic structure of the pelagic ecosystems in the western, central and eastern parts of the tropical Pacific Ocean,
2. to establish an isotope-derived (upwelling-related) biogeography of the pelagic tropical Pacific ecosystems, and
3. to characterize large-scale tuna movements related to upwelling regions along the equator.

Results of this study should help define ecosystem linkages leading to tuna production and the effect of climate variability on the systems. This information is important for both fisheries production and ecosystem modeling of the equatorial Pacific Ocean.

2. Progress during FY 2002.

2.1. Meetings

The first meeting of the project PIs was held in Honolulu in July 2002. All four PIs were present. The implementation of the program was discussed, including sampling, laboratory analysis, database standardization, staff, administration and priorities. Project funds were not used to finance this meeting.

The second PI meeting, funded by the project, will take place in Noumea from 28 April to 2 May 2003. The four PIs, a collaborator Brian Fry and a Ph.D. student Brittany Graham will attend. Progress and problems will be presented and actions for the following year prioritized.

2.2. Funding

Administrative difficulties hindered transfer of first year project funds to SPC until March 2003. SPC received $29,765 USD and the full amount was transferred to CICIMAR and IATTC in April 2003. This delay in receiving funds caused the initiation of at-sea sampling efforts in the eastern Pacific to be delayed. CICIMAR and IATTC are subcontracted by SPC, and the SPC-CICIMAR-IATTC year 1 budget is $102,176 USD. It is not known when the remainder of the year 1 budget will reach the PIs. Funds were available to the University of Hawaii (UH) beginning January 2003.

SPC funds were used to implement sampling and analysis in the western/central part of the Pacific while waiting for funds to become available from PFRP. SPC has been working on a trophic-ecology project in the western Pacific since September 2000.

2.3. Sampling on tuna vessels

2.3.1. Western/central Pacific

In the western/central Pacific, observers collected samples from the National Observer Programs of the area. Sampling kits were distributed to Papua New Guinea (8 kits), Fiji (5), Federated States of Micronesia (2), Solomon Islands (5), Marshall Islands (1), Kiribati (5), Cook Islands (4), French Polynesia (11) and New Caledonia. Observers on longline and purse-seine vessels are collecting muscle and liver samples from 2 specimens of each species (tuna, shark, billfish and other bycatch species) per set. Predator sampling is widespread from Papua New Guinea to French Polynesia from west to east, and from the Federated States of Micronesia to New Caledonia from north to south. Since July 2002, 17 sampling trips have been completed: 4 longline trips in New Caledonia, 8 longline trips in French Polynesia, 1 longline trip and 1 purse seine trip in Papua New Guinea, 1 purse seine trip in Federated States of Micronesia, and 1 longline trip and one trolling trip in the Cook Islands.

In Hawaiian waters, under the primary objectives of the PFRP project # 757282, 340 samples were collected from Hawaiian FADs and Cross Seamount. Samples collected include stomachs contents and tissue samples for isotope analysis from bigeye and yellowfin tuna. Results of analyses of these samples will allow us to better link data from the western and eastern Pacific.

Of the 750 stomachs collected from 43 species of predatory fishes, 504 have been examined in the laboratory. The most numerous predatory fishes species are yellowfin tuna (71 specimens), bigeye tuna (30), skipjack tuna (47), albacore (50), blue shark (15), silky shark (10), wahoo (32), lancetfish (*Alepisaurus ferox*) (32), dolphinfish (38), moonfish (22), escolar (11), and rainbow runner (22). The data have been entered in a database, but not yet analyzed.

Trophic level of the predators will be estimated by using the stomach contents as well as stable isotope analysis of the muscle and liver samples. From the 746 muscle and 748 liver samples collected, 185 and 185 samples, respectively, were freeze-dried for isotopic analysis. We will also

use the stable isotope analyses of plankton, prey and predators to establish an isotope-derived biogeography.

