Bluefin Futures Symposium:
Posters

SPAWNING OF ATLANTIC BLUEFIN TUNA (ABFT) FARMED IN THE WESTERN MEDITTERANEAN SEA

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Poster, 18/1/16 to 20/1/16

Mediterranean tuna farms account for over 60% of the eastern Atlantic bluefin tuna (ABFT) catch quota. Besides the direct impact of purse seining in wild stocks, ABFT farming practices may have environmental implications that are still poorly known. An unexplored potential source of interactions of ABFT farms with wildlife is the release of eggs into the environment in places other than spawning grounds. Purse seine-caught ABFT schools are known to spawn in towing cages as they are transported to farms. We show here that farmed ABFT are also capable of spawning during at least two subsequent reproductive seasons following their capture. The reproductive potential of ABFT commercial stocks was investigated in a farm located in the western Mediterranean Sea from 2012 through 2014, using occurrence and number of postovulatory follicles (POF) as proxies of spawning fraction and realised batch fecundity, respectively. Even though the spawning fraction among the farmed fish was lower than that observed in the wild, the mean fecundity of captive spawners was similar to that of wild fish.; Consequently, the amount of fertile eggs released from grow-out cages is thought to be significant. Larvae hatched from eggs spawned in farms are likely to grow and join wild-born ABFT juveniles that utilise nearshore areas of the western Mediterranean as foraging grounds. Depending on the volume of fish ranched for over one year in farms and the larval survival rate in the region, the escape through spawning may have a significant impact on the ecosystem and could also affect the recruitment, thus influencing the population dynamics of ABFT in the Mediterranean Sea.

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RECENT MOVEMENTS AND ECOLOGY OF MATURE PACIFIC BLUEFIN TUNA AT THEIR PRIMARY SPAWNING GROUNDS

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Poster, 18/1/16 to 20/1/16

Pacific bluefin tuna *Thunnus orientalis* (PBFT) play important economic and ecological roles in the western Pacific Ocean, and improved management is becoming an increasing priority. While integrating new research approaches into traditional fisheries

management has been challenging, new analytical approaches can provide understanding of PBFT movements and ecology that can, if not quantitatively, qualitatively facilitate and inform management decisions. Basic information on movements of sexually mature PBFT in the western Pacific, and the forage base that sustains large PBFT in this region, remains a knowledge gap in basic PBFT life history. We used stable isotope analysis to investigate recent movements and trophic ecology of 261 giant (>180 cm), sexually mature PBFT entering their major spawning grounds off Taiwan. We performed amino acid-compound specific isotope analysis (AA-CSIA) on a subset of PBFT and select prey to assess the trophic position of PBFT in the western Pacific and to validate putative recent trans-Pacific migration from the eastern Pacific Ocean. Bayesian isotopic mixing models showed that all PBFT foraged predominantly off eastern Japan and the offshore Kuroshio-Oyashio transition region, with minimal inputs from the Sea of Japan and Taiwan waters. Contrary to previous diet generalizations, PBFT did not appear to feed primarily on zooplanktivorous forage fish (e.g., sardine, anchovy) but on higher trophic level prey including mackerels, squids, and pomfrets. AA-CSIA confirmed a high trophic position (>5) of PBFT in this region and identified recent trans-Pacific migration of two individuals. In conjunction, these data provide information on the movements and foraging of giants captured off Taiwan and set the stage for future studies comparing the movements and ecology of PBFT using different spawning grounds in the western Pacific Ocean.

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ACOUSTIC TAGS PERMIT LONG-TERM MONITORING OF ATLANTIC BLUEFIN TUNA

Barbara A. Block, Steve Wilson, Robbie Schallert, Mike Stokesbury, Mike Castleton, and Andre Boustany

