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STANDARD FORM C

PRELIMINARY CRUISE REPORT

Cruise Name/Number:	F2016-092 Bluefin Tuna Ecology and Coral Reef Ecosystem Research

Authorizations:

Coastal State	Authorization Document Number	National Participant(s)
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NOTE: Research cruise # F2016-092 has a concurrent National Oceanic and Atmospheric Administration cruise identifier: NF-18-02. In the following materials, cruise # NF-18-02 is synonymous with F2016-092.

Scientists from the National Oceanic and Atmospheric Administration (NOAA) Southeast Fisheries Science Center (SEFSC), the University of Miami's Cooperative Institute for Marine and Atmospheric Studies (CIMAS) in Miami, Florida collaborated on a joint project with the Scripps Institution of Oceanography at University of California San Diego, Florida State University, University of Hawaii, Instituto Español de Oceanografía, Malaga, Spain and El Colegio de la Frontera Sur in Mexico aboard the NOAA Ship *Nancy Foster* (NF) during survey number NF-1704 (synonymous with F2016-092).

Bluefin Tuna Ecology (ABT)

Atlantic bluefin tuna (ABT) *thunnus thynnus*, is the highest-valued Atlantic tuna species on the global fisheries market today. This species is an important export for American fishermen, with the majority of the product going to Japanese markets. The United States also imports ABT for consumption from a number of nations. ABT are known to spawn in the Gulf of Mexico during summer (May and June), but the numbers of spawning individuals and the geographic extent of spawning are unknown. Management of the ABT fishery in the Atlantic Ocean, Gulf of Mexico, and the Caribbean Sea is carried out in accordance with agreements by the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the National Marine Fisheries Service (NMFS). In U.S. waters, ABT are subject to two regulations: the Magnuson-Stevens Fishery Conservation and Management Act and the Atlantic Tunas Convention Act. Given the highly migratory behavior of this species, its management is a complex, international concern. ABT are overfished throughout their range in the Atlantic Ocean, and current population levels are at a historic low. To gain a better understanding of the importance of alternative spawning sites and to improve management of the western Atlantic stock, our work focuses on areas adjacent to confirmed spawning grounds (Gulf of Mexico) and assesses the potential contribution to the overall spawning activity in the region.

Previous work

Plankton surveys targeting larval ABT have been completed by NMFS annually in the northern Gulf of Mexico since 1977 using a fixed-grid of stations. However, this current ichthyoplankton sampling strategy is limited to the U.S. Exclusive Economic Zone (EEZ). NOAA and ICCAT scientists traditionally use the larval abundance data collected from surveys in the northern Gulf of Mexico to calculate a larval index of spawning stock biomass. Variability in the current larval index is high: up to 100% of the mean and larger. It is likely that physical oceanographic factors contribute to this variance, but relationships between the distribution of ABT larvae and environmental conditions are not well known. Additionally, little is known about ABT spawning outside the U.S. EEZ. Initial analyses of larval ABT abundances from 1977 to the present indicate that while larvae are found across the Gulf of Mexico between late April and early June, it is not clear what effect, if any, mesoscale features have on these observed larval distributions. This uncertainty is partially an artifact of the design of the fixed-grid surveys, as the distance between sampled stations is large enough to preclude reliable correlations between ABT larvae and environmental gradients. Also the current index does not take into account multiple sources of larvae and the possibility of extended regional spawning. Some of our previous sampling expeditions have found relatively small numbers of ABT larvae adjacent to the Gulf of Mexico. As these areas have not been included previously in the standard larval surveys, it is critical to define possible alternative spawning sites. Results from our 2015 survey have provided evidence that larval transport via the Yucatan current, and persistent eddy translation south of Cuba may be important mechanisms for maintaining regional population connectivity. Our 2016 survey extended the larval survey into the relatively unexplored regions of the western Caribbean in Cuba to determine the extent of ABT spawning and use adaptive sampling methods to further develop a larval habitat model for this species. Additionally, these data may increase our understanding of larval transport, the role of eddies in larval retention, trophic ecology, and other mechanisms by which larvae are either exported or retained.

