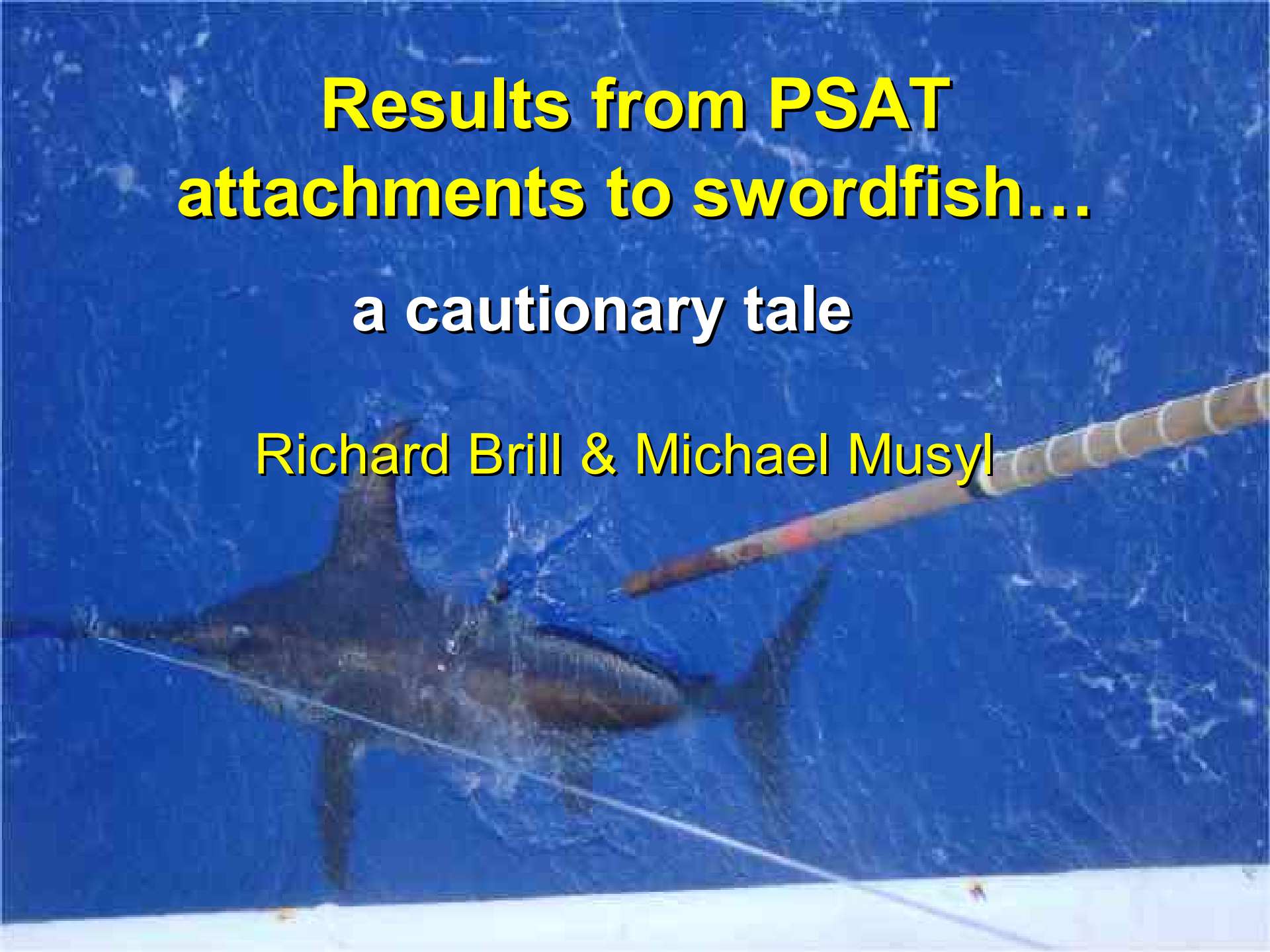


Results from PSAT attachments to swordfish...

a cautionary tale

Richard Brill & Michael Musyl



PSATS deployed to date

- 32 blue sharks
- 4 shortfin mako
- 8 oceanic white tip sharks
- 4 silky sharks
- 7 bigeye thresher sharks

– 28 swordfish

- 36 blue marlin
- 1 black marlin
- 1 striped marlin

- 3 yellowfin tuna
- 4 bigeye tuna

Total: over 140 fish

Participants: Dan Curran, Tom Kazama, Dave Itano, and crew & officers of NOAA vessels *Townsend Cromwell* and *Oscar Elton Sette*.

Related Activities & Participants

- Oceanographic correlations: **Mike Laurs, Keith Bigelow**
- Physiological modeling: **Hans Malte, Christina Larsen**
- Post hooking mortality – physiological correlates:
 - Sharks and marlin: **Chris Moyes et al.**
 - Sea turtles: **Yonat Swimmer et al.**
- Data archiving/analysis: **Mike Musyl, Lianne McNaughton**
- Kalman filter development: **John Sibert, Anders Neilsen**
- Stock assessment and habitat models: **Pierre Kleiber, Keith Bigelow**
- Visual function of pelagic fishes: **Kerstin Fritsches, Eric Warrant**

Original Objectives (swordfish):

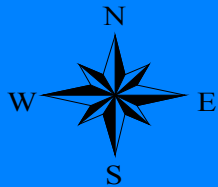
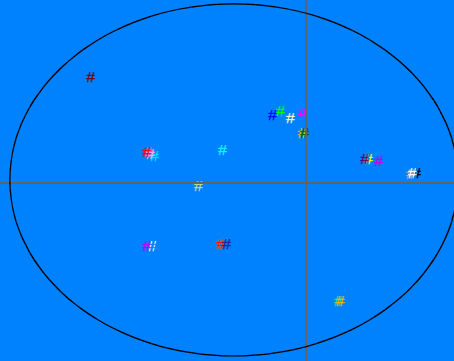
Chronicle vertical and horizontal movement patterns

Allow refinement of population assessment models based on fish distribution and environmental conditions

Can swordfish be taken on longline gear configurations that reduce/eliminate turtle bycatch?



