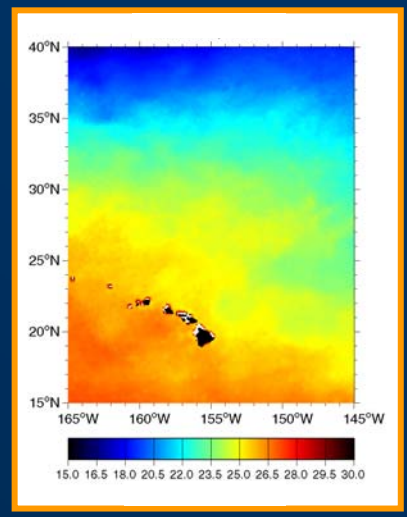
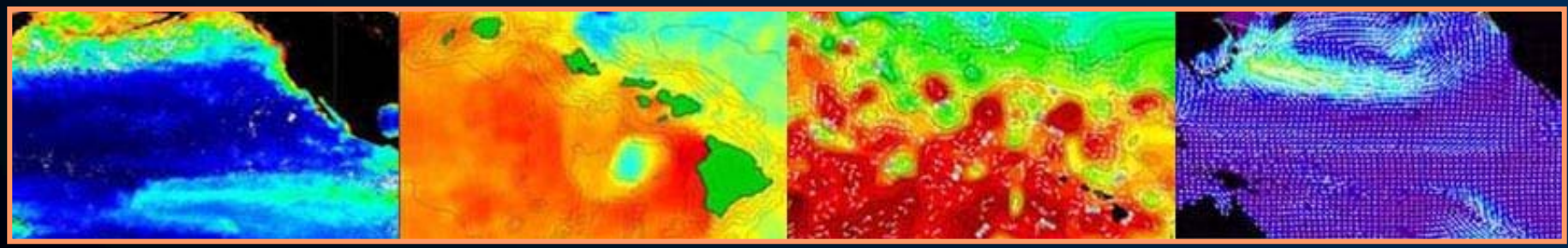
Identifying critical habitat of swordfish and loggerhead turtles from fishery, satellite tag, and environmental data



Evan A. Howell[1], Donald R. Kobayashi[1], Hidetada Kiyofuji[1], Sei-Ichi Saitoh[2], and Jeffrey J. Polovina[1]

[1]Pacific Islands Fisheries Science Center
Ecosystems and Oceanography Division
Honolulu, HI, USA

[2]Laboratory of Marine Bioresource and Environment Sensing
Graduate School of Fisheries Science
Hokkaido University
Hakodate, Hokkaido, Japan



Why look at turtles, swordfish, and the environment?

- Hawaii-based longline fishery targets billfish and tuna, swordfish important commercial catch, unfortunately also interactions with loggerhead turtles during swordfish sets

- Loggerhead turtles endangered species, need to minimize this bycatch in longline fishery (existing cap in fishery: 17 interactions – In 2006, reached in March)

- Previous work has shown operational effects on bycatch, but less work has been done to look at environmental effects on bycatch of loggerhead turtles

- Research has shown an environmental habitat of frontal areas for both loggerhead turtles (Polovina et al., 2000; 2004) and swordfish (Seki et al., 2002)

- Using environmental data we can begin to try and minimize bycatch by separating the preferential environmental habitat of these species

Project goals

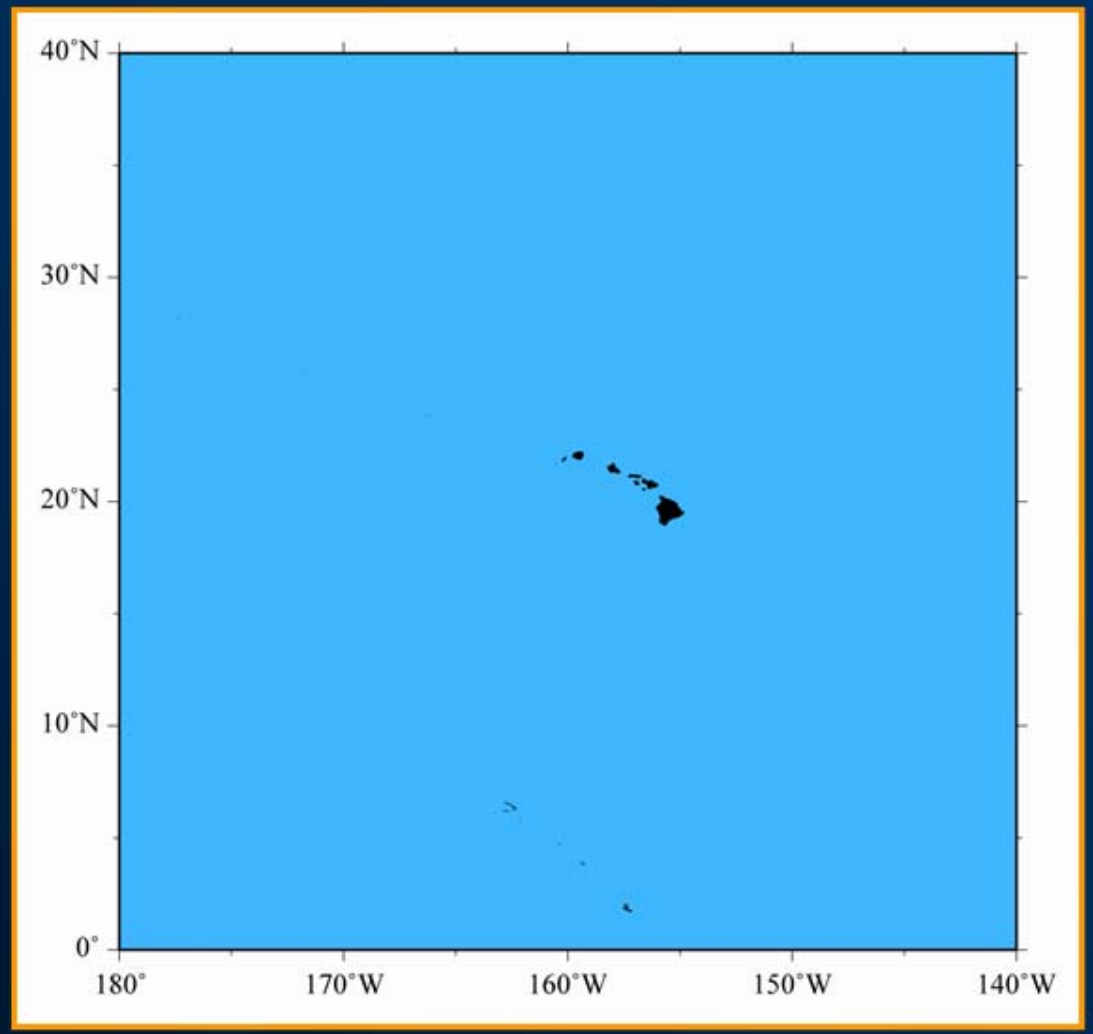
- Create products simple to understand and use
- Useful in management decisions
- Successful in minimizing bycatch of loggerhead turtles

Initial Hypotheses

- Based on previous research loggerhead turtles and swordfish fishery associated with fronts/frontal areas (STF ~ 17ºC and SSTF ~ 20ºC)
- Fall/winter months should then more important as this is when fronts and fishery intersect (targeting swordfish)
- If so we can assume higher interactions in the SST range 17ºC (STF) – 20ºC (SSTF) in the first quarter
- As the fishery moves out of the frontal area in spring, bycatch of loggerheads decreases
- Question: Can we begin to separate swordfish and turtle habitat from remotely-sensed environmental data?