Current work

During this 2017 research survey aboard NF, we continued our study of the distribution and abundance of ABT and other tuna larvae in the Gulf of Mexico. However, this project's ship time also supported the RESTORE Act Science program, focusing on the impacts of nitrogen in the Gulf of Mexico. We focused on the linkages between ecosystem biogeochemistry (δ15N of nitrate and exported material; nutrient uptake rates), phytoplankton (biomass, composition, taxon-specific growth and grazing rates), zooplankton (biomass, composition and grazing rates; trophic position by stable isotopic analyses, SI), and larval tuna (abundance, size, growth rate, gut contents, and trophic position with SI). Our collaborators in this research included scientists from University of Miami, Scripps Institution of Oceanography at University of California San Diego, Florida State University, University of Hawaii, Instituto Español de Oceanografía (IEO) in Spain, El Colegio de la Frontera Sur (ECOSUR) and the Instituto Nacional de Pesca (INAPESCA) in Mexico.

The ship sampled the boundaries of mesoscale features (i.e. anticyclonic eddies) and targeted ABT larvae to assess relationships to new production nitrogen sources, food-web interactions that lead to preferred ABT prey, and variability of larval trophic position. In addition, the 2017 survey applied similar adaptive sampling methodology used in past NF expeditions in both predicted larval ABT and other tuna habitats, as well as incorporate new techniques in areas that are key to understanding larval transport and retention across the region. Satellite imagery (sea surface temperature, altimetry, and ocean color), satellite-tracked instrumentation, and ocean modeling forecasts were used to guide the sampling (adaptive sampling).

Methods and accomplishments

The shipboard survey work outlined above included the following sampling techniques for the NOAA RESTORE project. See appendix 4 for detailed sampling information.

Plankton sampling: 120 plankton tows using a 90cm-bongo net, 16 tows using a mini-bongo net. 19 ring net tows were taken from the surface to 100 m with a 1-m rig net to collect and calculate mesozooplankton biomass and grazing. In addition to satellite and in situ measurements, we targeted ABT (*Thunnus thynnus*) in the GOM using the BFT_Index" model available at http://www.aoml.noaa.gov/phod/research/ecosystems/fisheries/bft_tseries.php

Physical oceanography sampling: 90 Conductivity-Temperature-Depth (CTD) casts from 0-300 or 500m measured temperature, salinity, dissolved oxygen, chlorophyll, colored dissolved organic matter (CDOM), and water velocity were also performed. 6 casts also measured photosynthetically-active radiation (PAR). Deeper casts from 1500-2500m were conducted (see appendix 4). Continuous surface measurements of temperature, salinity, chlorophyll, CDOM, and water velocity were collected via the ship's flow-through system and hull-mounted acoustic Doppler current profiler (ADCP). 7 satellite-tracked, Lagrangian surface drifters were also deployed.

Nitrogen Fixation using Flow Cytometry Experiments: A total of 414 preserved flow cytometry samples were taken. These were for phytoplankton and bacteria rate estimates at 11 stations, plus an additional 3 stations for water column abundances. 66 live flow cytometry (FC) samples were analyzed on shipboard for abundance estimates of phytoplankton and a new methodology to estimate the abundance of microzooplankton using a flow cytometric dye that stains food vacuoles was tested with an additional 66 samples. For Elemental Nitrogen (N2)-fixing organisms, we collected 54 samples for profiles of the larger nitrogen-fixing organisms that might be present – in particular, *trichodesmium*. We collected 18 samples for stable nitrogen analyses and a sample of sargassum was collected for the same purpose. To assess nano-plankton from 0.8 to ~10 µm in diameter, we prepared 69 epifluorescence slide samples (50 mL sample each). For larger nano-plankton and micro-plankton, an additional 69 microscope slides were prepared.

