# PFRP

Pelagic Fisheries Research Program

university of hawai'i at mānoa

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# Process or Progress? Time to Fish or Cut Bait for Western Pacific Commission

*John Sibert*

The second session of the Scientific Committee (SC) of the Commission for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPFC) convened August 7-18, 2006 in Manila, Philippines. The SC's primary activity is scientific assessment of stock status. At the Manila meeting, reports on the status of bigeye, yellowfin, and albacore tuna stocks in the WCPFC convention area, as well as preliminary reports on striped marlin and swordfish in the southwest Pacific, were presented to scientific experts from the Pacific island member countries and Australia, China, Chinese Taipei (Taiwan), Japan, Korea, and the United States.

The primary conclusion of the bigeye and yellowfin assessments is that overfishing is occurring on both stocks, but that both stocks are currently at levels capable of producing maximum sustainable yield (MSY). (See page 3.) Both stocks are declining, and if current levels of fishing mortality are maintained, both will fall to levels below those capable of producing MSY within five to 10 years.

Overfishing of yellowfin and bigeye in the Western Central Pacific Ocean (WCPO) is old news. The Standing Committee on Tuna and Billfish (SCTB), predecessor to the WCPFC-SC, reached this conclusion in 2001.

At that time, the assessment procedure was new, and the data covered only the period from 1962 to 1999. Based on this preliminary assessment, the SCTB concluded that the increasing catch of juvenile bigeye and yellowfin in the surface fishery around drifting objects might be contributing to overfishing of yellowfin and bigeye stocks and recommended "that there be no increase in fishing mortality in surface fisheries on these species in the WCPO until uncertainty in the current assessments has been resolved."

The intervening years have seen refinements in the stock assessment methodology, extension of the time series back to 1952, increases in data coverage, and a continuous increase in fishing effort. The conclusions have remained unchanged. There is overfishing of bigeye and yellowfin stocks in the WCPO and increased mortality on juveniles in the surface fishery associated with drifting objects is a primary cause.

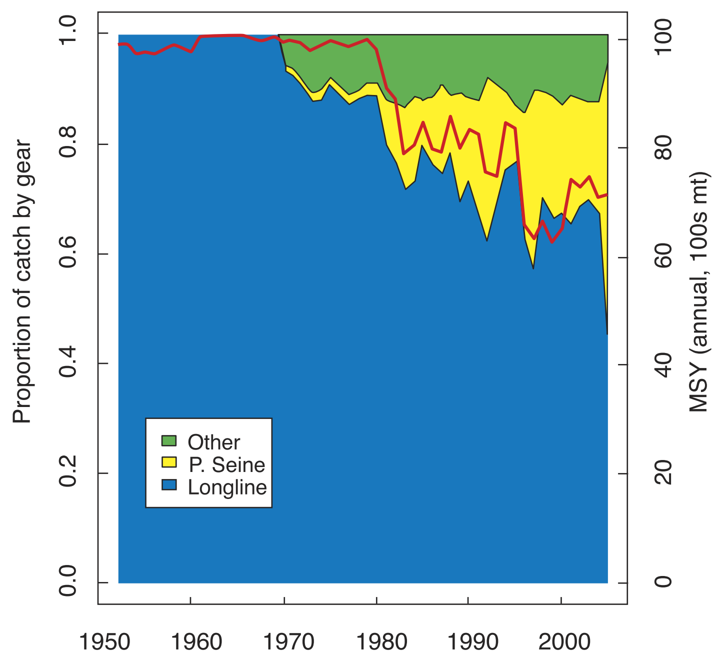


**Figure 1. Proportion of the annual bigeye catch by main gear type for the entire WCPO in comparison to the trend in annual equilibrium yield from the bigeye stock (MSY, red line) for 1950 through 2005.**

No legal mechanisms were in place to regulate fisheries for highly migratory fish stocks prior to the establishment of the WCPFC in 2004. Nevertheless, resolutions calling for "reasonable restraint in respect of any regional expansion of fishing effort and capacity" were supported during the lengthy negotiations that created the Commission and by international initiatives of the Food and Agriculture Organization of the UN and by the

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1999 International Plan of Action for the Management of Fishing Capacity.