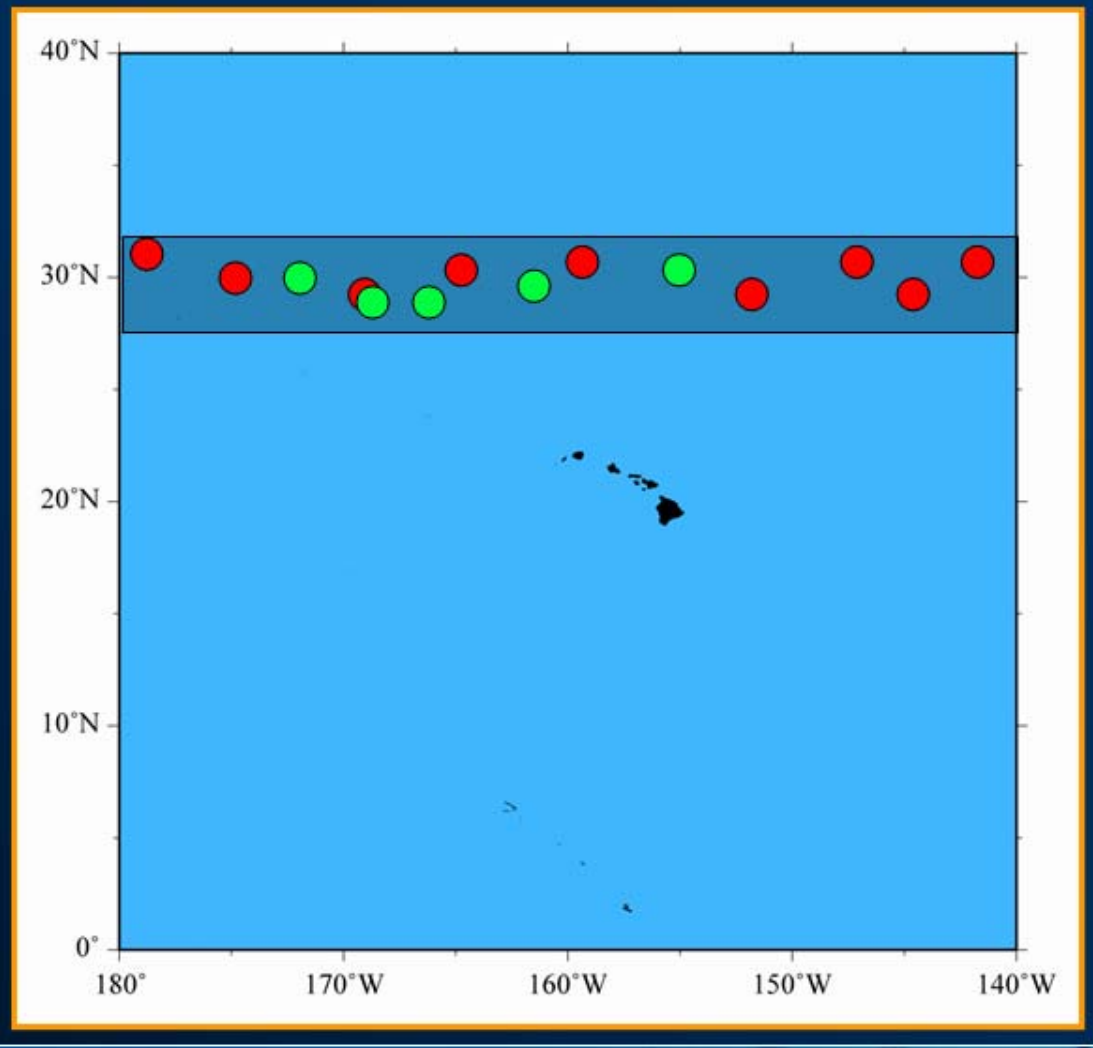
The Hawaii Longline Fishery

- Operates in a box 180-140ºW, 0-40ºN year round
- Billfish and Tunas
- Want to refine temporal and spatial space for this study



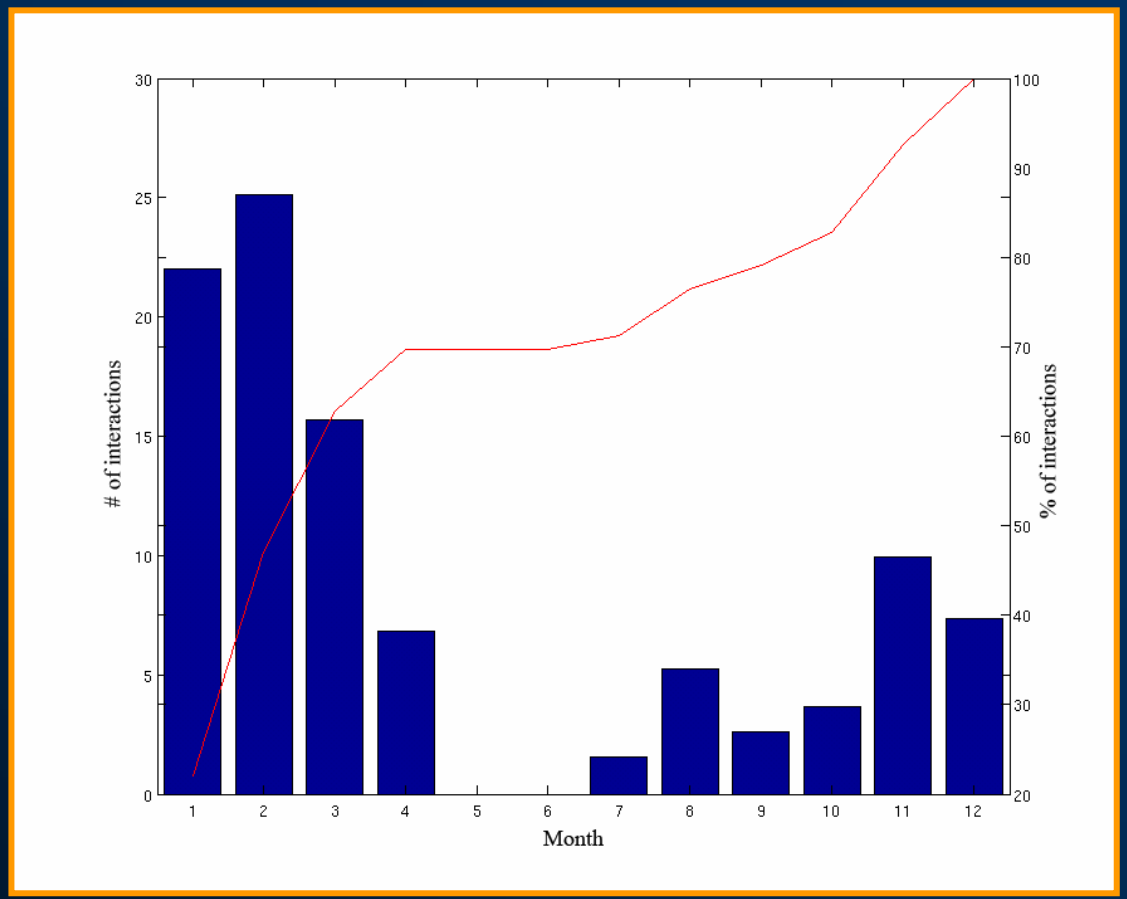
The Hawaii Longline Fishery

- Operates in a box 180-140ºW, 0-40ºN year round
- Billfish and Tunas
- Want to refine temporal and spatial space for this study
- Env. important as fronts come down in 1st quarter