Sediment Trap Array Experiments: during each cycle the deployment and recovery of the sediment trap bookended operations leading to three 2 to 4 day deployments. Three depth horizons (50 m, 120 m, 200 m) were sampled with 8 sample tubes per depth. Total thorium concentration profiles (dissolved + particulate) were sampled at the beginning and end of each cycle at 12 depths. In addition, 6 samples were taken during deep CTD casts (2500 m) to allow for Th-232:U-238 calibration. During each night of a cycle water from the CTD rosette was used to make 2.2 L incubations for the in situ drift array. 96 of these incubations used 15N-nitrate to measure nitrogen uptake rates while 192 incubations were spiked with 13C-bicarbonate for 13C primary productivity measurements. A total of 48 incubations were conducted in dark bottles to serve as controls for phytoplankton production. The water from each CTD rosette was also sampled for Particulate Organic Matter (POM) leading to 66 distinct measurements. In addition, deckboard incubations were used to measure nitrogen utilization rates within the surface mixed layer. A total of 80 samples were taken for nitrate uptake using a 15N-nitrate spike and incubated for 4 – 24 h (6 h typical) as well as an addition 80 samples for ammonium uptake using 15N-ammonium (paired incubations, triplicates). 66 triplicate incubations for nitrification using a 15N-ammonium spike were conducted. Each incubation was for 24 hours in the surface (clear) incubator.

Dilution Experiments: phytoplankton pigments (279 fluorometric Chla, 210 HPLC samples) Samples (2.2 L) were collected for phytoplankton pigments from 11 hydrographic casts, 8 profiles of grow and grazing rate experiments and 3 shipboard dilution experiments. Samples (285 mL) for fluorometric analysis were filtered, extracted 24 h in 90% acetone and analyzed for chlorophyll-a and phaeopigments on shipboard. Samples (2-2 L) for analysis by high-pressure liquid chromatography were filtered, frozen in liquid N2 and will be analyzed on shore for group-specific chlorophylls and carotenoid accessory pigments. Two-treatment dilution experiments were conducted during three experimental cycles to determine rate profiles (subsurface to 115 m depth) of phytoplankton growth and microzooplankton grazing. All bottles were incubated under ambient conditions of temperature and light for 24 h on the drift array. Community and population-level analyses will be done using samples collected for Chl a, flow cytometry and HPLC pigments.

Anticipated dates for delivery of final results:

Metadata:	January 2019
Raw Data:	Furnished upon request after 2019
Processed Data:	January 2019
Data Analysis:	January 2019
WODC Data Registration (if applicable):	N/A
Data Distribution Method:	A complete data set will be sent off to each coastal state through diplomatic channels (DVD hardcopy). An identical data set will also be made available for public ftp download by the coastal states.

The completed NF-17-04 (F2016-092) itinerary is outlined in Appendix 1 (attached).
The completed NF-17-04 (F2016-092) cruise track and station locations are illustrated in Appendix 2 (attached).
A complete listing of all NF-17-04 (F2016-092) drifter tracks and deployment locations is found in Appendix 3 (attached).
Survey participants are listed in Appendix 4 (attached)
The completed NF-17-04 (F2016-092) station locations, station occupation times, and station operations are detailed in Appendix 5 (attached).

Appendix 1

NF-17-04 (**F2016-092**) Completed Itinerary

Leg 1:

07 May 2017: NOAA Ship *Nancy Foster* departs from Key West, Florida, USA
19 May 2017: NOAA Ship *Nancy Foster* arrives at Progreso, Mexico

Leg 2:

22 May 2017: NOAA Ship *Nancy Foster* departs from Progreso, Mexico
02 June 2017:NOAA Ship *Nancy Foster* arrives at Miami, Florida, USA