Swordfish PSAT
deployments were
concentrated in the
North Pacific
Transition Zone

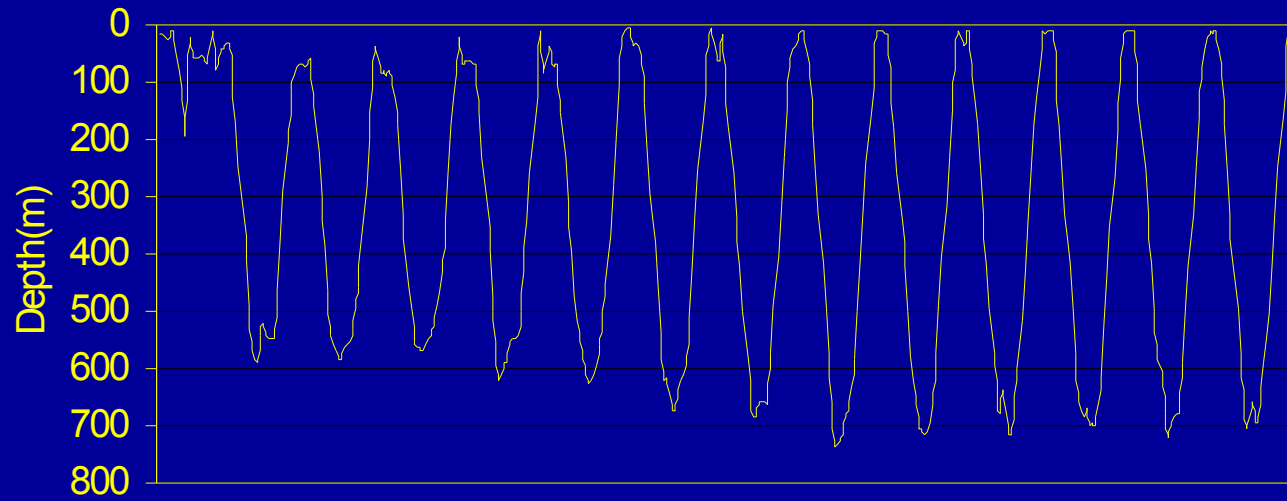


Swordfish 2000-2003, n=28

Swordfish were caught on standard longline gear, and tagged in the water

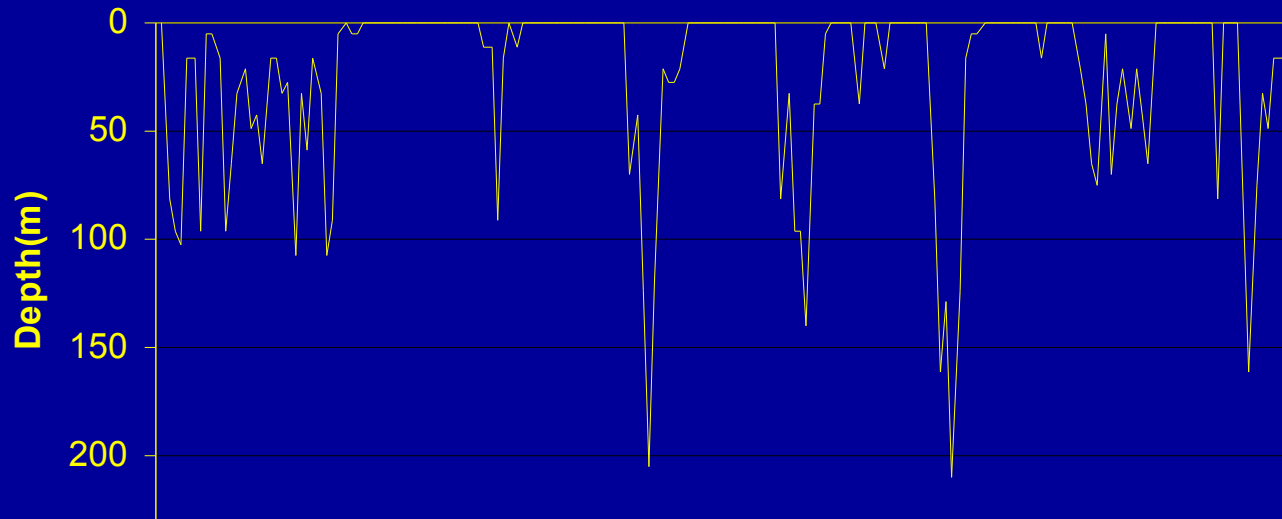


Swordfish #3



33 day trace

Swordfish #2



14 day trace

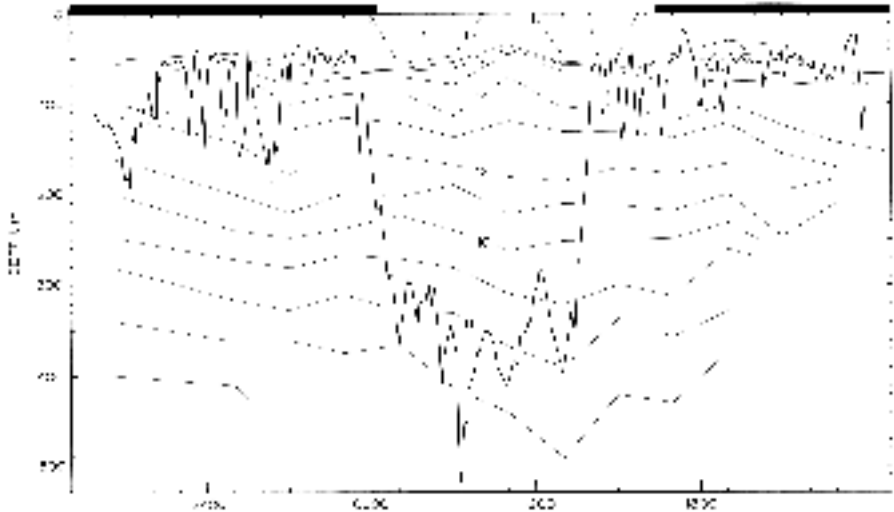
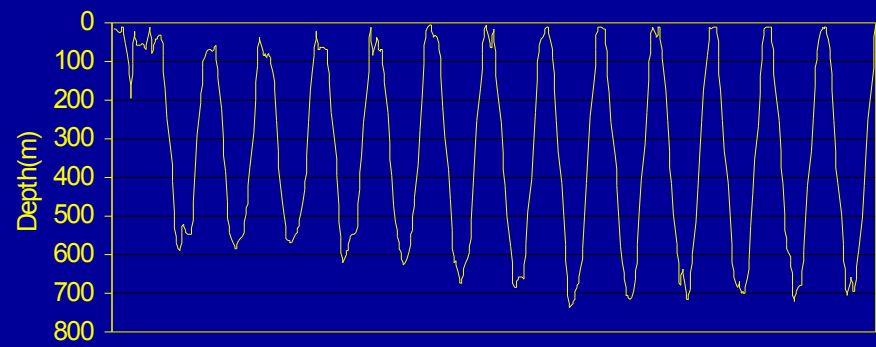