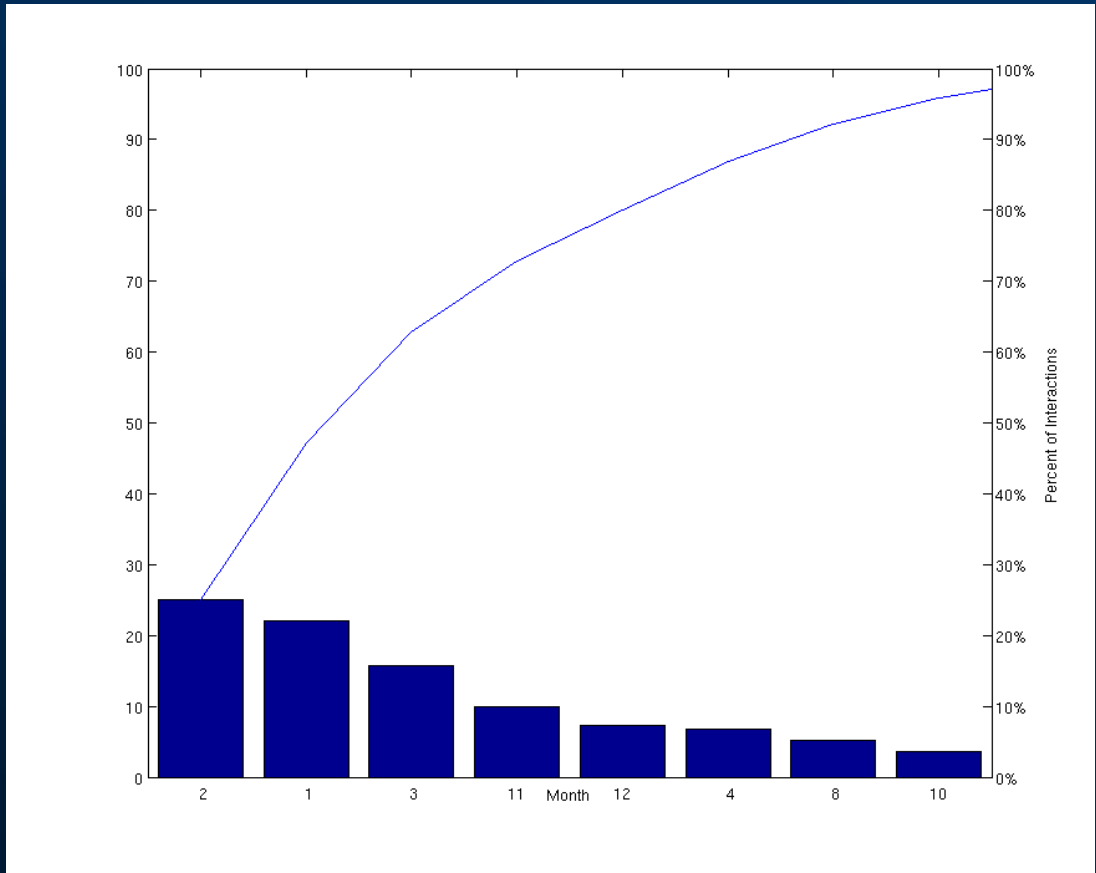
Which months are important to the fishery?

- 90% of loggerhead interactions Oct-Apr



Which months are important to the fishery?

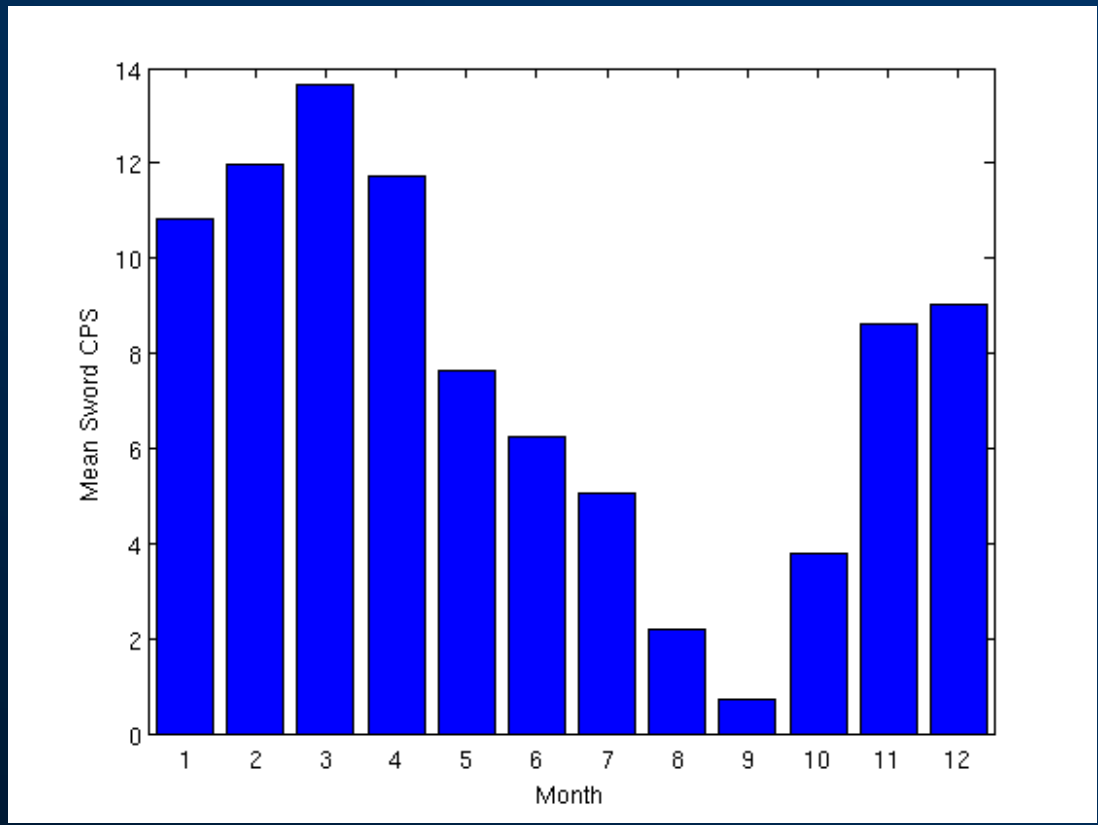
- 90% of loggerhead interactions Oct-Apr
- In rank, 60% Jan-Mar



Howell et al. – 15th Annual PICES meeting Yokohama, Japan: October 13-22, 2006

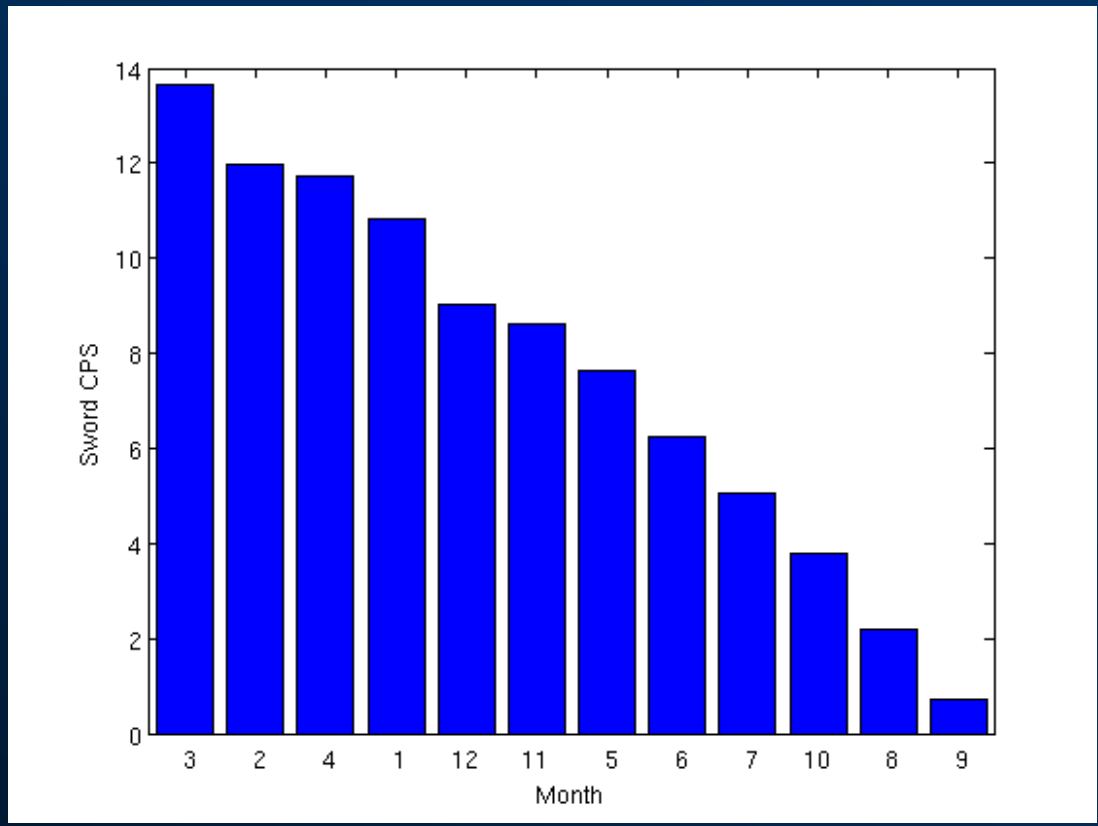
Which months are important to the fishery?