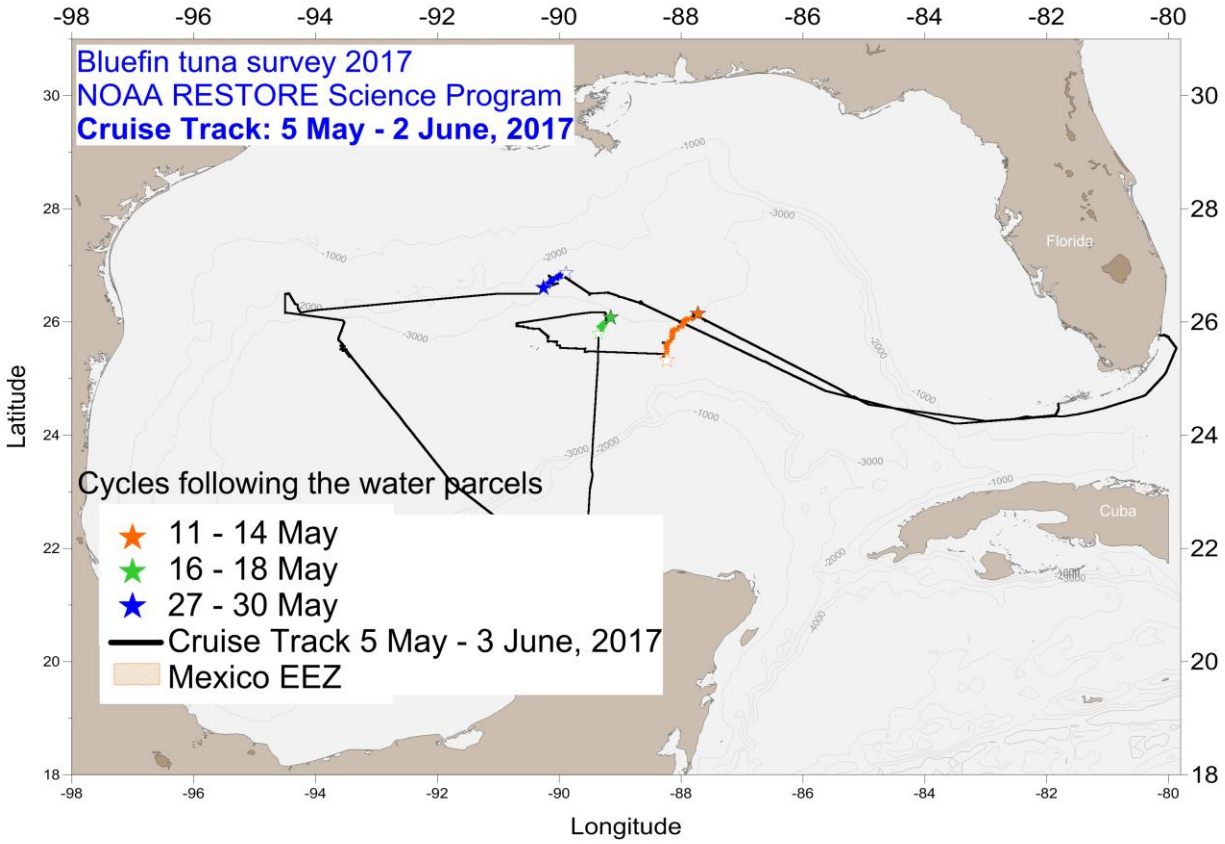
Leg 3: (TRANSIT only, no sampling)

03 June 2017:NOAA Ship *Nancy Foster* departs from Miami, Florida, USA
06 June 2016:NOAA Ship *Nancy Foster* arrives at Charleston, South Carolina, USA

NOTE: Discrete oceanographic/biological station measurements were only collected on legs 1and 2.