These resolutions were widely violated and the total tuna catch for 2005 in the WCPFC convention area exceeded over 2,100,000 mt, the largest on record, and an increase of around 5% over the previous record in 2004. The record catch was dominated by high catches of skipjack tuna, not considered overfished, which increase fishing mortality on juvenile bigeye and yellowfin as all three species are captured in mixed aggregations on floating objects. As a consequence, the 2005 bigeye catch was also the largest on record, but the 2005 yellowfin catch was well below the 1998 record-high catch.

The impact of the fishery on the stock varies among regions and fleets and between species. The impacts in the equatorial regions are highest where spawning stocks of both yellowfin and bigeye have been reduced to about 30% of levels predicted in the absence of fishing. In contrast, spawning stocks in subtropical regions are approximately 70% of the levels predicted in the absence of fishing.

The domestic fisheries of Indonesia and the Philippines have had the greatest impact on yellowfin stock in the western equatorial region. Farther to the east, the purse seine fishery has a greater impact on the yellowfin stock. The situation of bigeye is somewhat different.

In the western equatorial region, both purse seine fishery associated with drifting objects and the domestic fisheries of Indonesia and the Philippines have had large impacts on the stock. Farther to the east, the longline fishery has had the greatest impact. High juvenile mortality from the purse seine fishery associated with drifting objects, coupled with high adult mortality from the longline fishery, have spread fishing mortality to the entire bigeye size spectrum. The movement rate of fish from the Indonesia and Philippines regions toward the East is estimated to be high, causing concern that high juvenile mortality in the West may be inhibiting recruitment of fish to populations farther East.

Equilibrium yield from a fishery depends on the total fishing mortality and where in the life history of the fish the mortality is applied  The impact of extending mortality from adults to juveniles has changed the impact of fishing on bigeye stocks and reduced the potential yield from the fishery.

Prior to 1970, the bigeye were exploited almost exclusively by longline in the WCPO, with a low mortality of small bigeye. The estimated MSY was substantially higher during this period (100,000 mt per annum) compared to that estimated for the fishery based on recent fishing mortality patterns that include high juvenile mortality (about 70,000 mt). The decline in the MSY over time follows the increased development of those fisheries that catch smaller bigeye, principally the surface fisheries (Figure 1).

The Scientific Committee considered various management options to address bigeye and yellowfin overfishing. For bigeye, the SC recommended a 25% reduction in fishing mortality from 2001-2004 levels to maintain the stock at levels capable of producing MSY at current levels of recruitment. The recruitment is currently above average, and a larger reduction in fishing mortality will be required if recruitment returns to its long-term average. For yellowfin, the SC recommended a 10% reduction in fishing mortality. For both species, substantially greater reduction in mortality would be required if the Commission were to take a more precautionary approach and require that stocks be maintained at levels 20% greater than the biomass capable of producing MSY.

The WCPFC has a clear mandate and responsibility to regulate fisheries for highly migratory fish stocks. The inaugural session of the Commission in December 2004 tasked the Scientific Committee to provide estimates of sustainable catch and effort levels for yellowfin and bigeye. One year later, the second session of the Commission essentially ignored the estimates provided by the SC and adopted measures that "restricted" effort to levels attained during the record high catch years of 2001-2004, an action unlikely to reduce fishing mortality.

The WCPFC is a relatively new organization with a difficult mandate, diverse membership, and complex legal structure. It is not surprising, therefore, that the first business of the Commission is to get itself organized. Indeed, during the long history of the negotiations leading to the creation of the Commission, progress was measured by the successful creation of procedures. The Commission is now functional and challenged by a well-documented fishery management problem. Its future credibility rests on early and decisive action to ensure a sustainable fishery.

In "Song for the Blue Ocean," Carl Safina mused that " … like many agencies entrusted with stewarding natural resources, the Atlantic tuna commission [International Commission for the Conservation of Atlantic Tunas] has always confused process with progress and progress with success. Procedure is still the commission's chief product." The WCPFC has the opportunity and responsibility to make real progress in stewardship at its third regular session in Apia, December 11-15, 2006.

All papers presented to the meeting are available online at http://wcpfc.org/sc2/Index.htm.


- *Report of the Fourteenth Meeting of the Standing Committee on Tuna and Billfish*, 9–16 August 2001, Noumea, New Caledonia. Secretariat of the Pacific Community, January 2002. http://www.spc.int/oceanfish/Html/SCTB/SCTB14/sctb14.rep.pdf.
- Safina, C. 1998. *Song for the Blue Ocean*, Henry Holt. NY. 458 pp.
- Williams, P., and C. Reid. 2006. "Overview of tuna fisheries in the western and central Pacific Ocean, including economic conditions—2005", WCPFC-SC2-2006/GN WP-1.