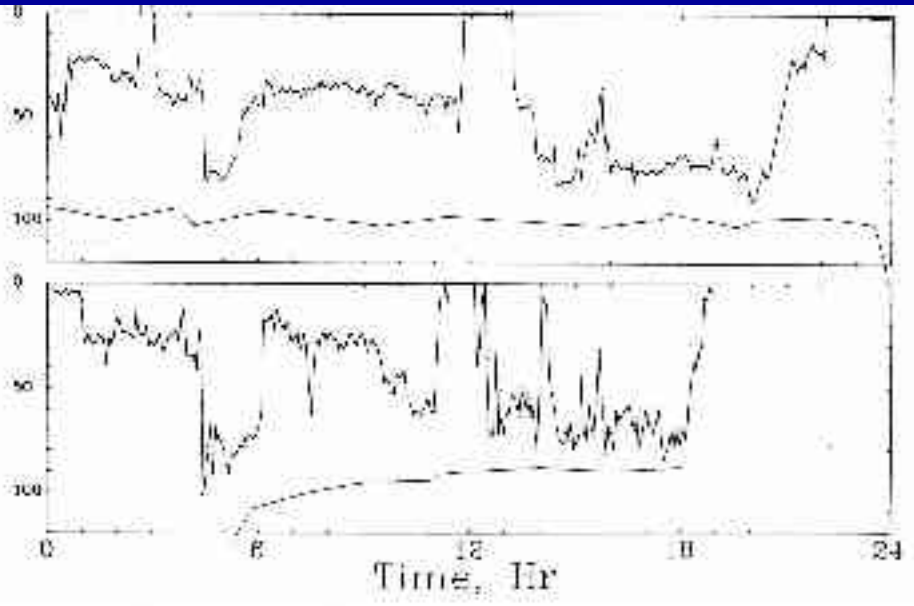


Figure 2. Depth profile of the swordfish #3 during the study (heavy line, depth, horizontal lines, °C is the red/black lines, right). The fish was in warm water (see the blue shading during the night) but descended into cold water during the light. The water temperature dropped to 10°C and the fish realized it cold water, to 8 hours.