- 90% of loggerhead interactions Oct-Apr
- In rank, 60% Jan-Mar
- Swordfish Mean CPS Nov-Apr



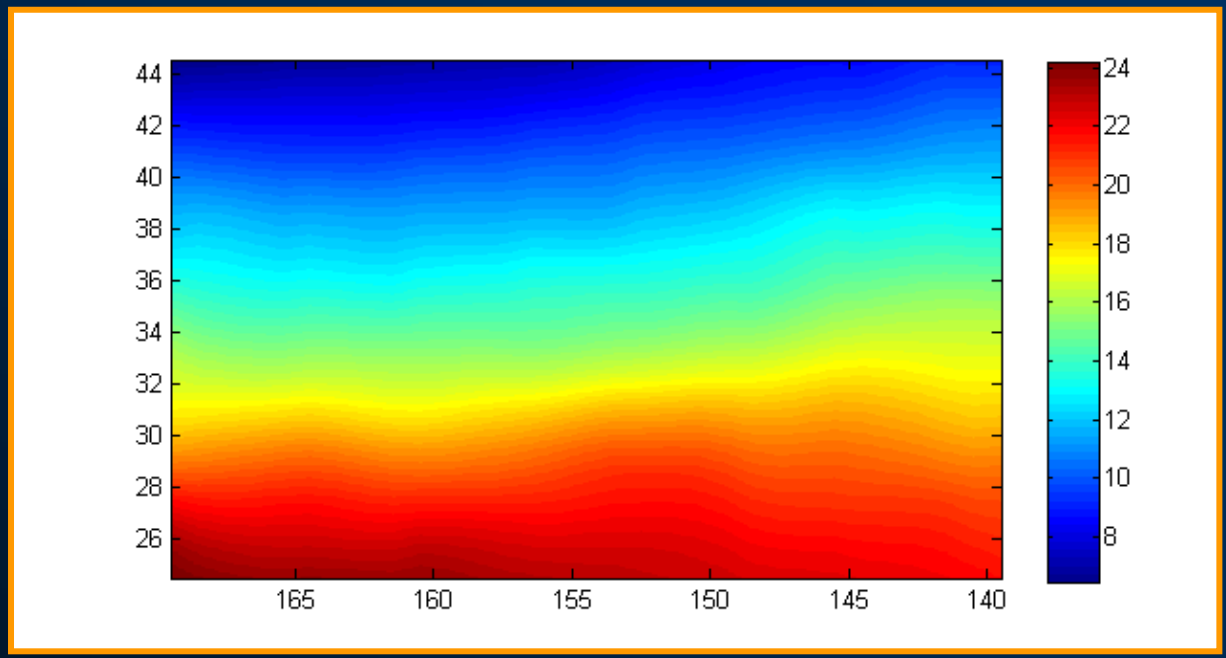
Which months are important to the fishery?

- 90% of loggerhead interactions Oct-Apr
- In rank, 60% Jan-Mar
- Swordfish Mean CPS Nov-Apr
- In rank, Jan-Apr
- Focus on 1st quarter, look at habitat (SST)



Habitat: Sea Surface Temperature

- So many env. datasets, why sea surface temperature (SST)?
  - Measured by multiple sensors in near real time, good spatial resolution
  - From SST field easily see frontal signature over entire CNP
  - of all RS products, what fishery is tracking on