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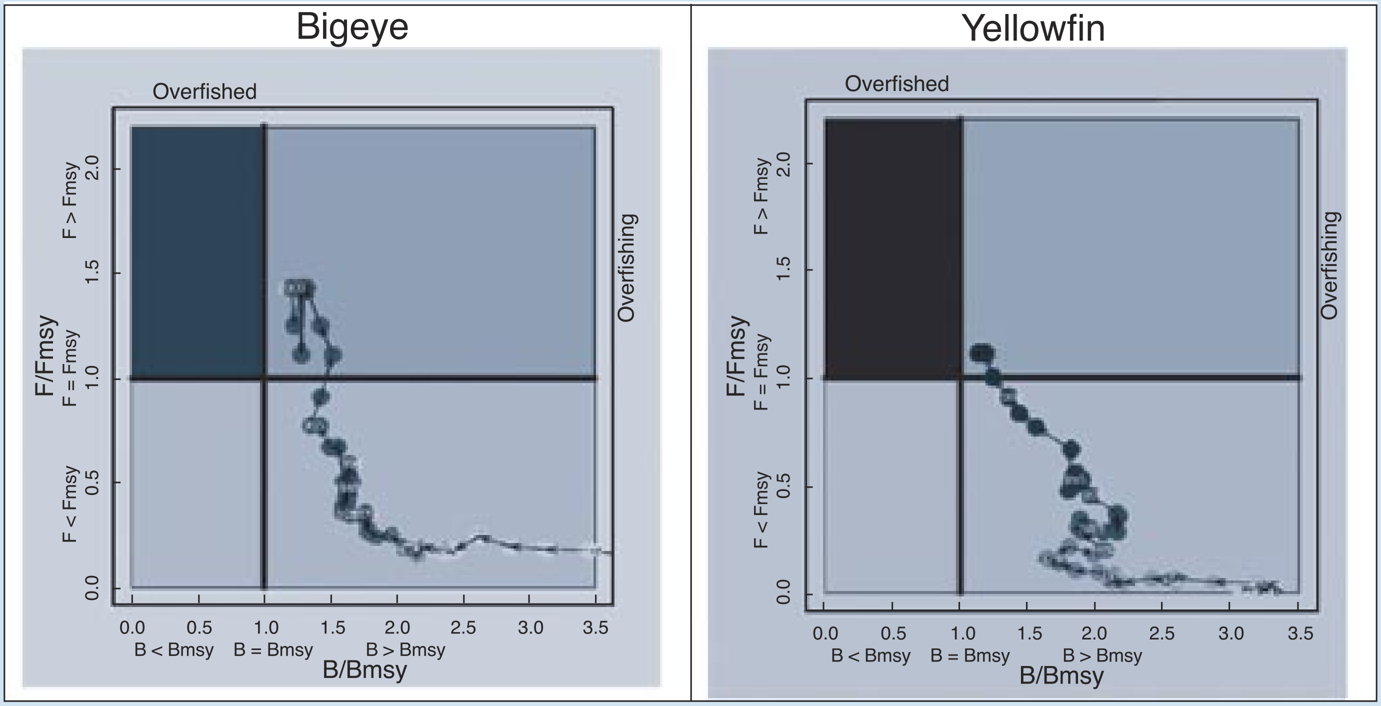


## Maximum Sustainable Yield

Modern fishery management depends on pre-determined "reference points" to determine when restrictions need to be imposed on fishing. Maximum sustainable yield, or MSY, is commonly used as a basis for creating reference points. MSY is the maximum catch or yield that can be taken from a population at equilibrium – that is if reproductive success and catches are held constant. In the case of large scale tuna fisheries, holding catches constant also means holding the composition of the fishing fleet constant because different components of the fishing fleet exploit fish of different ages. In general, the biomass of the stock at MSY will be about 30-40% of the biomass of the stock in the absence of fishing.

The ratio of current fishing mortality to the fishing mortality at MSY (F/Fmsy) and the ratio of the current biomass to the biomass at MSY (B/Bmsy) are two commonly used reference points. If the ratio of F/Fmsy exceeds one, overfishing is occurring. Similarly if B/Bmsy exceeds one the stock is in an over-fished state. Plotting these two reference points against one another provides a useful index of the state of the fishery.