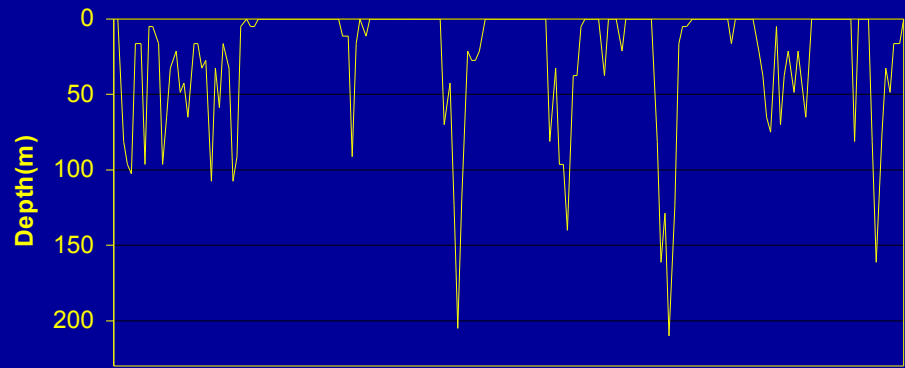
Swordfish #3



33 day trace



Swordfish #2

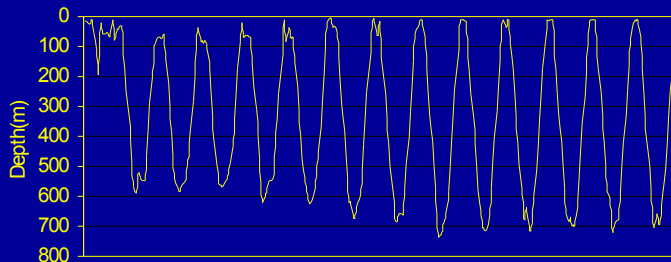


14 day trace

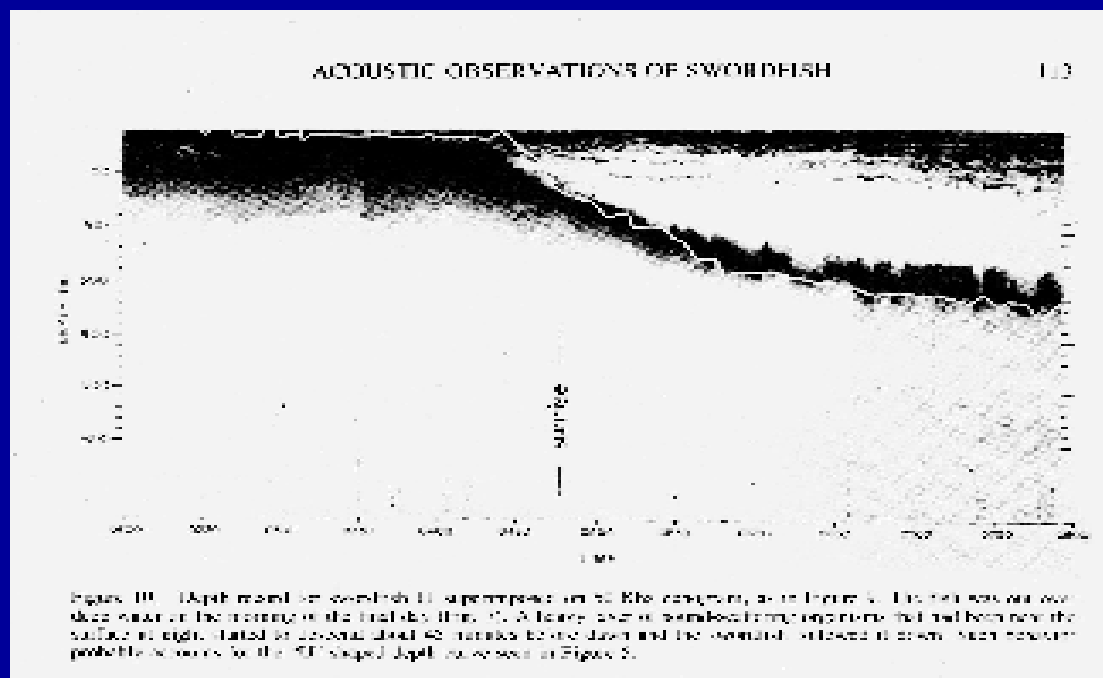
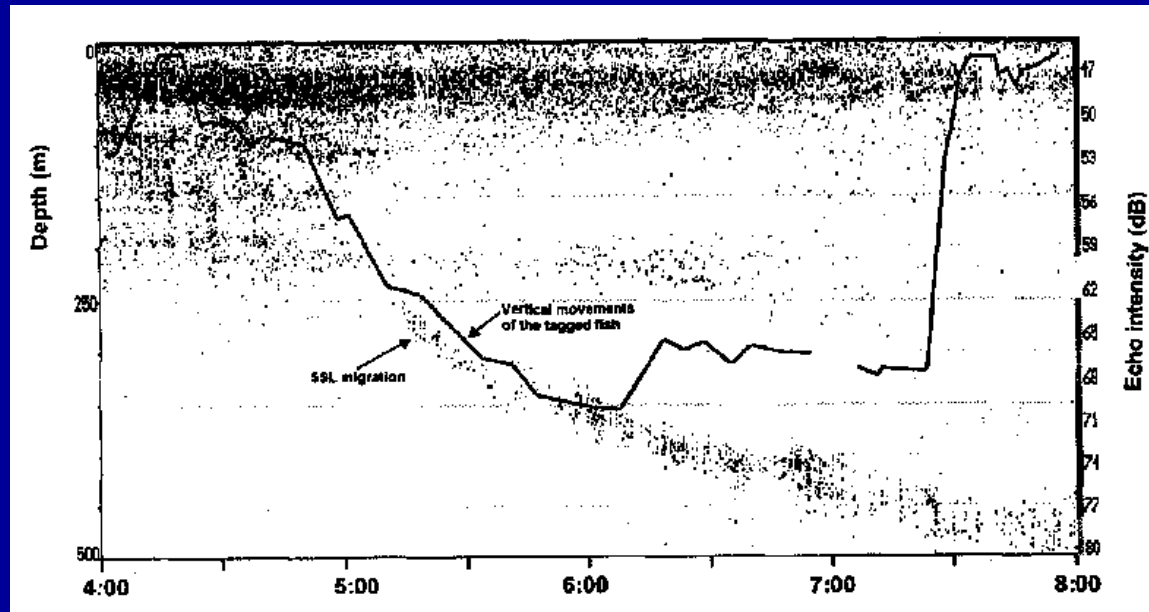
As with bigeye tuna,