Appendix 2

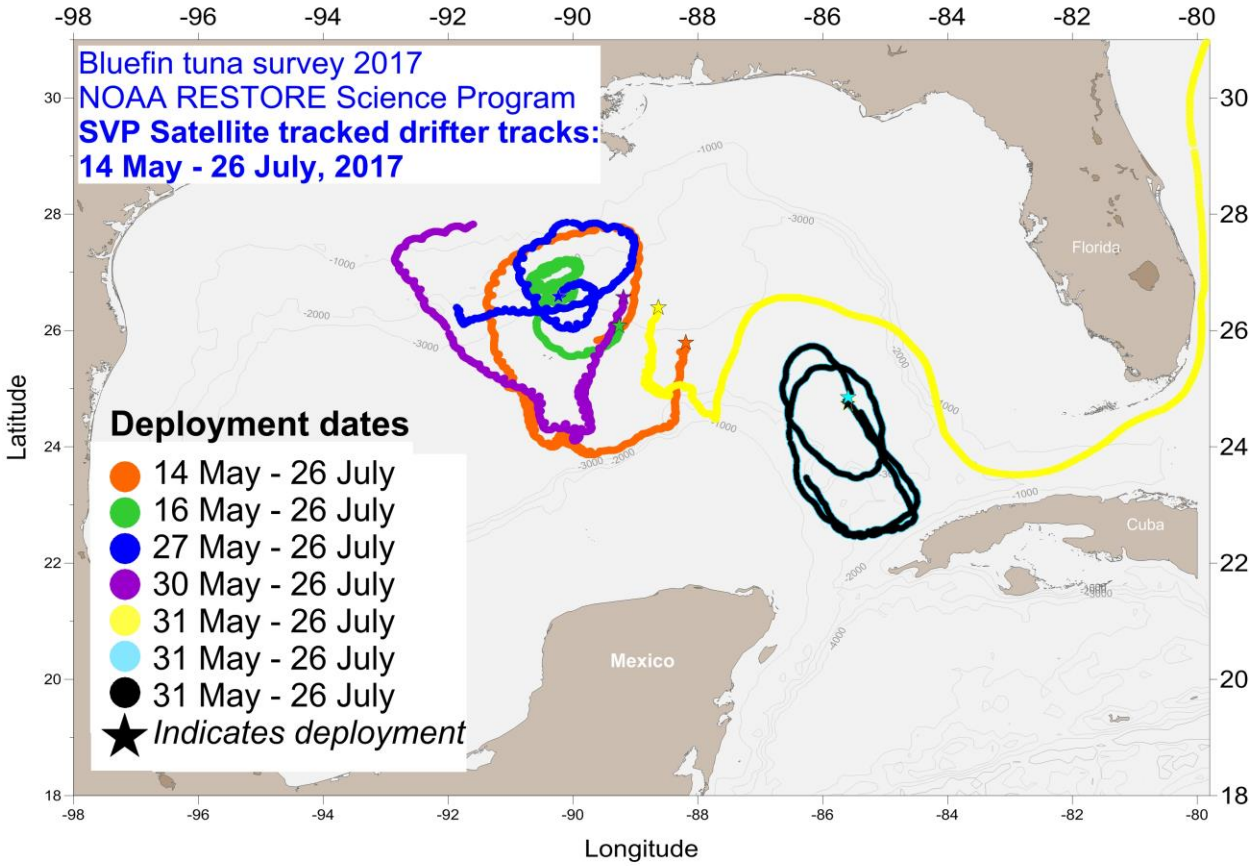
NF-17-04 (**F2016-092**) completed survey Track and station locations



The ship track is shown in black from 5 May to 3 June, 2017 aboard the NOAA Ship Nancy Foster (WTER). Completed sampling stations are plotted for the research survey NF-17-04 (F2016-092) are shown above. Station markers indicate the three experiments or cycles that were conducted. For a detailed description of station activities at each marker location see Appendix 3.

Appendix 3

NF-17-04 (**F2016-092**) survey drifter tracks and deployment positions from 14 May to 26 July 2017.



Seven track lines following the path of seven SVP satellite tracked drifters buoys deployed starting on 14 May up to 26 July, 2017 during survey NF-17-04 (F2016-092) aboard the NOAA Ship Nancy Foster (NF1704). Deployment details shown below. *NOTE: all drifters above will continue to transmit data (position and temperature until they ground or battery malfunctions or expires.*

WMO #	Date (GMT)	Deployment Coordinates	SST (°C)	Color
4201505	14-May-17	25° 30.432', 88° 14.22'	26.17	
4201508	16-May-17	25° 59.34', 89°15.42'	25.29	
4201520	27-May-17	26° 37.788', 90°11.4'	26.69	
4201519	30-May-17	26° 49.668', 89°59.388'	29.6	
4201507	31-May-17	26° 19.992', 88°39.852'	27.12	
4201517	31-May-17	24° 46.992', 85°38.172'	28.86	
4201518	31-May-17	24° 46.992', 85°38.172'	28.86	

Appendix 4

Participants aboard NOAA Ship *Nancy Foster.*

Leg 1: 07 May 2017: to 19 May 2017 (top panel listed from left to right, top to bottom). S. Harned, J. Beatty, J. Mostowy, C. Quackenbush, M. Stukel, M. Landry, L. Vasquez-Yeomans, K. Ford, T. Kelly, K. Selph, R. Thomas, A. Shiroza, S. Privoznik, E. Malca

Leg 2 participants (22 May 2017 to 02 June 2017) are in the bottom panel listed from Left to right, top to bottom. E. Malca, J. Beatty, J. Mostowy, R. Morrow, R. Thomas, N. Norton, C. Quackenbush, T. Kelly, M. Landry, A. Mnich, L. Fitzgerald, L. Carrillo, K. Selph.

NF1704 Participants