The plots above show the trends in annual bigeye (left) and yellowfin (right) stock status, relative to Bmsy (x-axis) and Fmsy (y-axis) reference points, for the period 1952–2005. The color of the points is graduated from light (1952) to dark (2005) to indicate time and the points are labeled at five-year intervals. (From Hampton, J., A. Langley, and P. Kleiber. 2006. "Stock assessment of bigeye tuna in the western and central Pacific Ocean, including an analysis of management options," WCPFC-SC2-2006/SA WP-2 and "Stock assessment of yellowfin tuna in the western and central Pacific Ocean, including an analysis of management options," WCPFC-SC2-2006/SA WP-1.)

# Spatio-Temporal Distribution of Albacore Catches in the North-Eastern Atlantic and Its Relationship with SST

*Yolanda Sagarminaga and Haritz Arrizabalaga*

Albacore tuna (*Thunnus alalunga*, Bonn 1788) is a highly migratory species widely distributed in three oceans. There are three distinct populations in the Atlantic: the northern Atlantic, the southern Atlantic, and the Mediterranean.

During winter months, North Atlantic albacore (both adults and juveniles) are located in the central Atlantic waters. When the spring seasonal warming starts, adults perform a reproductive migration to the northwestern Atlantic (in front of Venezuela coast and in the Sargasso Sea). Meanwhile, juveniles and pre-adults (1- to 4-years-old) perform a trophic migration to the north-eastern Atlantic into the Bay of Biscay and the southeast of Ireland.

During their trophic migration to northeast Atlantic waters, juvenile albacore are exploited by surface gears from June through October (mainly by Spanish trolling and baitboat fleets, representing more than 50% of the total catch in the last decade). Adults are caught in deeper waters of the tropical Atlantic mainly by Chinese Taipei and Japanese longline fisheries representing nearly 20% of the catch in the last decade.

Tuna pelagic habitat has been delimited according to physiological tolerance studies to critical ambient variables such as temperature and dissolved oxygen. In the case of albacore, several studies provide optimum sea surface temperature ranges for albacore in different areas of the world (Figure 1).

The development of the swimming bladder, as well as higher thermoregulation capacity, allows adult albacore to occupy deeper waters than juveniles that are bound to stay at surface layers (0-50 m) preferably close to the thermocline level.

In the area and period where these NE Atlantic juveniles' migration occurs, sea surface temperature increases from June to the end of August, when maxima are achieved, and decreases later on. This SST evolution clearly reflects the seasonal latitudinal displacement of the Intertropical Convergence Zone (ICTZ) affecting the study area. However, in the inner Bay of Biscay, SST increases and decreases earlier than in corresponding latitude offshore waters (Figure 2).

## Data

Fishery data used are the daily albacore catch location data (latitude, longitude, and date) registered in logbooks supplied to skippers of the basque trolling fleet during the 1987-2003 period (hereafter named "catch locations"). In total they add up to 18,000 records.

The environmental data used concern the sea surface temperature (SST) estimations from the NOAA/NASA AVHRR Oceans PATHFINDER Sea Surface Temperature Data Set (PO.DAAC Product #216 -). Images used from 1987 to 2000 are "All-pixel" SST, ascending passes of 8-day averages with 4 km of spatial resolution.

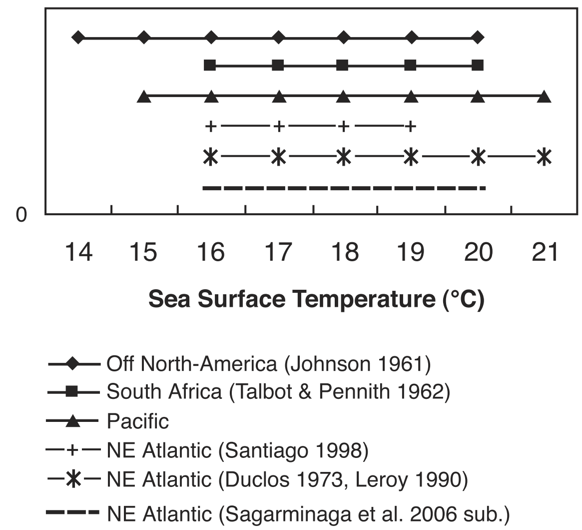


**Figure 1. Reported optimum sea surface temperature ranges for albacore in different areas of the world.**

## Data Analysis

The broad scale spatio-temporal distribution of albacore catches was studied through a series of descriptive statistical maps made up by aggregation of catch locations into the ICES statistical rectangles. This was made using GIS tools (ESRI ARCVIEW software and AVENUE scripts).

