JIMAR ANNUAL REPORT FOR FY 2012

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NOAA OFFICE *(Of the primary technical contact)*: JIMAR/PFRP

NOAA SPONSOR NAME:

PROJECT PROPOSAL TITLE: Examining Pelagic Food Webs using Multiple Chemical Tracers

FUNDING AGENCY: JIMAR/PFRP

NOAA GOAL *(Check those that apply)*:

- [x] To protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management
- [ ] To understand climate variability and change to enhance society's ability to plan and respond
- [ ] To serve society's needs for weather and water information
- [ ] To support the nation's commerce with information for safe, efficient, and environmentally sound transportation.
- [ ] Mission Support

PURPOSE OF THE PROJECT *(One paragraph)*:
Middle trophic level organisms (namely macroplankton and micronekton) are the decisive link between primary producers and top predators as well as food items of many commercially important pelagic predators. However, the trophic dynamics of many macroplankton and micronekton are poorly known. Consequently, fishery models and ecosystem-based management decisions would benefit greatly from detailed information on the trophic dynamics of these organisms in the pelagic environment. We are utilizing multiple chemical analyses (bulk stable isotopes, compound specific isotopes, lipid biomarkers, and mercury concentrations) in conjunction with supplementary stomach content analyses to characterize the pelagic food web, incorporating organisms from primary producers to top predators in waters surrounding the Hawaiian Islands. Our specific objectives are

1) evaluate variation in diet amongst
    a. commercially important top predators
    b. major taxonomic and ecological groups of middle trophic level pelagic animals
2) determine major trophic connections between epipelagic, mesopelagic, and bathypelagic habitats and communities.

Results from this project will increase our understanding of trophic connectivity between the forage base and top predators and further elucidate the structure and variability of pelagic food webs, which is necessary information for ecosystem-based managers and ecosystem modelers.

PROGRESS DURING FY 2011 *(One-two paragraphs)*:
Include a comparison of the actual accomplishments to the objectives established for the period, along with reasons for the slippage if established objectives were not met

We have met most of our target goals for this third year of the project which principally included laboratory analysis of collected samples and data analysis. In the beginning of the project year (August 2011) we performed additional zooplankton and micronekton sampling aboard the RV Kilo Moana using both the $1m^2$ and $10m^2$ MOCNESS systems. In this way we obtained depth discrete samples to over 1000 meters for biochemical analysis. In addition we filtered particles in water at discrete depths to 2000 meters. During this cruise we collected 50 water samples, 180 zooplankton samples, and 1090 micronekton samples. Nearly all of the laboratory analysis (mercury, fatty acid analysis, and AA-CSIA) of samples was completed. Popp, Drazen and Choy all visited our colleagues at CSIRO in Tasmania last winter. During this time the final samples were examined for fatty acid biomarkers, including additional predators and numerous representatives of their micronekton prey. Data analysis continued and our three main findings are outlined below.

Large mesopelagic fishes such as lancetfish, escolar, snake mackerel and opah are poorly studied yet their populations are apparently increasing in the central North Pacific (Polovina et al 2009). The diets of all but lancetfish have not been described which prevents mechanistic hypotheses about the population changes. We have described the diet of bigeye and smalleye opah, lancetfish and snake mackerel. Escolar were also studied but the high proportion of empty stomachs prevented an adequate description of diet. The opah species consume more cephalopods than the lancetfish which eat predominantly hatchetfishes, salps and hyperiid amphipods (which live inside the salps). These lancetfish results align largely with previous studies from this and other regions although the findings continue to surprise scientists because these fish have an enormous gape and large dagger-like teeth. Based on detailed examination of squid beaks the squids eaten by opah are overwhelmingly more active Onychoteuthids and Ommastrephids whereas the lancetfish consumed many more sluggish cranchiid and histioteuthid squids. The snake mackerel have a diet similar to opah including the composition of the squid but with greater proportions of fish overall. Particularly interesting was that lancetfish and opah (both bigeye and smalleye) consume a large amount of plastic. Across all fishes we examined 23% ingested plastic and for lancetfish it was 58% of individuals. These fishes do not likely occur at the surface thus the plastic (which is positively buoyant based on lab tests) was probably consumed in the water column where it had become neutrally or negatively buoyant due to biofouling. Although plastic ingestion has been noted in a few fishes they were all surface caught animals. Our results imply that plastics are also common in deeper strata of the water column.