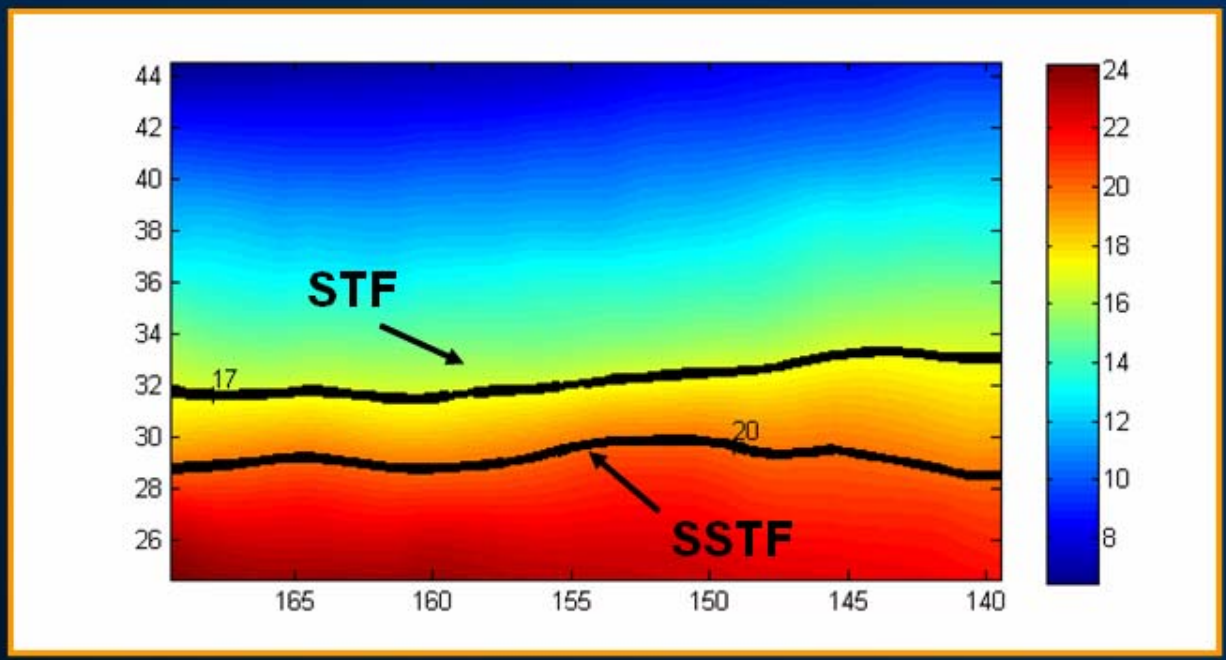


Howell et al. – 15th Annual PICES meeting Yokohama, Japan: October 13-22, 2006

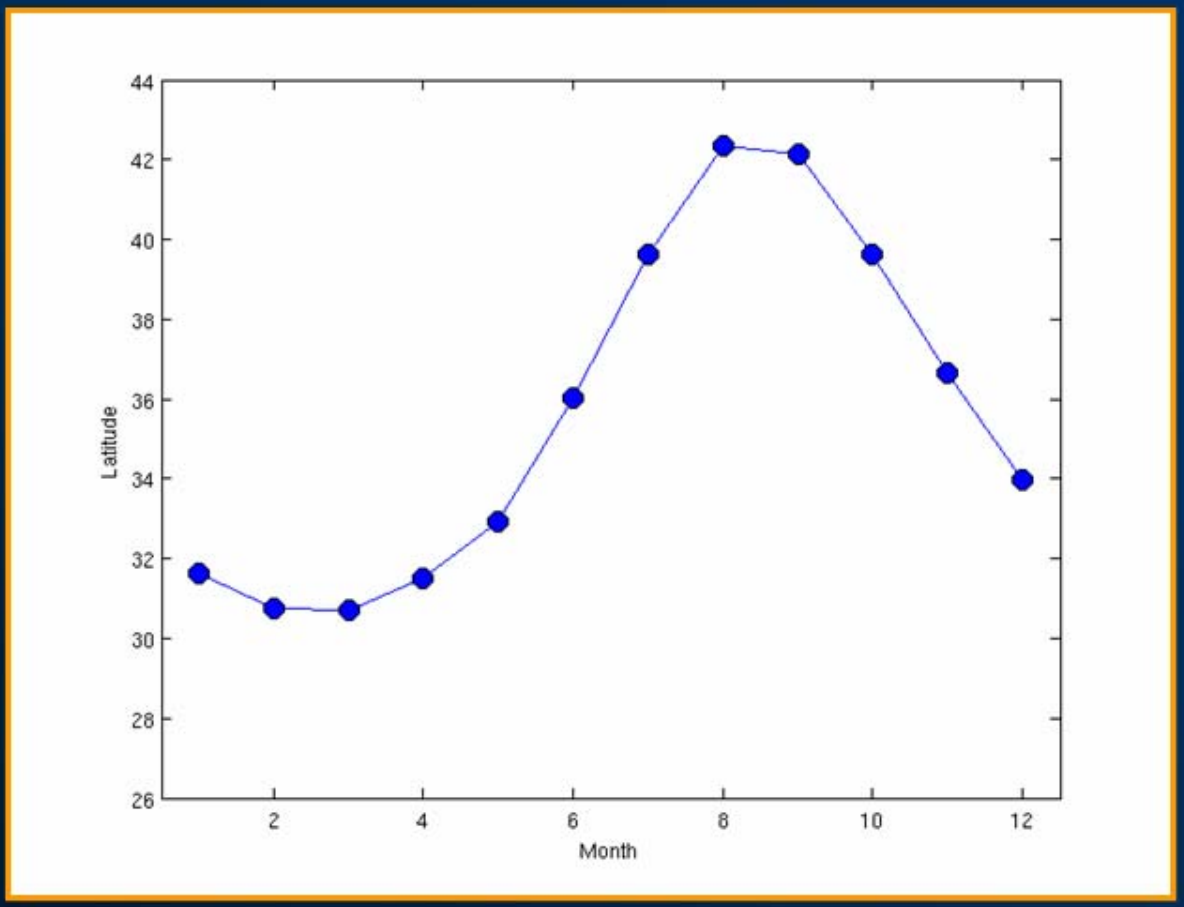
SST Fronts: Background and movement

- Frontal system has north south movement, southern minimum in 1st quarter, northern maximum in 3rd quarter

- We can track the movements of the frontal system by satellite

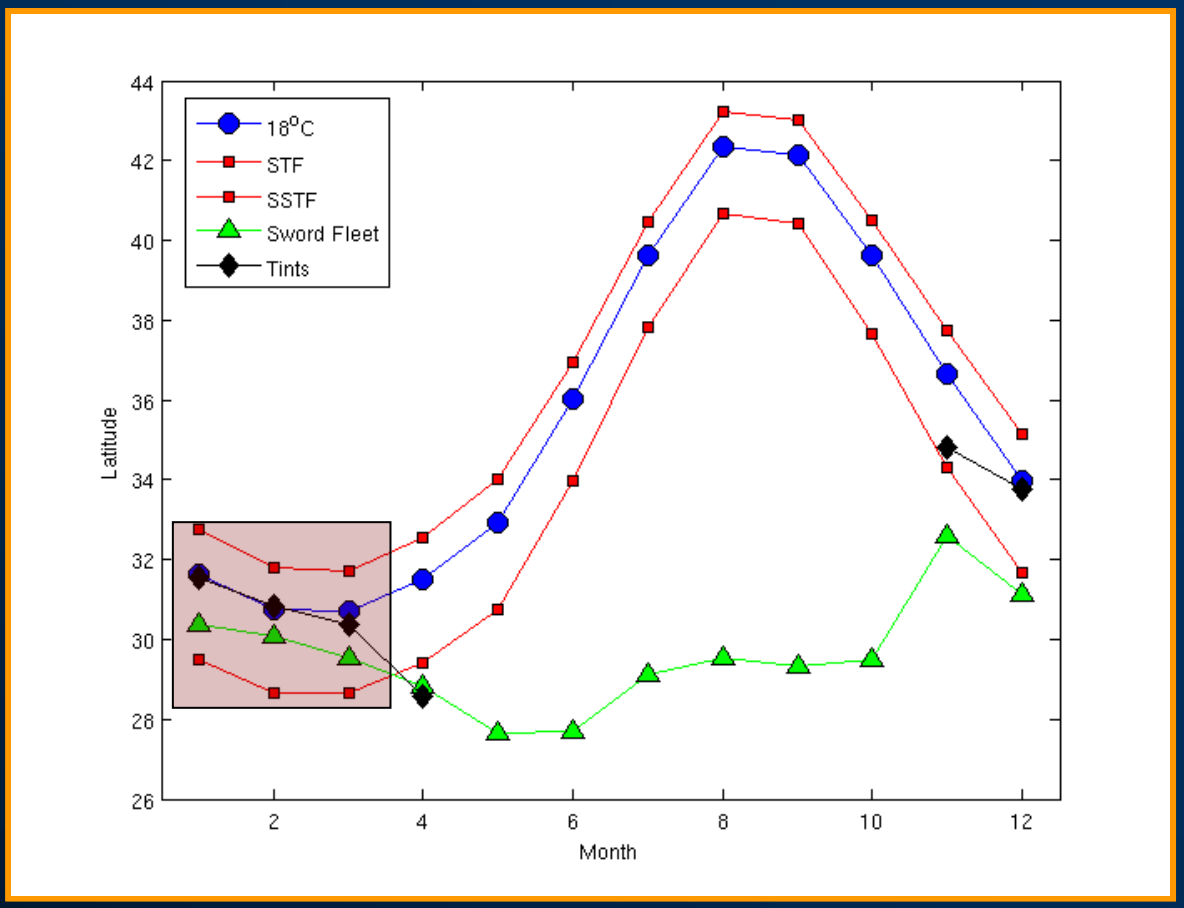


SST Fronts: Background and movement



SST Frontal Movement and the fishery

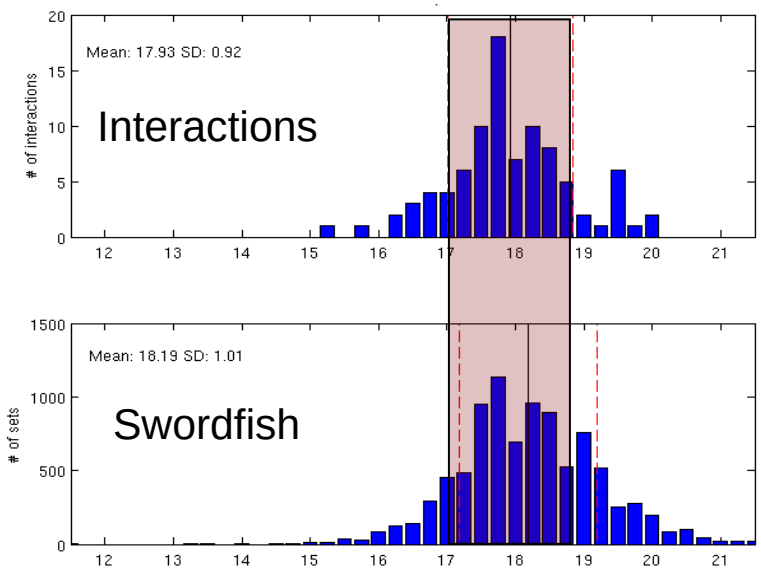
- Monthly latitude position of isotherms (mean 170W-150W)
- ~75% of all swordfish sets and loggerhead interactions in this longitude band
- Crossover in 1st quarter
- Swordfish sets slightly south



Howell et al. – 15th Annual PICES meeting Yokohama, Japan: October 13-22, 2006

Temperature range crossover

- 1st quarter data for loggerhead interactions (top) and swordfish sets (bottom)
- Bulk of thermal range between 17ºC-19ºC
- From this may be able to set SST “warning” band
- But is turtle population truly situated at ~18C?



