JIMAR ANNUAL REPORT FOR FY2000

P.I. NAMES:

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PROJECT PROPOSAL TITLE:

The Role of Oceanography in Aggregation and Vulnerability of Bigeye Tuna in the Hawaii Longline Fishery from Satellite, Moored, and Shipboard Time Series

FUNDING AGENCY:

Pelagic Fisheries Research Program

1. Purpose of the Project:

Stock assessment of bigeye tuna (*Thunnus obesus*) is generally based on longline fishery catch-per-unit-effort (CPUE) as an index of abundance of the stock. Unfortunately, fishery-dependent CPUE does not necessarily reflect abundance of the stock, but rather the catchability of the stock. Catchability, in turn, is dependent to a considerable extent upon variable oceanographic conditions. Since the preferred foraging habitat of bigeye tunas appears to be the 8-15^{o} C water at or near the base of thermocline, variability of thermocline depth could significantly affect aggregation of bigeye tunas. According to work by Boggs, Brill and others, bigeye tunas remain in the upper 10-90 m at night and repetitively migrate vertically between 350-500 m and 50-150 m during the day. This behavior suggests that at times when the thermal structure is depressed, bigeye tunas may be generally deeper and less aggregated due to their extended vertical migrations. Although the stock abundance may be unchanged, catchability and CPUE are reduced. Conversely, when the thermal structure is elevated, the habitat is generally shallower and bigeye tunas may be more aggregated, resulting in increased catchability and CPUE. Likewise, horizontal and vertical velocity shears have a profound effect on catchability and CPUE by modifying the depth of penetration and performance of longline gear. Based on these considerations, the role of oceanography on the aggregation and vulnerability of bigeye tuna in the Hawaii longline fishery are being investigated: 1) to examine closely the relationships between bigeye tuna CPUE and oceanographic features observed using moored, shipboard, and satellite time series of the vertical and horizontal structure of the upper ocean, and 2) to utilize those relationships to develop methods to improve stock assessment estimates based on standardized logbook CPUE using remotely sensed observations of sea surface height, sea surface temperature, ocean color, and surface winds.

2. Progress during FY2000:

BIGEYE Mooring

During FY2000, the Bigeye Oceanography Program had a productive inaugural year with significant progress in several areas. The first major component of this program, deployment of an oceanographic mooring to provide a high resolution time series of the vertical structure of temperature and currents in an area with moderately high and temporally varying values of CPUE, was well

established. With assistance and technical expertise provided by the TAO Project Office at NOAA's Pacific Marine Environmental Laboratory (PMEL) in Seattle, the BIGEYE mooring was designed, instrumented, built and deployed on December 11, 1999 at 20º36.0'N, 161º24.2'W from the NOAA Ship *Ka'imimoana* in 4,685 m of water. The BIGEYE site was selected based on bigeye tuna CPUE, variability of CPUE, proximity to TOPEX altimetric satellite crossover paths, variability of oceanographic structure, and linkages to other Pelagic Fisheries Research Program (PFRP) projects. The BIGEYE mooring is presently recording temperature at 13 depths (25, 50, 75, 100, 125, 150, 200, 250, 300, 350, 400, 500 and 700 m), currents at 5 depths (50, 100, 150, 200 and 350 m), conductivity (salinity) at 2 depths (50 and 350 m), dissolved oxygen at a depth of 350 m, and pressure at a depth of 50 m. Position updates are telemetered from the mooring to Honolulu Laboratory using an ARGOS transmitter to allow near real-time monitoring of the mooring's status. The mooring and all of the data are scheduled to be recovered in December 2000 using the NOAA Ship *Ka'imimoana*.