2.3.2. Eastern Pacific

In contrast to the western Pacific, a sampling program using observers on tuna vessels in the eastern Pacific Ocean (EPO) was not in force prior to this PFRP project. During this fiscal year, project PIs made two trips to sampling ports in the EPO, one to Manta, Ecuador and one to Mazatlán, Mexico, and laid the groundwork for sampling by observers. On both trips, vessel owners and cannery officials were given information on the study and their cooperation for cutting tunas at sea was requested and obtained. Training sessions were held for IATTC office personnel and observers who were in port. An observer manual, containing species identification guides and sampling guidelines, was prepared. Sampling equipment and supplies for the first year of the project were purchased using IATTC funds, and shipped to Ecuador and Mexico.

No trips have been completed nor samples obtained by observers as of the drafting of this report. Samples have been taken, however, from 2 yellowfin, 3 bigeye, and 1 skipjack tuna that had been tagged with archival tags by the IATTC in the EPO. The data from the archival tags will provide a record of the movements of these particular fish. Once progress has been made in defining an isotope-derived biogeography in the pelagic tropical ecosystems, the movement patterns inferred from the stable isotope markers in the liver and muscle samples of these tunas will be compared to the tag-derived movement records. Samples from archival-tagged tunas will continue to be collected during subsequent years of the project, providing a means to ground truth hypotheses regarding large-scale tuna movements.

2.4. Sampling on research vessels

2.4.1. Western/central Pacific

During 2 exploratory trips in the EEZ of New Caledonia, 17 samples of particulate organic matter (POM) and 56 samples of zooplankton were collected using plankton nets of different mesh-size. These samples were frozen and sent to the UH for isotope analysis. During these trips, pelagic prey organisms were also collected using a pelagic trawl. About 190 samples of small fish, squid and crustaceans were stored frozen. These samples will allow an evaluation, based on isotope values, of the intermediate trophic levels occupied by these prey.

2.4.2. Eastern Pacific

Preparations are being made for sampling POM and zooplankton in conjunction with the *Stenella* Abundance Research Project (STAR) of the U.S. National Marine Fisheries Service, La Jolla, California. STAR is a multi-year study designed to assess the status of dolphin stocks that have been taken as incidental catch by the tuna purse-seine fishery in the eastern tropical Pacific. Two research vessel cruises will take place simultaneously during July – December 2003, and will survey a large portion of the eastern and central Pacific (for cruise track please see http://swfsc.nmfs.noaa.gov/prd/star/default.htm). Oceanographic data will be collected on these cruises. NMFS scientists have agreed to collect samples of POM, zooplankton, and various fishes and invertebrates for this PFRP project.

2.5. Sampling to analyze within-fish isotope variability

Systematic samples were collected from tuna to examine within-fish isotopic variability. This is an issue because the initial sampling design calls for sampling muscle from the dorsal area of purse-seine-caught fish, but from the belly region of longline-caught fish, and it is necessary to confirm that the data from these two loci are comparable. Samples of muscle from different regions of the body, liver, stomach wall, gill, and eye were taken from 2 large yellowfin tuna in the western Pacific and 1 large, 1 medium, and 1 small yellowfin in the eastern Pacific. The specimens from the western Pacific were freeze-dried and sent to the UH for analysis. The specimens from the eastern Pacific were stored frozen and will soon be sent to the UH for analysis.

2.6. Isotope analysis

All samples received from the Western Pacific and the 340 samples from the central Pacific are in the process of being lipid extracted or homogenized before stable isotopic analysis. The carbon and nitrogen isotopic composition have been determined on nearly 100 of the lipid-extracted tissue samples. Much time in the laboratory has been devoted to logistics of sample preparation and analysis. Four general findings from the stable isotope analyses have nonetheless emerged:

1. Liver, red, and white muscle tissues are isotopically distinct in juvenile tuna and show constant offset in their isotopic values. The implication of this result is that any one of these tissues can be use to characterize the isotopic composition of an individual.
2. Juvenile tuna are isotopically similar at 5 different FAD locations; however, one subset had a uniquely high signature relative to others of comparable size. The uniquely high isotopic values could be explained by (a) a different nutrient source feeding the plankton at the base of the food web fed upon by this school, (b) starvation, or (c) cannibalism of young tunas.
3. Adult yellowfin and bigeye tuna collected from Cross Seamount have isotopic signatures nearly two trophic levels higher then the nearshore Hawaiian juveniles.
4. Initial results from the western Pacific show that nitrogen isotopic values for bigeye are greater than those for yellowfin tuna.