Poster, 18/1/16 to 20/1/16

Atlantic bluefin tuna are a large and long lived species with a lifespan of over 30 years. In the western Atlantic a population of bluefin tuna breeds in Gulf of Mexico (GOM) spawning area with high fidelity to this region. Pop-up satellite archival tags indicate site directed fidelity from Canadian foraging grounds to these spawning grounds which is hypothesized to maintain the genetic structure observed in the GOM populations. The homing exhibited by bluefin tuna carrying satellite archival tags provides the opportunity to test whether acoustic tags and detections would prove effective means for monitoring these mature year classes of Atlantic bluefin on a yearly basis. We tested the hypothesis that acoustic tags would enable long term monitoring by attaching 100 Vemco acoustic tags with a three year battery life, to bluefin tuna (Vemco V16-4h, 6L). Bluefin tuna demonstrated high redetection rates one year post release with 80% crossing receiver lines in year one post tagging, and 56% after year two. Acoustic detections per individual fish range from 3 detections to 4759. Residency times on the foraging ground can be estimated with mean arrival and departure dates across the Cabot Straight. The mean time of entry to the Gulf of St. Lawrence in summer quarter is July 8th and the mean exit date in the fall is October 15. Bluefin tuna have been

detected for over 1500 days post deployment and have been recaptured up to 4 years post deployment in the GSL with secure attachments still intact for the tags. Acoustic tags have the potential to provide a fisheries independent survivorship estimate and the results indicate that this technology could provide a tool for monitoring the proportion of the western fishery utilizing these foraging areas.

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TOWARDS A FISHERY-INDEPENDENT ABUNDANCE INDEX FOR EAST ATLANTIC JUVENILE BLUEFIN TUNAS: OUTPUTS OF A DIRECTED ACOUSTIC SURVEY IN THE BAY OF BISCAY

Nicolas Goñi, Iñigo Onandia, Jon Uranga, Udane Martinez, Guillermo Boyra, Haritz Arrizabalaga, Igor Arregui, and Josu Santiago

Poster, 18/1/16 to 20/1/16

Uncertainties regarding the Atlantic bluefin tuna stock status and the problems associated to fishery-dependent abundance indices raised the need to develop fishery-independent abundance indices for this species. In the eastern temperate North Atlantic, the Bay of Biscay is a well-known summer feeding area for juvenile bluefin tuna. An acoustic survey was performed in the Bay of Biscay during July 2015 on-board a baitboat fishing vessel, using a long-range 90kHz sonar and a SIMRAD EK60 38kHz scientific echosounder. The survey followed systematic transects throughout the fishing ground defined according to bluefin tuna catch locations by baitboats in the summers 2000 to 2011. Along these transects, all bluefin tuna detections by sonar and echosounder were recorded. In each aggregation, no-kill fishing events were conducted in order to verify the species as well as to sample the sizes of the bluefin individuals. The spatial distribution of detected bluefin schools is shown, and for some schools, the estimated number and size of individuals is provided. Work is ongoing in order to set the methodology to produce an acoustic, fishery independent abundance index in the Bay of Biscay as an alternative to the one, based on catch rates, that is being used in the stock assessment of the East Atlantic and Mediterranean bluefin tuna.

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SHORT-TERM PAIN AND LONG-TERM GAIN: USING PHASED-IN MINIMUM WEIGHTS TO REBUILD THE PACIFIC BLUEFIN TUNA (*THUNNUS ORIENTALIS*) STOCK

Lisa E. Ailloud, Todd Gedamke, John M. Hoenig

Poster, 18/1/16 to 20/1/16

The Pacific bluefin tuna stock is highly depleted. A long history of high exploitation rates on very young fish has driven the spawning stock biomass down to just 4% of virgin conditions. We explored the potential benefits of setting a minimum weight regulation

as a possible mechanism for rebuilding the stock. Through simulations, we estimated the short- and long-term effects on yield and biomass of different minimum weight restrictions and tolerance levels for sub-legal size fish in the catch. Data from the 2014 assessment were used to populate the simulations. A variety of scenarios was considered for growth compensation and the stock-recruitment relationship, and the present value of the fishery over a 20-year period was calculated by discounting future earnings according to a range of interest rates. Setting a minimum weight of 18 kg maximized the long-term value of the fishery but resulted in a 70% loss in yield in the first year. To reduce short-term pain to the fishery, we explored the benefits of a phased-in management strategy whereby the minimum size gradually increases as biomass rebuilds. By implementing the minimum weight in two phases (12 kg in year 1, 18 kg in subsequent years) the long-term value of the fishery was maintained and the short-term pain was reduced to a 63% loss in yield in any one year. By implementing the minimum weight in three phases (5 kg in year 1, 11kg in year 2, 18 kg in subsequent years) the short-term pain was further reduced to a maximum loss of 45% in any one year.