swordfish vertical movements are correlated with movements of prey species

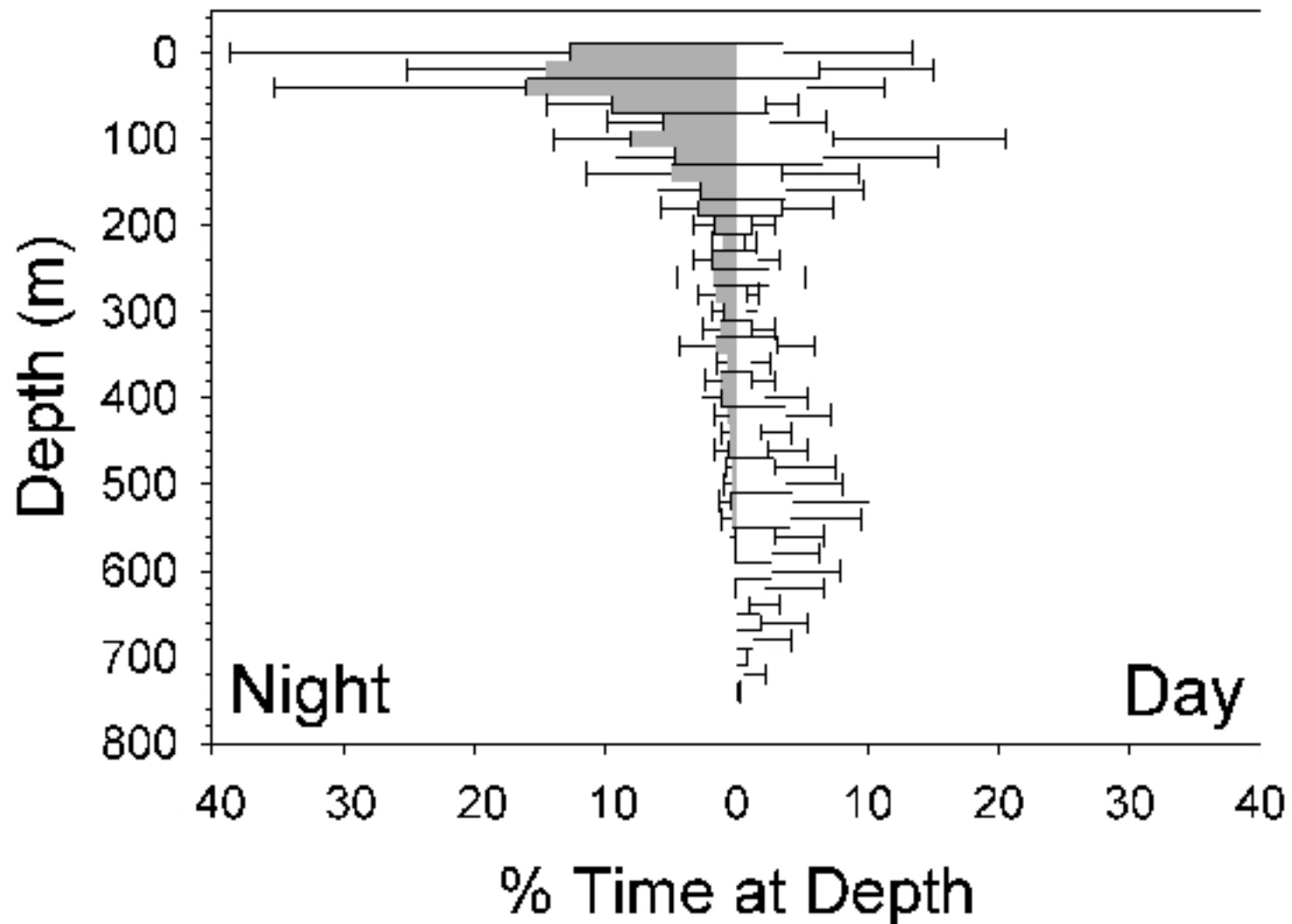
Swordfish #3



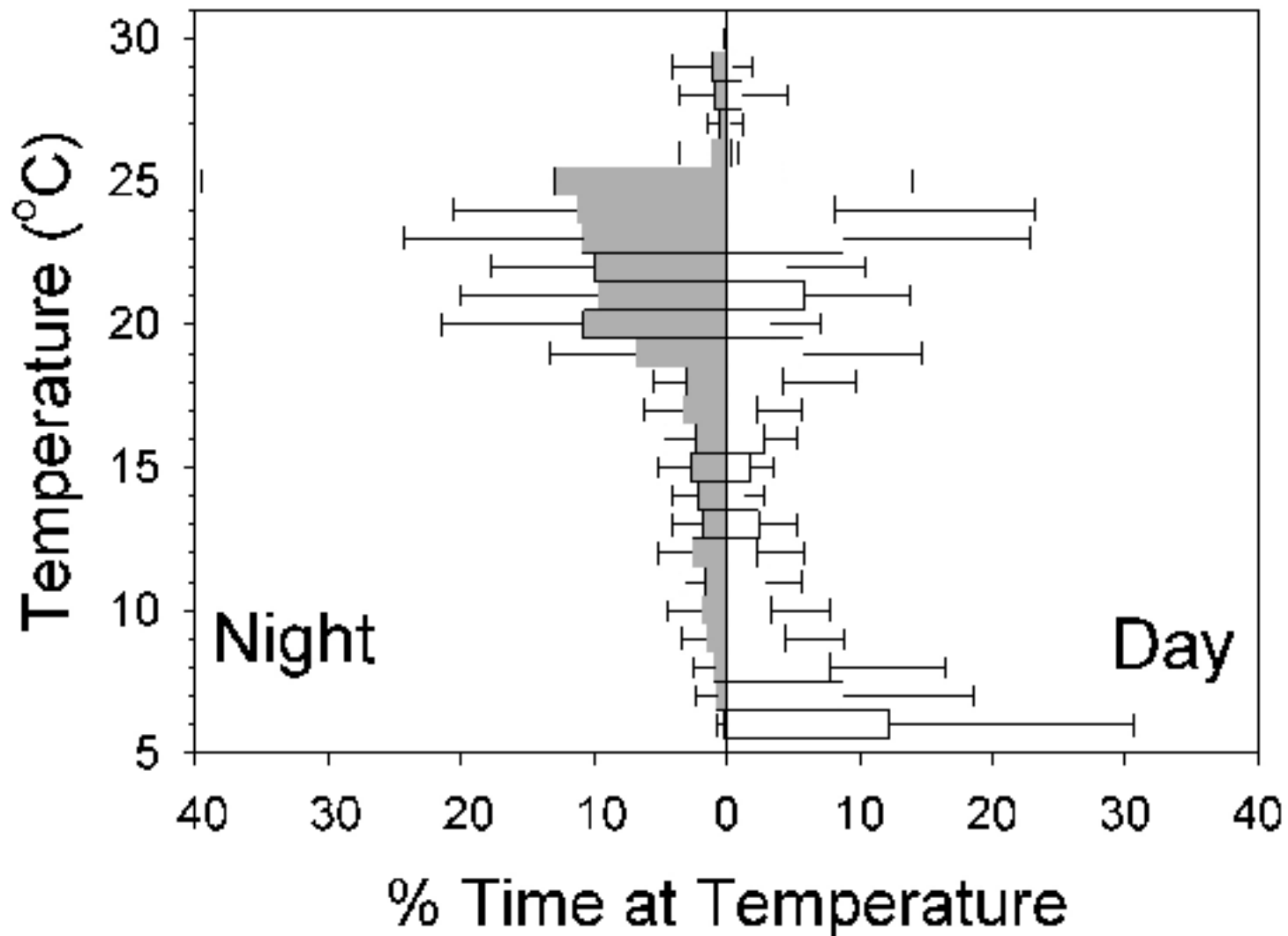
33 day trace



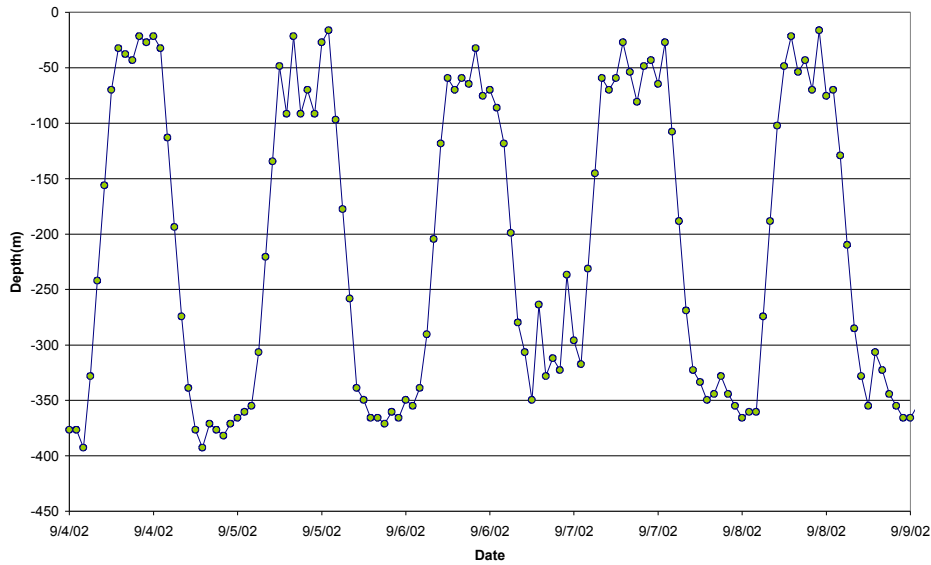