Preliminary results suggesting a possible differentiation of catches in and out of the Bay of Biscay—supported by differences in the oceanographic characteristics and in the spatial distribution of catch locations, as well as some authors' hypothesis about two different migration pathways (i.e., Bard 1981)—led us to perform a point clustering analysis using the k-means method for each week.

This method seeks K centroids (two in our case) that minimize the sum of the distance from every point to each of the K centers and assigns each data to the nearest K cluster. Then, two sample comparison statistic tests were performed to test whether the weekly cluster pair positions are significantly different.

The relationship between albacore catches and SST was performed by extracting the SST values corresponding to the pixels coincident in time and space (hereafter "SST-at-catch") for each catch location. This was done using routines written in Interactive Data Language (IDL) code.

The frequency distribution of SST values on catch locations was used to assess the preferential SST range for young albacore. Three distributions were extracted—one including the whole pool of catch location data, and two more corresponding to the two different clusters found in the previous analysis.

To test if these SST-at-catch distributions reflect the actual SST distribution of the area or are significantly differentiated from it, Kolmogorov-Smirnov analyses were performed comparing the weekly SST-at-catch distributions with the SST distribution in the broad area where historically catch locations were produced during that week.

Besides this, Kolmogorov-Smirnov tests and the Mann-Whitney median comparison test were produced for comparing the SST-at-catch distributions of each weekly cluster pair to determine if the two groups found are also differentiated by their relationship with SST.

### Results

Most albacore catches by basque trollers occur between 40°N-53°N and 25°W-0°W. Moreover, this spatial distribution of catches shows a pattern that is observed repeatedly from year to year through the period analyzed. The inner Bay of Biscay is the area where the highest number of catch locations is registered.

The fishing period starts in early June and ends in mid-November. Most of the catches are quite evenly distributed from the second week of June until the first week of September where a gap is recorded due to the interruption of fishing activity during local festivities. From then on, the number of catches begins to decrease until the end of October, with only occasional catches in November.

Two statistically significant weekly clusters were found. Results from the statistical tests show (Figure 3) a common start of catch occurrences in the Northeast of Azores which moves north-east-

**(continued on page 6)**


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## UPCOMING EVENTS

### Pelagic Fisheries Research Program (PFRP) Joint Workshop with GLOBEC-CLIOTOP Working Group 3

November 14-17, 2006, Imin Conference Center, University of Hawai‘i, Honolulu
Contact: John Sibert at sibert@hawaii.edu or
Dodie Lau at lau@hawaii.edu
Online information: http://www.soest.hawaii.edu/PFRP
(see page 8 of this newsletter for more information)

### The North Pacific Marine Science Organization (PICES) Workshop

*Oxygen Minimum Systems in the Ocean: Distribution, Diversity and Dynamics*
October 24-26, 2006, Concepción, Chile
Coincides with the 2006 SCOR (Scientific Committee on Oceanic Research) General Meeting
Contact: secretariat@PICES.int
Online information: http://www.pices.int

### The North Pacific Marine Science Organization (PICES) International Conference

*The Humboldt Current System: Climate, Ocean Dynamics, Ecosystem Processes and Fisheries* (co-sponsored with IMARPE, IRD, NASA, FAO, GLOBEC, ICES and IMBER)
November 27-December 1, 2006, Lima, Peru
Contact: secretariat@PICES.int
Online information: http://www.pices.int

### Third Regular Session of the Western and Central Pacific Fisheries Commission (WCPFC)

December 11-15, 2006, Apia, Samoa
Online information: http://www.wcpfc.org/

### International Pacific Marine Educators Conference

January 15-19, 2007, University of the South Pacific, Suva, Fiji
Contact: Sylvia Spalding at sylvia.spalding@noaa.gov
Online information: http://www.wpcouncil.org

### The North Pacific Marine Science Organization (PICES) International Symposium

Fifth International Conference on *Marine Bioinvasions* (co-sponsored by ICES, PICES, the U.S. National Sea Grant College Program and NOAA)
May 21-24, 2007, Massachusetts Institute of Technology, Cambridge, Massachusetts