ARGOS loggerhead turtle position data

- Have a database of daily best position data for >50 loggerhead turtles in this space/time

- Dates range from 1997 to 2006 with mean SCL 64.84 cm (fishery: 60.5 cm)

- Take turtle positions in 1st quarter

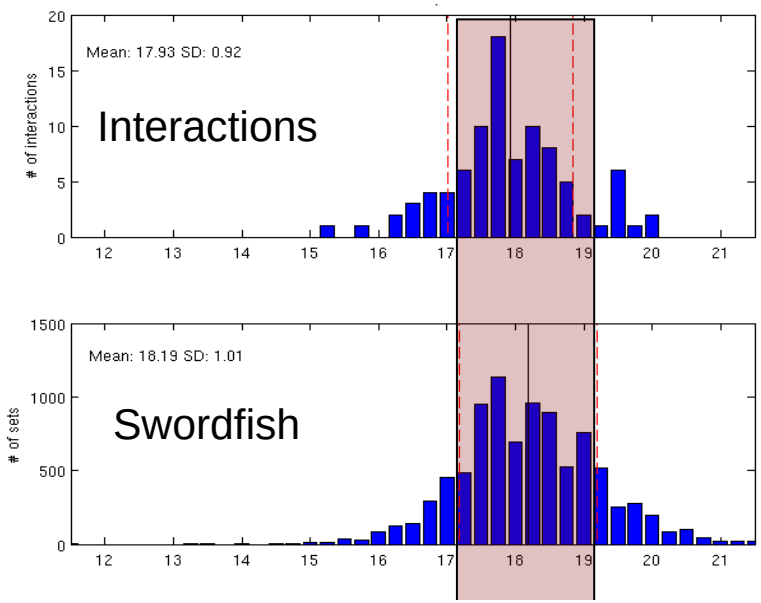
  Only and match to SST

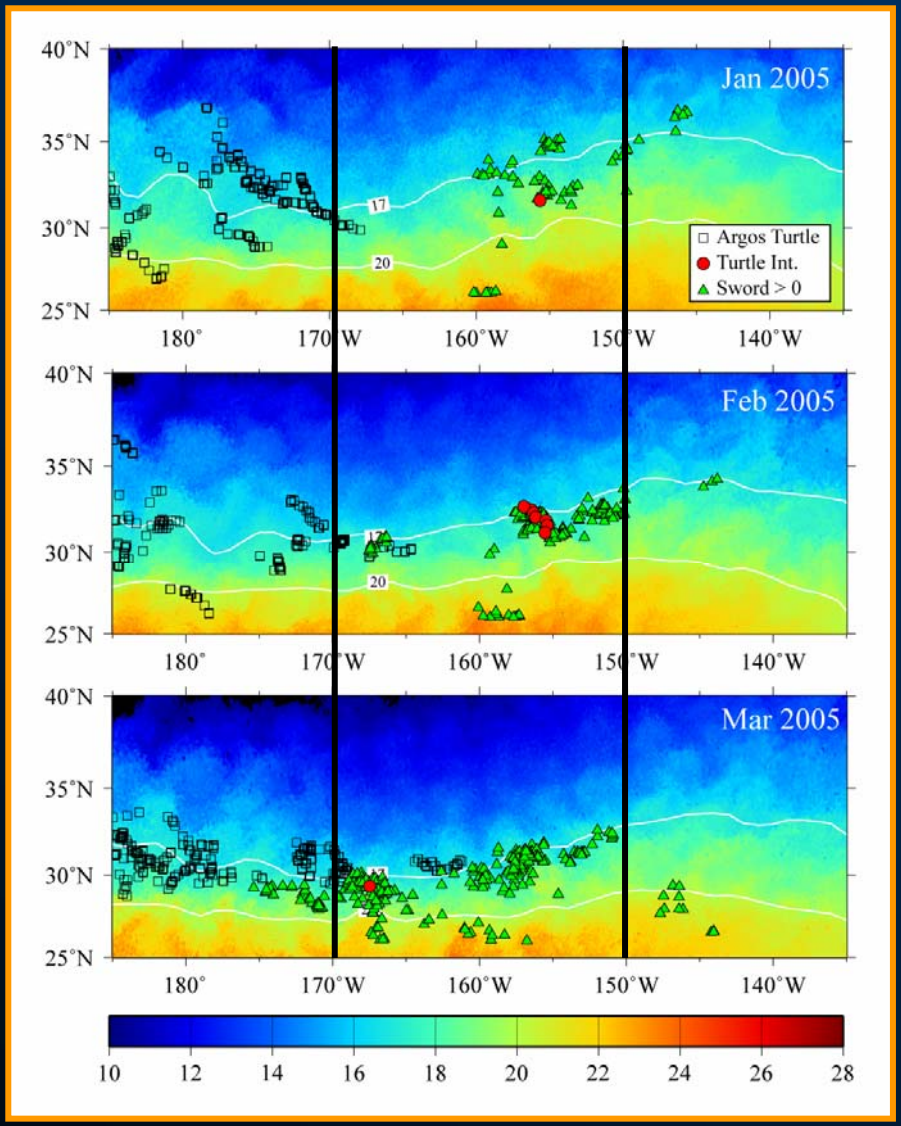
- Compare this “real” SST distribution

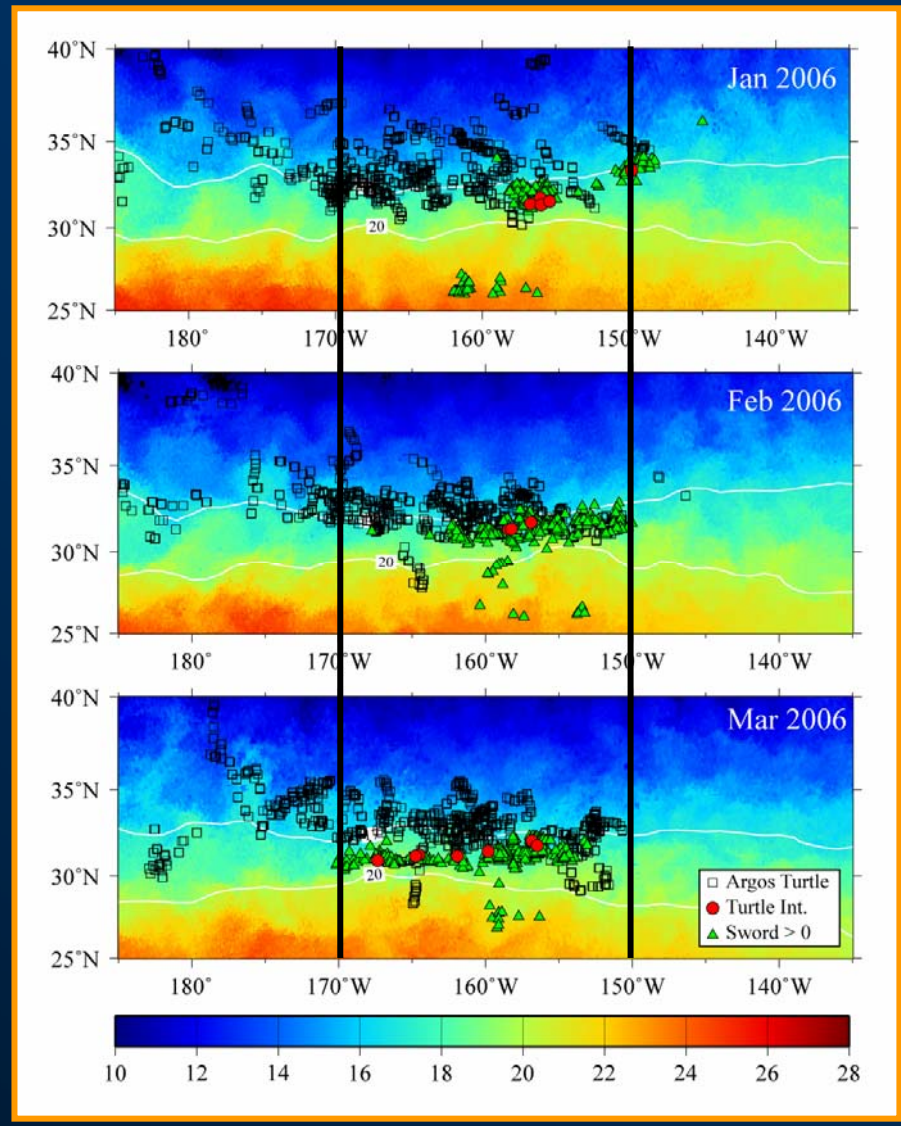
  to observed turtle locations

Temperature range crossover

- 1st Quarter
- Comparing ranges of SST
- SST range for ARGOS turtles is colder (turtles to north)
- From this rough cut, would predict higher turtle interactions to the north
- In a spatial sense…




Jan 2005
Feb 2005
Mar 2005
Argos Turtle
Turtle Int.
Sword > 0
17
20
40°N
35°N
30°N
25°N
180°
170°W
160°W
150°W
140°W
10
12
14
16
18
20
22
24
26
28


Jan 2006
Feb 2006
Mar 2006
Argos Turtle
Turtle Int.
Sword > 0
20
40°N
35°N
30°N
25°N
180°
170°W
160°W
150°W
140°W
10
12
14
16
18
20
22
24
26
28