Swordfish time at depth



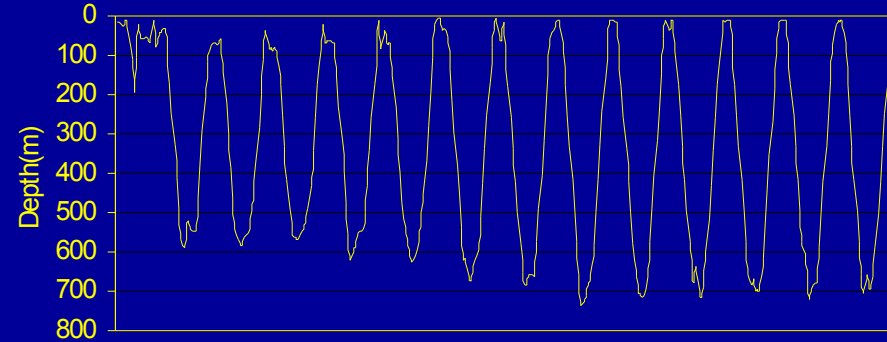
Swordfish time at temperature



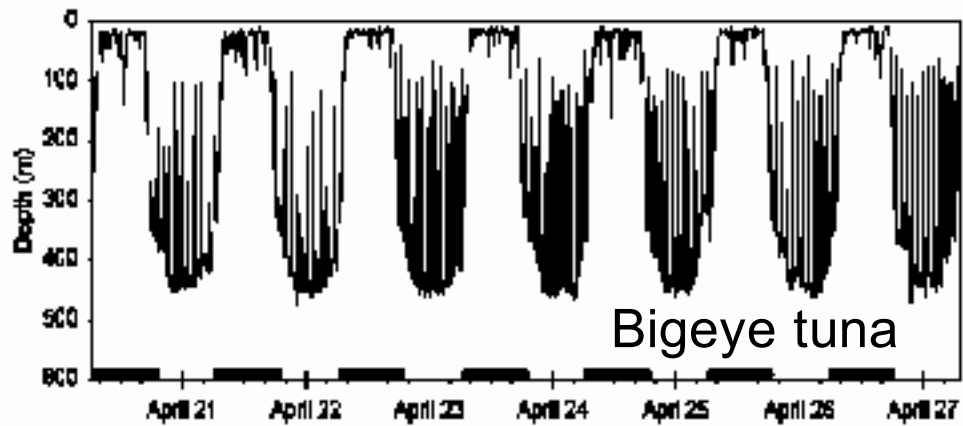
Bigeye thresher shark



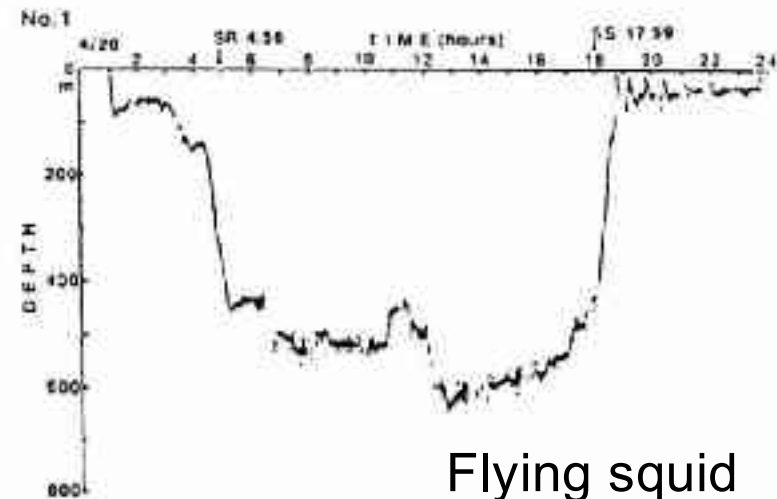