Spatio-Temporal (continued from page 5)

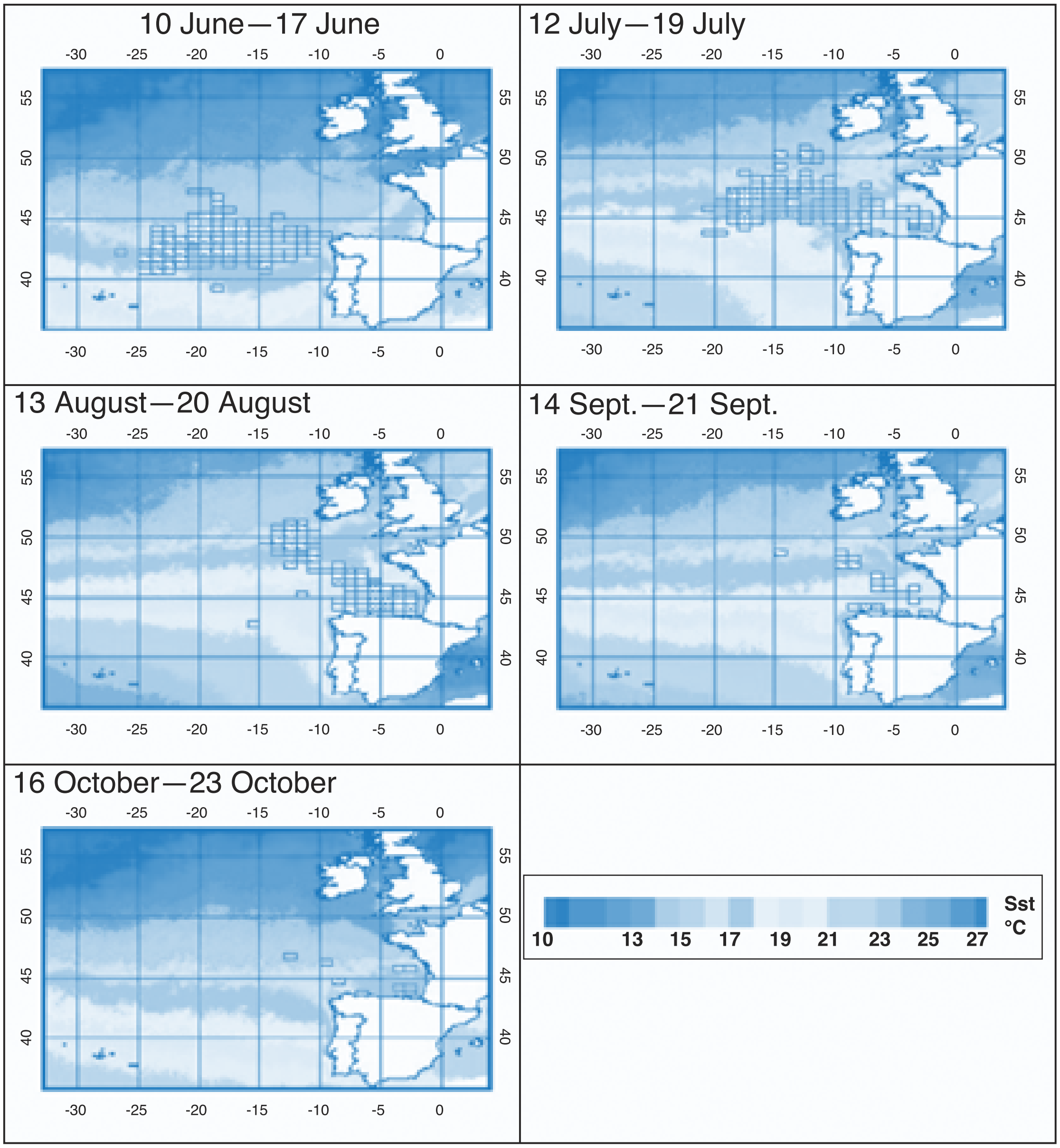



**Figure 2. Evolution of SST in the area and period where NE Atlantic albacore juvenile migration takes place. Overlaid squares represent ICES statistical rectangles with registered catches during the week represented.**