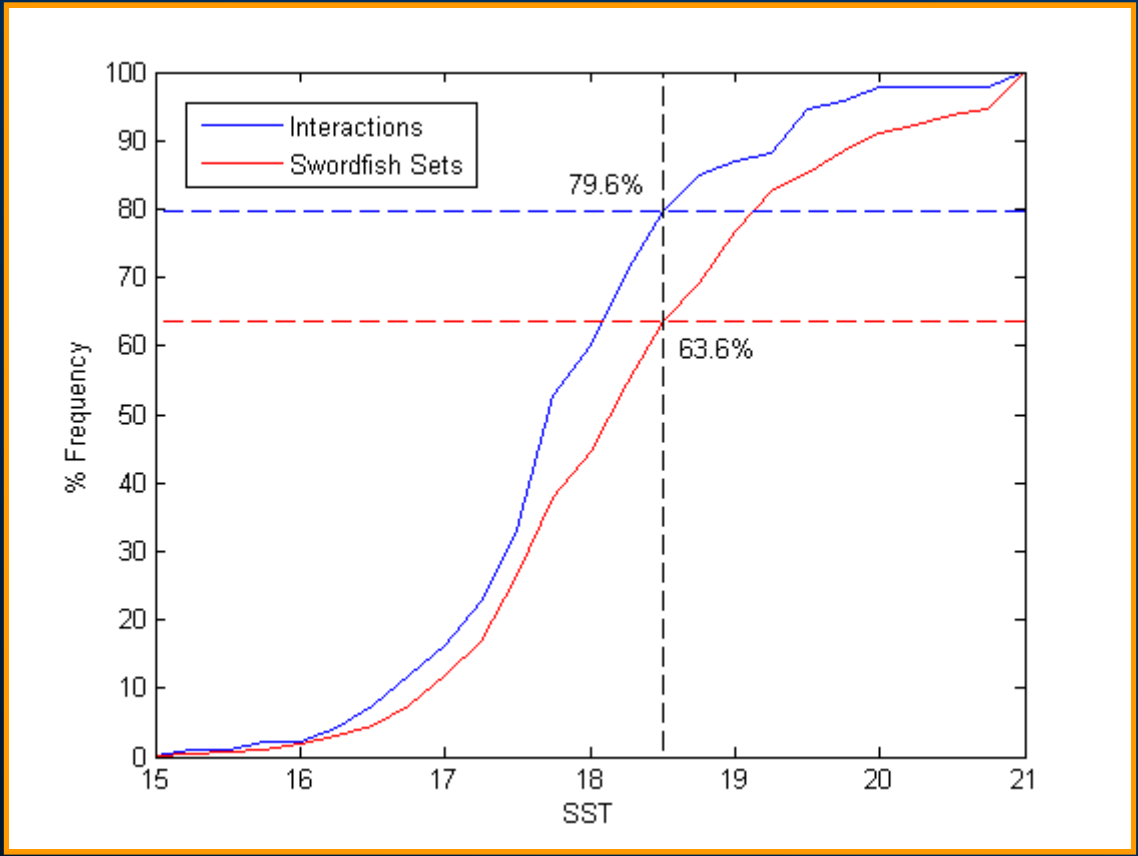
Can we separate Swordfish from Turtles?

- Attempt to find areas of low interactions and high Sword CPUE

- First cut…

- May be possible to being to separate these two species by SST-based habitats

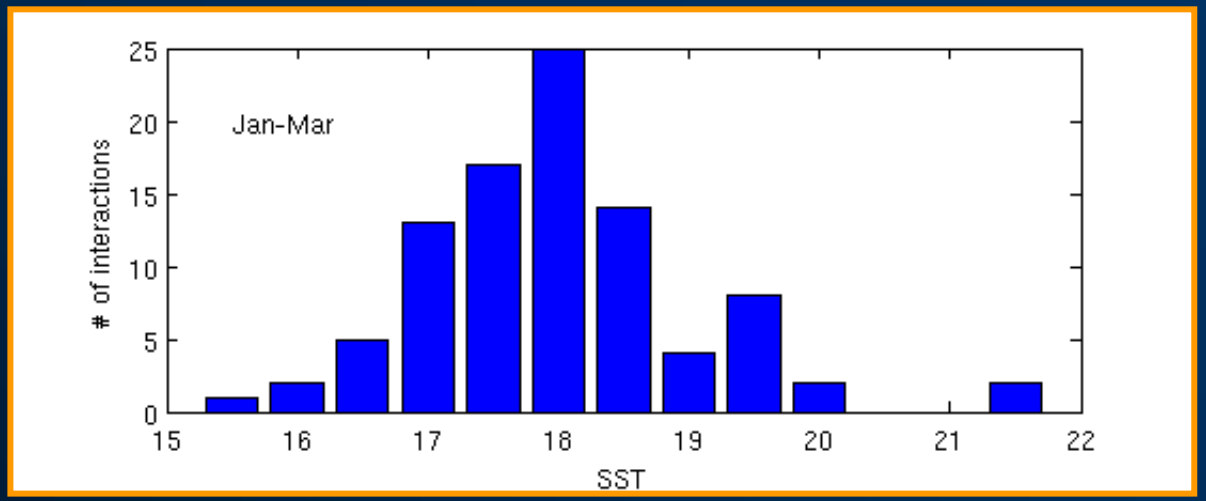
1st quarter

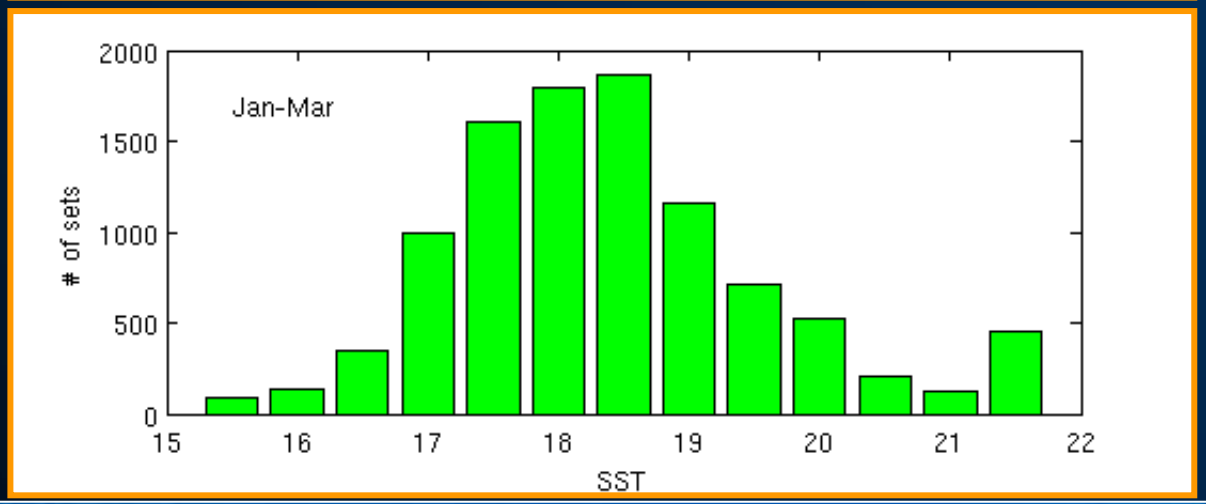


Howell et al. – 15th Annual PICES meeting Yokohama, Japan: October 13-22, 2006

What happens if we shift the effort?