Swordfish #3



33 day trace



Bigeye tuna



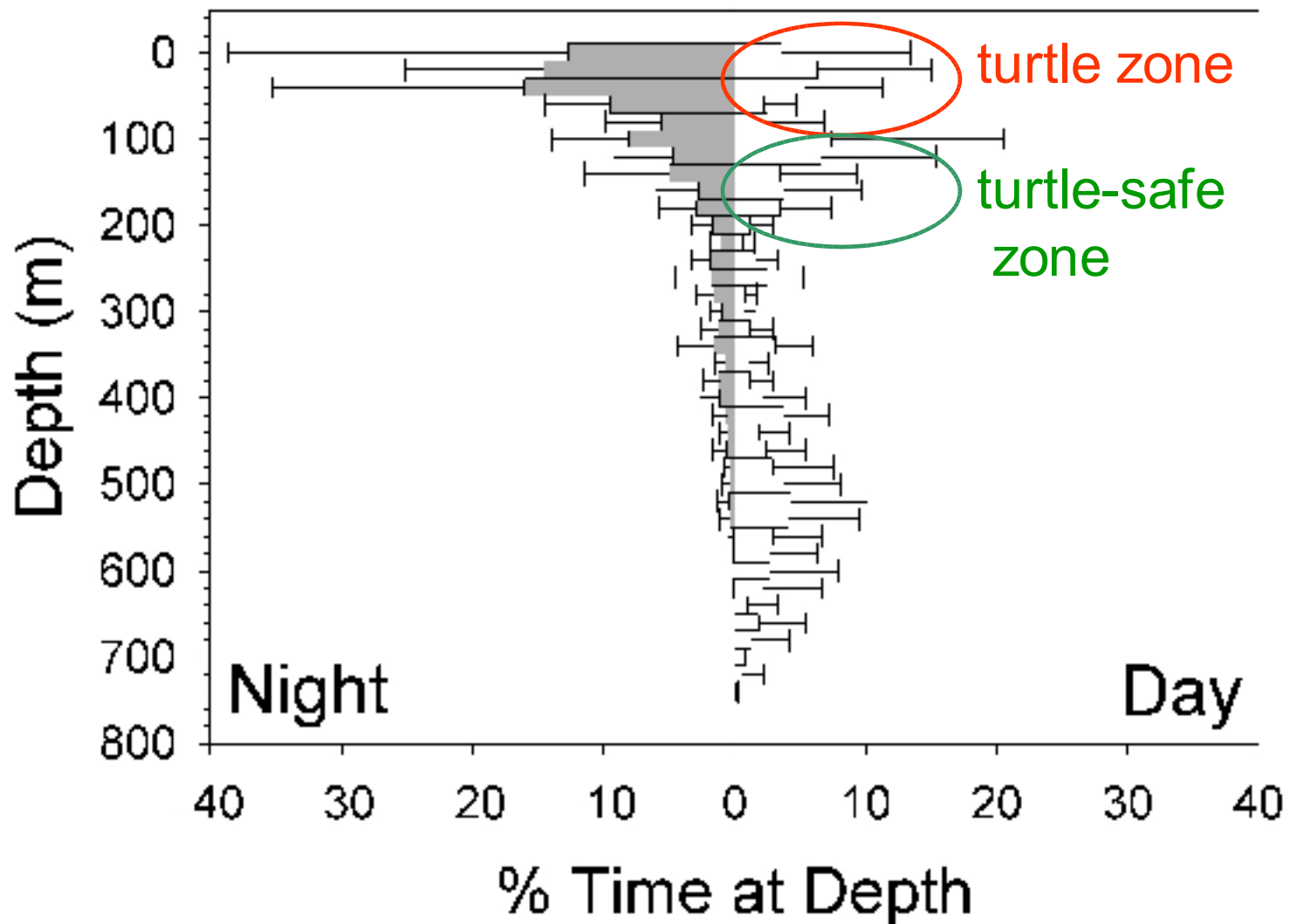
Flying squid

No. 3

There is a "guild" of large pelagic predators that have evolved remarkably similar behaviors!