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TRANSDOTT- TRANSLATION OF DOMESTICATION OF *THYNNUS THUNNUS* INTO AN INNOVATIVE COMMERCIAL APPLICATION- ADVANCES

Christopher Bridges, Hillel Gordin, Robert Vassallo Agius, Matthew Spagnol, Angus Sharman, Bill Koven, Grethe Rosenlund, Karl Sveinsoll, Stephan Schulz, Florian Borutta, Jan Giebichenstein, Dimitra Nousdili, Dubi Helman, Roni Mor, Patricio Urrutia, Bent Urup, and Michele Deflorio

Poster, 18/1/16 to 20/1/16

The TRANSDOTT project proposal was aimed to further advance the technologies developed in SELFDOTT and implement them within the industry. The major objective of this project was to translate/ transfer the state of the art technologies to the industry which has the experience in up-scaling and implementing it into a working protocol.

Starting in April 2012, based on an already established broodstock in Malta thirty BFT were assigned to a broodstock cage fitted with a PVC egg collector. In 2013, more fish were added to the broodstock on a yearly basis and the spawning biomass was 2,380kg in 2013 and 4,800kg in 2014. The broodstock were fed an improved diet throughout the project, from the beginning of April to enhance spawning quality. The sea temperatures were also monitored using data loggers at different depths of the broodstock cage. All fish introduced into the broodstock cage were tagged and biopsied after the spawning period or in a separate cage before transfer. The egg collection method was reassessed following the failures of 2012 through MRRA/MAR's collaboration with Korean researchers and the use of a 'trawl-net' type of egg collector that was installed outside the cage so as to collect the eggs by use of the currents. The fish spawned naturally in both 2013 and 2014 however a drop in SST in 2013 stopped spawning that was once again started by GnRHa induction. In 2013 egg collection started on the 16th June and over 10 million viable BFT eggs were collected. In 2014, spawning started on the 8th June and over 40 million viable BFT eggs were collected,

with a maximum of 6.2 million eggs collected in one day. This was positive proof of the work done on the current studies in previous years and the set-up of the egg collector.

Eggs obtained in all years were distributed to partners and interested institutes or companies that were willing to collaborate with TRANSDOTT by sharing results. A total of 8.6 million eggs were sent to the partners in 2013 (16 shipments) and 26 million eggs in 2014 (28 shipments). BFT eggs were also sent to companies outside the consortium for research purposes in Germany and Spain. This proved that Malta is the ideal location for the production and distribution of BFT eggs throughout the Mediterranean and beyond, due to very favorable logistics and short travelling distances on land.

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OCEAN ACIDIFICATION EFFECTS ON TOP OCEAN PREDATORS- A COMPARATIVE STUDY USING AS A MODEL THE FAST GROWING LARVAE OF THE ATLANTIC BLUEFIN TUNA

Jan Giebichenstein, Christopher Bridges, Robert Vassallo Agius, Matthew Spagnol, Angus Sharman, and Hillel Gordin

Poster, 18/1/16 to 20/1/16

Within the remit of the EU FP7 TRANSDOTT project and the German BIOACID project it has been possible to combine techniques established to investigate the influence of Ocean Acidification (OA) on eggs and larval stages of marine fish with broodstock management of a top Oceanic Predator, the bluefin tuna, *Thunnus thynnus*. Over the past few years it has become viable to hold broodstocks of the bluefin tuna (BFT) in captivity and induce them to spawn thus providing fertilised eggs in large number for aquaculture. Since it is not possible to hold fully adult BFT in incubation conditions as yet the possible effect on early life stages was investigated using both control and simulated "Oceans of the Future" levels of CO_2 of 390 µatm and 1200 µatm. Freshly fertilised BFT eggs were collected via an egg collector attached to a spawning cage situated in the registered concession area of Malta Fish Farming, and transported to the hatchery facilities of Malta Aquaculture Research Centre, Fort San Lucjan, Marsaxlokk, Malta. The eggs were hatched at stocking densities between 15,000 – 20,000 eggs per 80L flow-through tanks which were fed from either an incubation header tank (IKS Isostar pH-Stat) set to pH 7.5(Treatment) or directly from the main seawater supply pH 8.1 (Control). Temperature and pH were monitored in both test and control tanks with an IKS system. The results, and the consequence, for bluefin tuna in a changing world are discussed.