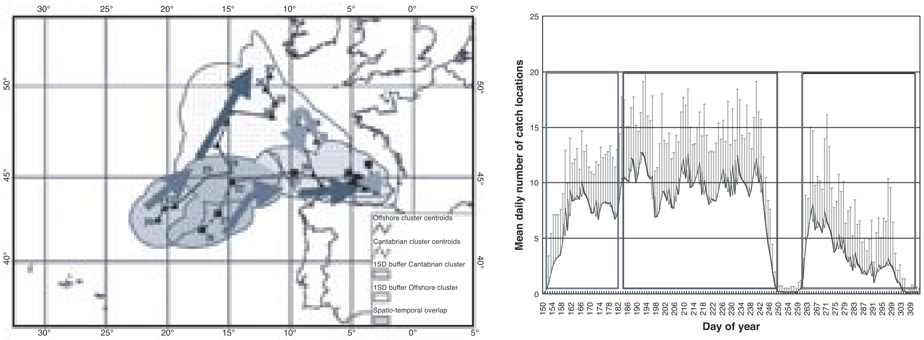
ward until week 22 (late June) when two groups of catches are differentiated. The first one follows a north-eastern direction towards the south-western coast of Ireland and the second one enters the Bay of Biscay, and remains there for several weeks.

At week 32 most vessels stop their activity. From week 33 onwards all centroids are closer within the Bay of Biscay, no clear differentiation between clusters at SST level can be made, and connection line directions are more erratic.

In addition, there is a decrease in the number of catch locations produced by the decrease in the number of vessels at sea (50%); at this stage, it is likely that fleet behavior disassociates from albacore behavior and reasons like distance to harbour, worsening weather, or others, take the lead for explaining distribution of catch locations during this last fishing period.

When the whole dataset is considered, the SST-at-catch are distributed between values of 13°C and 24°C, but a high proportion of them (47%) occur in the range between 16°C and 18°C (Figure 4). The whole distribution has a mean of 17.8°C and a standard deviation (SD) of 2.1°C.

Nevertheless, there are differences in these values if we considered them by week and by cluster. Mean and SD of SST values recorded at catch locations are higher from week 26 (end of July)




Time series of mean number of catches from Day of Year 150 (30th May) to 309 (11th November)

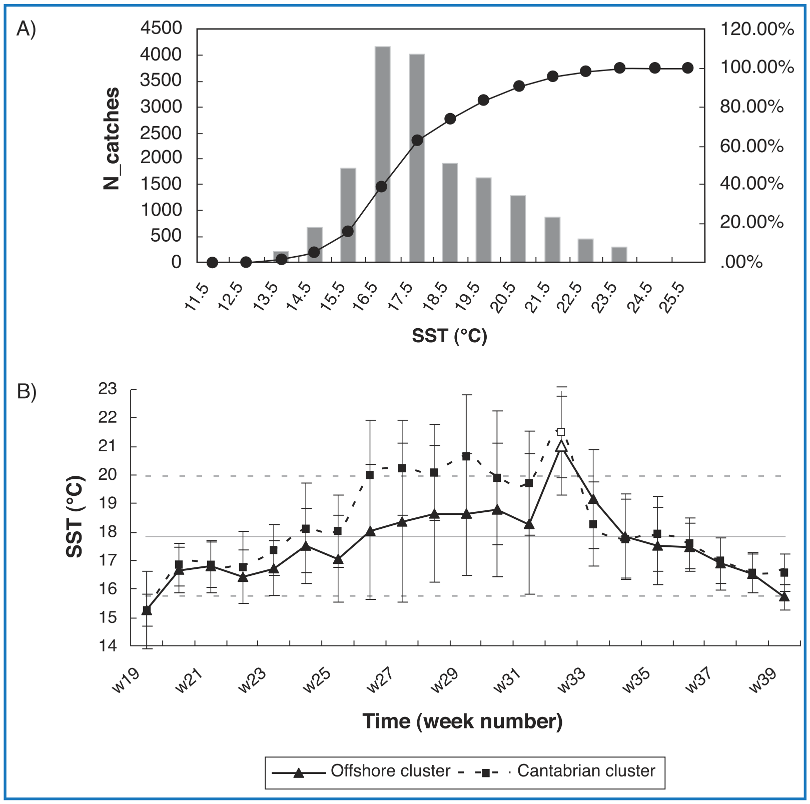
Week 20-22: Common start of catch occurrences in the NE of Azores.