2.7. Laboratory experiments

A tuna tank to be built for feeding experiments is not yet complete. Dr. Kim Holland has suggested that the outdoor tank will be built and ready for preliminary testing by early summer 2003. We hope these feeding experiments will allow us to measure differences in the isotope composition of slow- and fast-turnover tissues, which should provide a more refined view of tuna movements. For example, by comparing isotopic compositions of tissues with different turnover rates from tunas caught in the open ocean, we hope to be able to estimate the number of days since diet switching due to migration from one feeding area to another.

3. Plans for the next fiscal year.

We will present results of this study at the PFRP PI meeting in December 2003 in Hawaii and at the Tuna Conference in May 2004 in Lake Arrowhead. Concomitantly to these meetings, PIs and collaborators will meet to discuss progress, problems and future plans and to discuss interpretation of the stomach content and isotopic analyses, the majority of which will be collected over the next six months.

3.1. Western/central Pacific

In the western/central Pacific, sampling will be pursued to increase the number of predator stomachs, muscle and liver samples collected. Stomach examination will continue and data will be included in an Ecopath model of the ecosystems.

Possibilities to join scientific cruises for collection of plankton and prey samples will be explored. There is a high probability of joining a Japanese scientific cruise in the western equatorial Pacific at the end of 2003. We will also explore the possibility of joining research cruises on NOAA vessels servicing the TOGA-TAO array in the central Pacific as well as small private fishing vessels targeting Cross Seamount.

3.2. Eastern Pacific

In the eastern Pacific, sampling on tuna vessels will hopefully be intensified. The original project budget called for sampling 20 trips per year, to meet the sampling design for the isotope analysis. However, the cost of sampling by observers is relatively low (supplies and bonuses), and the

additional diet data obtained will greatly help parameterize a new ecosystem model for the eastern Pacific. This will provide valuable input for continuing efforts to incorporate ecosystem considerations in fisheries management.

It is anticipated that another series of STAR cruises will be conducted by the U.S. National Marine Fisheries Service, La Jolla, California in the eastern Pacific next fiscal year. There is a high probability that samples of POM, zooplankton, and various fishes and invertebrates will be collected for this PFRP project on those cruises.

4. List of papers published in refereed journals during FY 2002.
None.

4. Other papers, technical reports, meeting presentations, etc.

5.1. Other papers

An article about this project was published in SPC Fisheries Newsletter:
Anonymous. 2002. New tuna project to start in 2003. SPC Fisheries Newsletter. 102: 22-24.

A short note explaining the aim of the project was included in an article published in Globec International Newsletter:
P. Lehodey. 2002. Oceanic fisheries and climate change project. Globec International Newsletter. 8 (2): 22-24.

5.2. Meeting presentations

V. Allain, R. Olson, F. Galvan, B. Popp. 2002. Trophic structure and tuna movements in the cold tongue-warm pool pelagic ecosystem of the equatorial Pacific. PFRP PI Workshop. Hawaii. December 2002.

B. Graham. 2002. Examining tuna trophic dynamics using stable isotope analysis: the Hawaiian template. PFRP PI Workshop. Hawaii. December 2002.

B. Graham, K. Holland, B. Popp, V. Allain, R. Olson, F. Galvan, B. Fry, D. Grubbs. 2003. Tuna trophic dynamics in the western and central tropical pacific. Tuna conference. Lake Arrowhead. May 2003.

6. Names of students graduating with MS or Ph.D. degrees during FY 2002.
No students have graduated. Ms. Brittany Graham was accepted in the Ph.D. program by the Department of Oceanography, University of Hawaii in September 2002. Ms. Graham is supported by a PFRP fellowship/graduate assistantship and is working jointly between this project and PFRP project 757282 of Holland et al.

7. Budget for the next year
There have been no changes to the budgets for CICMAR, IATCC and UH. Changes to the SPC budget reflect an increase in travel expenses for Dr. Brian Fry (collaborator, now at Louisiana State University) and to print T-shirts with our project logo as a gift for observers. The modified detailed budget is attached.