Research Cruises

The second major component of the Bigeye Oceanography Program is a series of shipboard surveys to expand the spatial representativeness of the mooring observations and to closely examine the vertical structure associated with mesoscale variability; e.g., eddies and frontal meanders. Three research cruises aboard the NOAA ship *Townsend Cromwell* to survey the mesoscale dynamic variability and its influence on biology were conducted in April and November 1999 and April 2000. During these cruises, closely-spaced conductively-temperature-depth (CTD) casts were conducted to observe water properties at very high vertical resolution. In addition to temperature and salinity, dissolved oxygen, nutrients, chlorophyll, and other accessory pigments were sampled. The April 1999 research cruise was also used to conduct bathymetric surveys of the proposed mooring site and to provide baseline descriptions of the oceanographic structure around this location. During the November research cruise, the surveys were conducted across two distinct cyclonic eddies, named Loretta and Mikalele. These features were continually monitored using satellite observations of sea surface temperature, sea surface height, and ocean color by the Hawaii CoastWatch program. CoastWatch personnel transmitted near real-time information on the positions of the eddies to allow shipboard scientists to bisect the eddies. Observations revealed marked vertical differences in the physical and biological structure of the two eddies. Surface thermal gradients measured both by satellite and in situ were stronger at the more recently formed (ca. one month) Mikalele eddy, but subsurface vertical structure was considerably more developed at the older (ca. 6 months) Loretta eddy. Consequently, substantial increases in chlorophyll at the surface and particularly within the subsurface chlorophyll maximum were measured within and at the periphery of the older eddy but not at the younger. This suggests that the cyclonic eddies may induce localized upwelling and upward nutrient flux which enhances primary productivity. Ocean currents around these eddies were observed to be very strong, with velocities as high as 80-100 cms^{-1} (~2 knots). The research cruises to date also suggest that the vertical thermohaline structure at the BIGEYE mooring is representative of the region on scales of 10^2 km and that eddies typically observed from satellite information deform the thermal structure into or below the thermocline.

Satellite Remote Sensing

The final major component of the Bigeye Oceanography Program involves examining

relationships between surface features observed using satellite remote sensing and both the vertical structure of the upper ocean temperatures and currents and fishery-dependent CPUE of bigeye tunas. Efforts during FY2000 were focused on relating satellite observations of pronounced mesoscale features, such as the Loretta and Mikalele eddies, to shipboard observations of the vertical structure. Additionally, preliminary analyses of the locations and CPUEs of longline vessels in relation to these mesoscale features were begun. During the periods observed to date, it appears that longline vessels may be avoiding the regions of strong currents and velocity shear associated with the cyclonic eddies.

3. Plans for the next Fiscal Year:

During FY2001, the Bigeye Oceanography Program will continue all data collection and analysis activities as originally proposed. The year 2 BIGEYE mooring is presently being re-designed to improve vertical resolution of ocean current measurements. Following additional analysis, two acoustic Doppler current profilers (ADCPs) will be purchased to replace the five existing current meters. This will facilitate improved calculations of vertical current shear, which has been shown to significantly affect longline gear performance. The existing BIGEYE mooring will be recovered and the year 2 mooring will be deployed in early December 2000. An oceanographic technician will be hired to process and analyze the mooring data as soon as it becomes available. Two research cruises are planned for FY2001 to continue characterizing the spatial representativeness of the BIGEYE mooring and examining the mesoscale dynamic variability and its influence on biological processes. Statistical analysis of fishery-dependent CPUE will be conducted and preliminary relationships with ocean features will be identified.

4. List of Papers Published in Refereed Journals during FY2000:

None

5. Other Papers, Technical Reports, etc.

Brainard, R.E., M.P. Seki, J.J. Polovina, and D.G. Foley. 2000. The role of oceanography in aggregation and vulnerability of bigeye tuna in the Hawaii longline fishery from satellite, moored, and shipboard time series, Proceedings of the 51st Annual Tuna Conference, Lake Arrowhead, CA.

Bidigare, R. R., C. L. Leonard, D. G. Foley, M. P. Seki, J. J. Polovina. 2000. Eddy formation and new production rates in the vicinity of the Hawaiian Islands. Presented at the 2000 NASA-SeaWiFs Principle Investigators Meeting, June 2000. [abstr.]

6. Names of Students Graduating with MS or Ph.D. Degrees during FY2000; Titles of their Thesis or Dissertation:

None