Week 23-32: Two groups of catches are differentiated: the first one follows a north-easterly direction towards south-western Ireland and the second one enters the Bay of Biscay, and remains there for several weeks.

Week 33-39: Centroids are closer in the Bay of Biscay, no SST differentiation between clusters, connection line directions more erratic, decrease in the n° of catch locations due to the decrease of n° of vessels at sea: fleet behavior probably disassociates from albacore behavior.

**(Left)**
**Figure 3. Synoptic representation of the results found on the spatio-temporal evolution of catches.**

**(Below)**
**Figure 4. Frequency distribution of sea surface temperature (SST) values at catch locations. (A) Data pool. (B) Segregated per week 8-day: Bay of Biscay cluster data (dotted line); offshore cluster data (solid line). Y-bars represent +/-1 standard deviation. The horizontal grey solid and dotted lines represent the SST average +/- 1 SST standard deviation calculated with the whole dataset. The white dot reveals a non-representative value corresponding to the week where too few catches are registered due to the stop of fishing activity during local festivities.**




to week 33 (end of September). The SST-at-catch distributions for each of the two clusters show that catches made in the Bay of Biscay are made in higher temperatures (mean of 18.2°C and SD 1.7) than the rest of the data (mean of 17.6°C and SD 1.3). In all cases the distribution of SST-at-catch distributions are statistically different from the natural SST distribution in the area, which confirms that these ranges are "preferred" values of SST.

## Discussion

In summary, our findings confirm that temperature is a strong environmental variable restricting North Atlantic albacore pelagic habitat. There is a close temporal relationship between the albacore catch displacement pattern and the seasonal northward displacement of the preferential thermal window for albacore juveniles (16-18°C), which probably reflects the North Atlantic albacore juveniles migration described by several authors. It has also been shown that North Atlantic albacore are able to make use of niches within the Bay of Biscay with significantly warmer water masses.

Although these results don't provide ecological or physiological explanations for this albacore spatio-temporal segregation, they provide elements to formulate a new hypothesis—do the different thermal conditions of catches belonging to the two clusters reflect different physiological or development states of individuals? Could this segregation be driven by different prey abundance or composition? Finally, in a global warming scenario, how would change affect the habitat of North Atlantic albacore in the future?

Keeping in mind that catch rate statistics of traditional fishing fleets are used to assess the stock status and decide management actions for a sustainable management, it is essential that these environmental aspects affecting albacore habitat are considered within the management process of the stock.

**PFRP**

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## The Role of Squid in Pelagic Marine Ecosystems

**A joint workshop sponsored by GLOBEC-CLIOTOP Working Group 3 and the Pelagic Fisheries Research Program (PFRP)**
November 14-17, 2006
Imin Conference Center, University of Hawai'i, Honolulu

You are cordially invited to the joint CLIOTOP/PFRP workshop on the role of pelagic cephalopods, especially large squid, in pelagic marine ecosystems. The workshop is to be held at the Imin Conference Center of the University of Hawai'i at Mānoa Tuesday through Friday, November 14-17, 2006. The workshop will convene jointly with the annual PFRP Principal Investigators (PI) meeting. The first two days of the joint workshop will include presentations of PFRP-sponsored research, and presentations addressing a thematic focus on processes occurring at mid-trophic levels—dynamics of prey species, horizontal and vertical variability in prey abundance, novel tools for analysis of trophic dependencies, and downward propagation changes in trophic structure due to changes in predator abundance. Thursday and Friday, November 16-17, will be devoted entirely to cephalopods.

The purpose of the joint CLIOTOP/PFRP workshop is:

- to consider the role of squid in pelagic ecosystems that support tunas and other upper-level predators;
- to consider how climate change might impact squid populations and the ecosystem;
- to consider the recent range expansions of *Dosidicus gigas* in the Pacific Ocean, especially in terms of its effects on ecosystems;
- to identify research needs for large pelagic squid to meet the goals of GLOBEC-CLIOTOP. Potential research proposals will be identified.

Contact Robert Olson (rolson@iattc.org) or Jock Young (jock.young@csiro.au) if you are interested in making a presentation about the role of squid in the ecosystem or in attending the joint workshop. Please contact John Sibert, PFRP (sibert@hawaii.edu) for more information on the PFRP PI meeting. Please contact Ms. Dodie Lau (lau@hawaii.edu) for questions regarding travel and accommodations.

PFRP Pelagic Fisheries Research Program

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