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COMBINED EFFECT OF DIETARY DHA AND TAURINE ON PREY CAPTURE SUCCESS, GROWTH AND SURVIVAL IN ATLANTIC BLUEFIN TUNA (*THUNNUS THYNNUS*)

W. Koven, O. Nixon, G. Allon, A. Gaon, S. El Sadin, A. Tandler, R. Vassallo Agius, H. Gordin

Poster, 18/1/16 to 20/1/16

A major factor influencing high mortality during larval rearing may be poor eye development which reduces the efficiency of prey capture leading to poor growth and survival. Two nutrients that are known to play critical roles in vision in vertebrates are the essential fatty acid; docosahexaenoic acid (DHA; 22:6n-3) and the beta amino-sulfonic acid; taurine. The retinal membranes of the larval BFT eye are particularly rich in DHA, which has been associated with photoreceptor differentiation, synthesis and membrane function while high levels of taurine protects photoreceptors throughout development.

A significant ($P<0.05$) DHA dose-dependent effect on BFT larval ingestion of hatchery grown, enriched rotifers (*Brachionus rotundiformis*) and retinal opsin synthesis was shown. In addition, a clear correlation was demonstrated between rotifer taurine levels (1.1, 4.4, 6.4 mg l-1) and the levels of this nutrient in 2-15 dph larvae (4.0, 10.4, 15.9 mg g-1 DW) feeding on them, particularly in the outer and inner segments of retinal photoreceptors. Moderate dietary taurine (4.4 mg/g DW rotifer) significantly ($P<0.05$) increased survival and tank biomass while low and high dietary taurine (1.1 and 6.4 mg/g DW, respectively) performed markedly ($P<0.05$) less well. Moreover, taurine also decreased calcium phosphate urinary calculi, a major source of mortality in this species. Overall these studies suggest that BFT first-feeding larvae require high dietary DHA to improve vision and prey ingestion rate while moderate dietary taurine is necessary for enhanced survival and growth from 2-14 dph. These findings have been incorporated into the current IOLR larval rearing protocol which produced approximately one thousand 46 dph BFT juveniles.

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UNLOCKING THE EVOLUTIONARY HISTORY OF THE MIGHTY BLUEFIN TUNA USING NOVEL PALEOGENETIC TECHNIQUES AND ANCIENT TUNA REMAINS

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Poster, 18/1/16 to 20/1/16

Using novel molecular techniques, DNA was extracted from Atlantic bluefin tuna vertebrae excavated from late Iron Age and ancient Roman settlements in coastal Iberia (Portugal and Spain, 4th-2nd century BC) and Byzantine-era Constantinople (4th-15th century AD), as well as vertebrae from the Massimo Sella archive located at the University of Bologna (Ionian, Tyrrhenian and Adriatic Seas, early 20th century). Comparisons have been made between the amount of DNA contained in each sample (measured via quantitative polymerase chain reactions), their age and the

environmental conditions which the bones have been exposed to. A high performance genotyping panel containing SNPs derived from two separate projects funded by the GBYP scientific program has been designed for the purpose of genotyping all historical samples along with modern samples, collected from the same geographic areas, to ascertain whether the population structure and spatial dynamics of the species in the Mediterranean Sea has changed over time. Included in the panel are 76 SNPs with high similarity to a wide variety of genes associated with the musculoskeletal system, development, metabolism, cellular function, osmoregulation and immune response. An additional 20 SNPs that provide significant discrimination between modern populations have been included in the panel. Significant differences in geographic and temporal SNP allele frequencies are revealed at several functional genes. By comparing the contemporary and historical genetic codes we are making efforts to shed light on the evolution of the species genome in response to nearly two millennia of fisheries pressure, a changing climate and pollution of the sea.

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