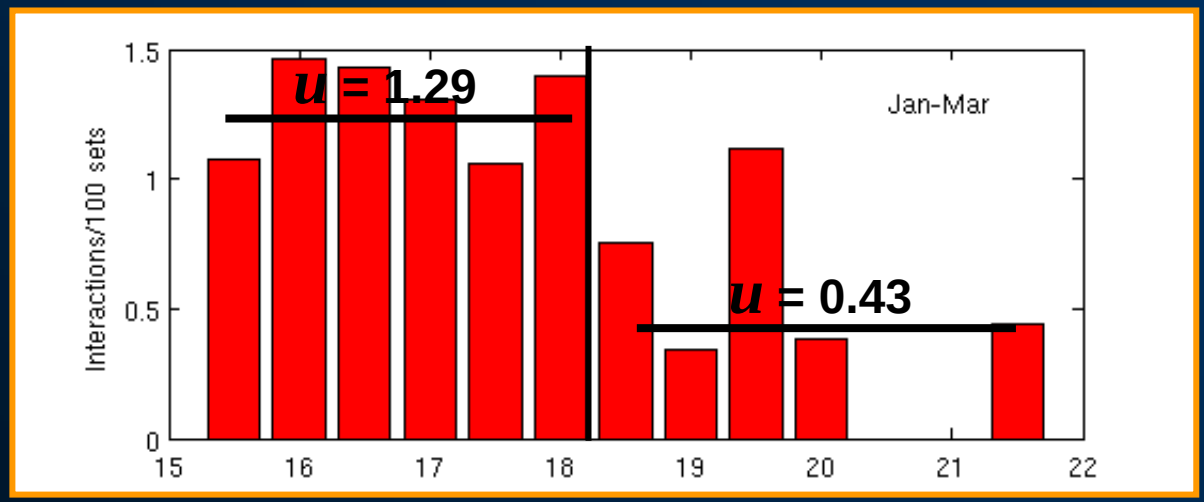
- If we decide that 18.25C is cutoff, estimated LH interactions?





What happens if we shift the effort?

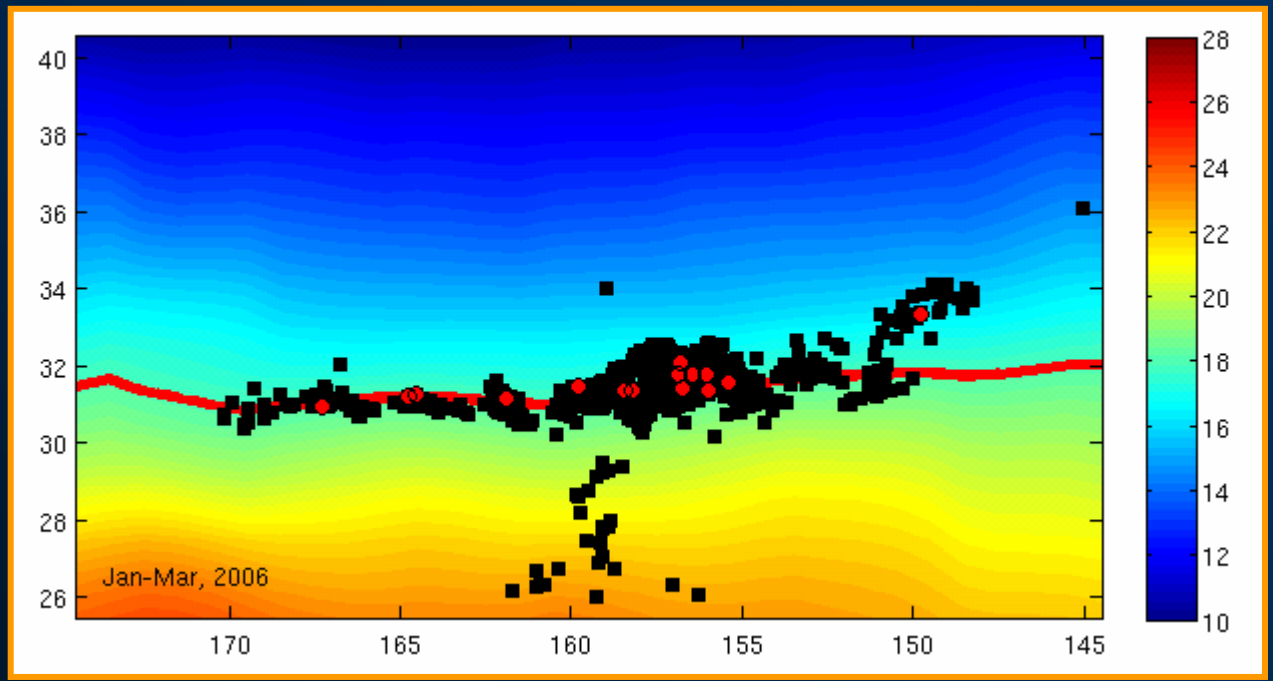
- If we decide that 18.25C is cutoff, estimated LH interactions?



Shifting effort below the 18ºC isotherm

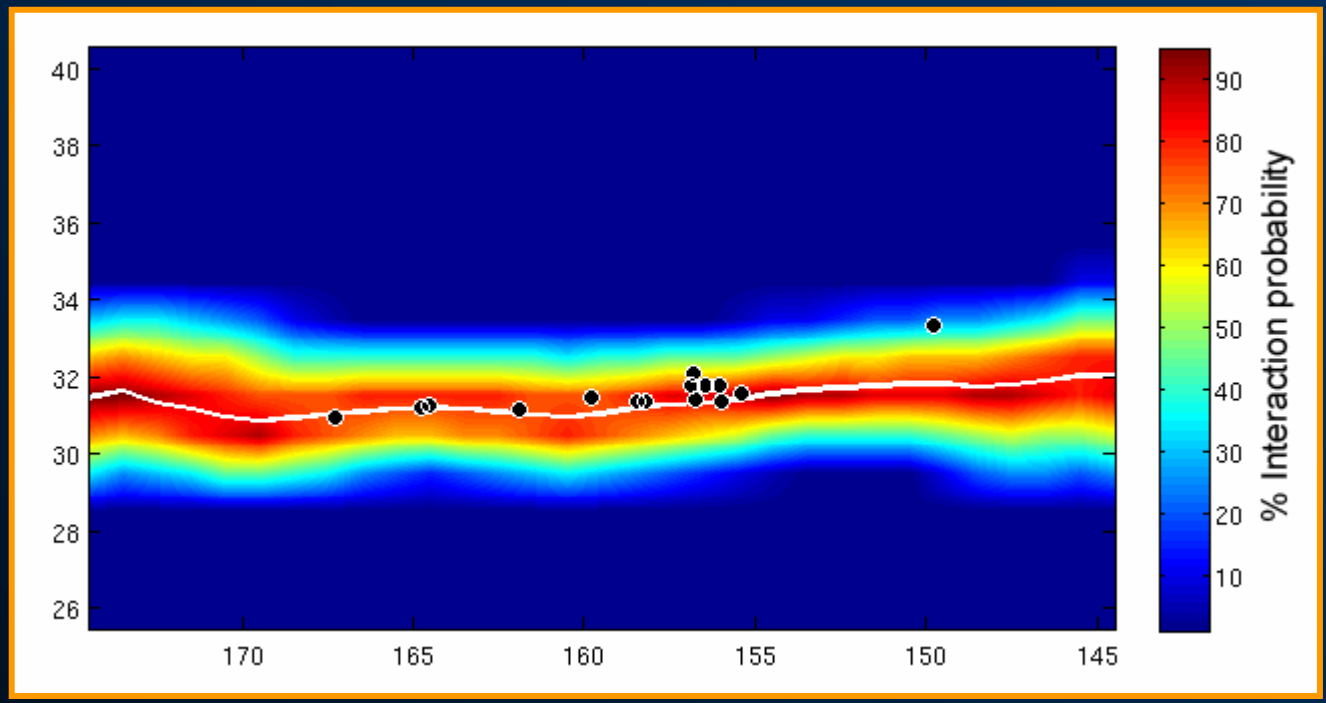
- For example, 2006 1st quarter, almost all effort close to 18ºC isotherm

- Where is area of highest danger for interactions based on SST?



Attempting to spatially map interaction zones from SST

- Can we come up with a “danger zone” map for interactions?
- Example: based on mean SST +/- 2 SD for 1st quarter 2006
- Would like to create for sword CPUE, overlay



What's left to do? Everything!

- Continue work separating habitats of the two species
  - More robust separation
  - Estimate movement of fleet in space/time (loss, Δ# of interactions, etc)?

- Continue to look at other environmental signals
  - Chlorophyll *a*
  - SST and Chl *a* gradients, other frontal indicators

- Work on forecasting tools (predict danger zones)?
  - Forecast interaction probability map (from SST Fields/chl *a*/gradients)
  - general stoplight signal based on frontal area

- Continue to work with management during this process to refine products