Information on the vertical connectivity of pelagic food webs is sparse yet these connections are important for understanding the production of commercially exploited fish stocks and the biological carbon pump. We hypothesized that vertical gradients in biochemical signatures would be evident due to the microbial reworking of detritus and its entry into deeper waters. Our preliminary results suggest that there are increases in $\delta^{15}N$ values with depth evident across several trophic levels. Particles increase ~6-7‰ from the surface to about 200 m and then remain fairly constant with depth. Zooplankton $\delta^{15}N$ values of all size fractions (0.5 mm to >5 mm) increase by about the same magnitude but over a greater depth range. Micronekton increase from $\delta^{15}N$ values of 6-7 ‰ in epipelagic species to over 9‰ in mesopelagics. The reasons for these depth related increases are not entirely clear. Conventional interpretation of these isotopic data would suggest that there is an increase of two trophic levels in zooplankton with depth and about one trophic level for the micronekton. However, amino acid specific isotope analysis suggests that there is both an increase in average trophic position of zooplankton with depth and based on the $\delta^{15}N$ values of phenylalanine baseline nitrogen isotopic values are also higher. This gradient may relate to microbial processes and if they are consistent over time may provide an isotopic fingerprint for depth of forage of vertical migratory species or those for which basic life histories and vertical habitat is currently not known. Analysis of micronekton amino acid isotopes is underway and should further illuminate this topic.

In conjunction with Joel Blum (U. of Michigan) we have been exploring the use of the isotopic compositions of mercury (Hg) to understand biogeochemical cycling of Hg and the source(s) of Hg in pelagic fishes. Mercury enters at the base of food webs and is transferred and bioaccumulated to higher trophic level organisms via diet. Therefore, examining Hg in fishes can aid substantially in reconstructing marine food webs. Mercury has seven stable isotopes, and the isotopic compositions of Hg display mass-dependent fractionation (MDF) during most biotic and abiotic chemical reactions. Additionally, Hg displays unusual large mass-independent fractionation (MIF) during photochemical radical pair reactions, where isotope fractionation is greater for the odd (^{199}Hg, ^{201}Hg) than the even (^{198}Hg, ^{202}Hg) isotopes. We measured Hg stable isotope ratios in a group of Hawaiian pelagic fish for which Hg concentration and median depth of occurrence are known. We hypothesized that the amount of MIF ($\Delta^{199}Hg$) in Hg from fish tissue would decline with depth of occurrence because methylmercury (MeHg) at shallower depths would undergo more photochemical demethylation prior to introduction into the marine food web. Changes in $\Delta^{199}Hg$ values with depth clearly support this hypothesis and indicate that Hg at shallower depths undergoes a greater extent of photochemical reduction prior to introduction into the marine food web and may provide a way to measure the depth of forage where Hg was acquired. Depth trends in $\Delta^{199}Hg$ and $\delta^{202}Hg$ values are inconsistent with production of MeHg in the photic zone, deposition of MeHg from the atmosphere or lateral advection of MeHg from coastal regions, because in these cases we would not expect to see decreases with depth in $\Delta^{199}Hg$ values in fish. We suggest that MeHg must be produced at depth (below the mixed layer) and is then advected upward into the photic zone where it becomes highly degraded (~80%) by exposure to sunlight and in the process acquires a very high and distinct $\Delta^{199}Hg$ value of 5-6‰.

PLANS FOR THE NEXT FISCAL YEAR *(One paragraph)*:
In this next fiscal year, the last small amount of laboratory analysis (AA-CSIA) will be completed. Data analysis and manuscript preparation will continue. Student Anela Choy plans to defend her dissertation in Spring or Summer of 2013.

LIST OF PAPERS PUBLISHED IN REFERRED JOURNALS DURING FY 2011
OTHER PAPERS, TECHNICAL REPORTS, ETC.
PUBLICATION COUNT
*complete excel attachment (*JIMAR publications request*)

GRADUATES:
Names of students graduating with MS or PhD degrees during FY 2011; Titles of their Thesis or Dissertation

AWARDS:
Name of JIMAR employees or project receiving award during the period, and Name of award

PERSONNEL *(on Subcontracts)*:
For projects that awarded subcontracts in the fiscal year, please provide the number of supported postdocs and students from each subgrantee.

C. Anela Choy, PhD student, University of Hawaii, Department of Oceanography
Elan Portner, undergraduate student, University of Miami

ACRONYMS:
Please provide the complete descriptions for any acronyms used in any areas of the report. For example: UH (University of Hawaii)
UH – University of Hawaii
CSIRO – Commonwealth Scientific and Industrial Research Organisation
TP – Trophic position
SC – stomach content
FA – fatty acid
RV – Research Vessel
MOCNESS – Multiple Opening/Closing Net and Environmental Sensing System
AA-CSIA-AA – amino acid compound specific isotope analysis
Hg – mercury
MeHg – methylmercury
MDF – mass-dependent fractionation
MIF – mass-independent fractionation