TROPHIC STRUCTURE AND TUNA MOVEMENT IN THE COLD TONGUE-
WARM POOL PELAGIC ECOSYSTEM OF THE EQUATORIAL PACIFIC

PFRP project # 659559

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Three-year project to begin in January 2003
The cold tongue – warm pool ecosystem

WARM POOL
- warm water
- low primary production
- tuna maximum biomass

COLD TONGUE
- strong divergent equatorial upwelling
- high primary production

El Niño Southern Oscillation events induce variability in environment and tuna distribution
Hypothesis

Tuna residing in the warm pool are expected to feed at higher trophic levels and move extensively. Tuna residing in the cold tongue system are expected to feed at relatively low trophic levels.

To test the hypothesis:

Diet analysis
Stable isotope composition analysis

Food web modelling
Trace tuna movements and trophic level variations
Objectives

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.
1. Define the trophic structure of the pelagic ecosystems

Identify the functional groups

- **Predators:** tunas, sharks, billfishes, predator fishes, marine mammals...
- **Prey:** forage fishes, cephalopods, crustaceans...
- **Plankton:** zooplankton, phytoplankton

Determine how energy and matter flow through these groups

- Stomach content analysis to quantify prey-predator interactions
- Stable isotope ratios to assess trophic position of the functional groups ($\delta^{15}N$) and as a tracer of the primary production source ($\delta^{13}C$)
Represent trophic flows into a biodynamic modelling

**Ecopath with Ecosim** *EwE*

**Ecopath**

**Ecosim**

Eastern Pacific: recently developed model by Olson and Watters (in press)

Central North Pacific: model developed by Kitchell *et al.* (1999)

Western Pacific: preliminary model developed by SPC in 2002
2. Establish an isotope-derived biogeography

Characterize the trophic structures in different production regimes contrasting low-productivity zones (warm pool) vs. high-productivity upwelling zones (cold tongue)

Map the different regions of primary and secondary production in the Pacific Ocean

N and C stable isotopes

\[ \delta^{15}N \quad \delta^{13}C \]
We anticipate large and clear regional signals linked to low/high-productivity zones:

High δ\textsuperscript{13}C values associated with rapid growing diatoms characteristic of upwellings and blooms

N composition is sensitive to trophic level

C composition often reflects the algal source of production

high values in the eastern Pacific and low values in the western part
3. Characterize large-scale tuna movements

On the basis of the isotope-derived biogeography established, isotope ratios of the fish will serve as **internal chemical tags** that are characteristic of areas where they are living.

δ\(^{15}\)N

δ\(^{13}\)C

PREY

PREDATOR

PREDATOR

PREDATOR

This predator is **NOT A RESIDENT** of the area where captured

Expected trophic level enrichment “RESIDENT FISH”

This predator is **NOT A RESIDENT** of the area where captured
Comparison of the isotopic composition of tissues (muscle, liver) and compounds (fatty acids) with different turn-over rates might allow estimating the number of days since diet switching (migration from a feeding area).

Liver: fast turn-over tissue
Muscle: slow turn-over tissue
Fatty acid profiles

Project 657282
Trophic ecology and structure-associated aggregation behaviour in Bigeye and Yellowfin Tuna in Hawaii Waters
Kim Holland, Richard Young, Richard Brill, and Laurent Dagorn

Laboratory experiments
diet change experiments on captive tunas to measure isotope difference between the different tissues when diet is changed

to develop this approach
Sampling programme

Sampling of stomach, liver and muscle samples from tunas and bycatch species by observers

National observer programmes
- Federated States of Micronesia
- Papua New Guinea
- Solomon Islands
- Marshall Islands
- Fiji
- Kiribati
- New Caledonia
- French Polynesia

IATTC observer programme
- Manta, Ecuador
- Mazatlán, Mexico

+ sampling of prey species, zooplankton, phytoplankton on opportunistic scientific cruises
Stomach content analysis

Analysis at SPC, New Caledonia for the western and central Pacific samples, at CICIMAR, Mexico for the eastern Pacific samples

Standardization of the methods to assure compatibility in the results

Identification of the prey to the lowest taxon possible
Measurement
Weighting
Enumeration
Stable isotope analysis

Analysis of the samples from the different areas at the Stable Isotope Biogeochemical Laboratory, University of Hawaii

Analysis with a mass spectrometer of muscle, liver, lipids for fatty acid profiles