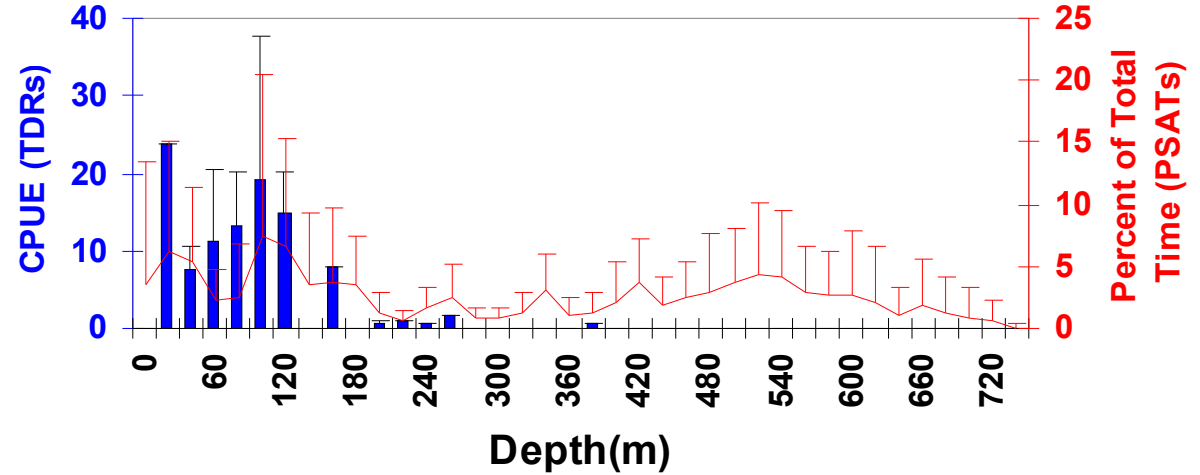
From: Y. Nakamura, 1993

Swordfish time at depth

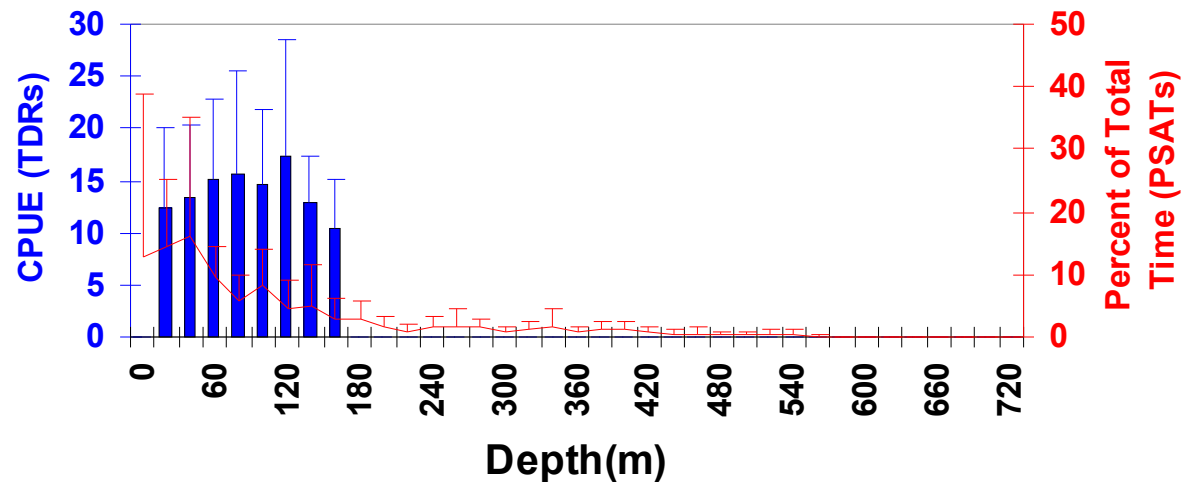


Can there be a viable daytime swordfish fishery by targeting hooks below $\approx 100\text{m}$?

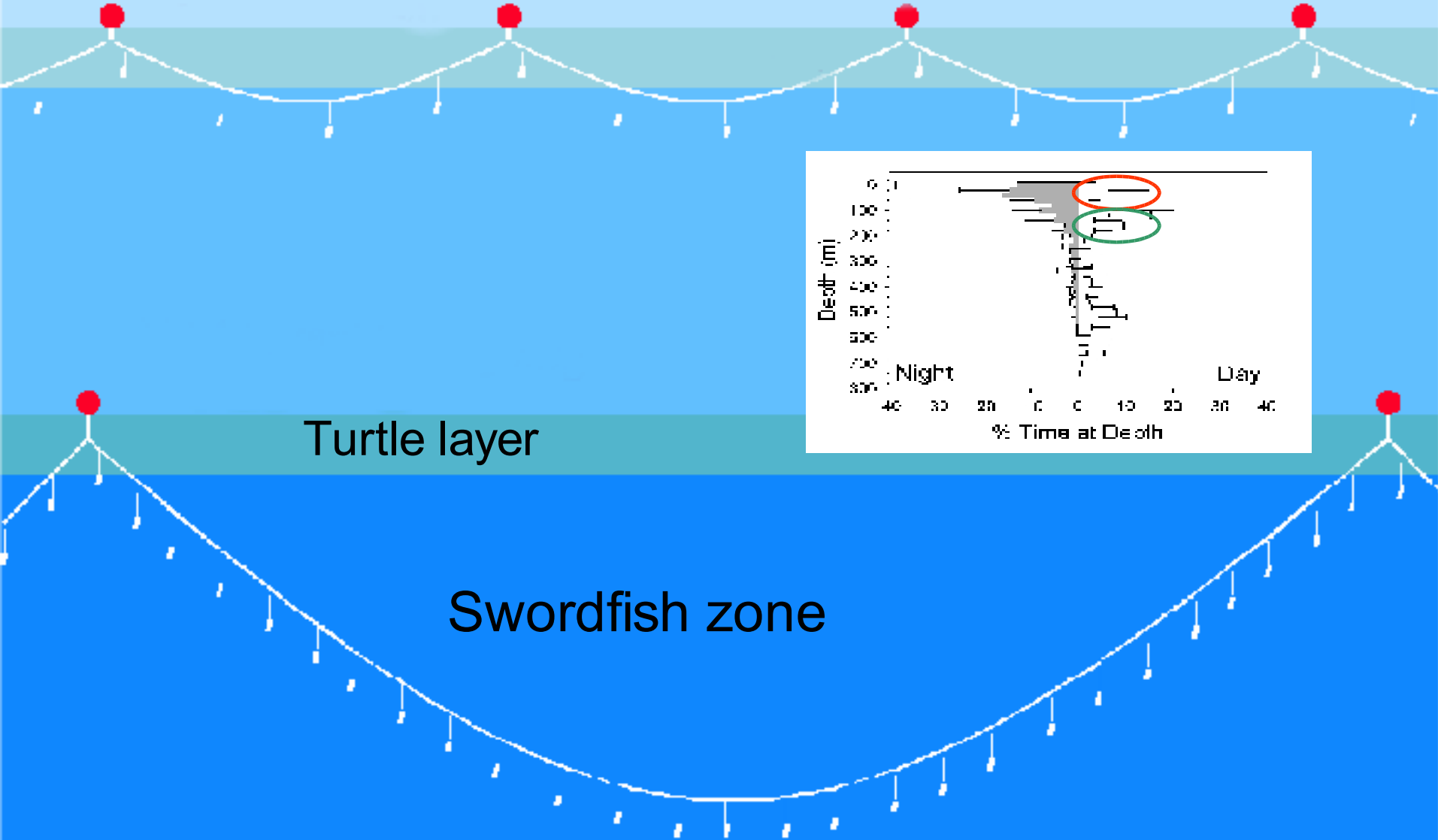
Swordfish CPUE v. Day Depth on 24 TDR Monitored Daytime Longline Sets, $r=66.90$, $P<<0.001$



Swordfish CPUE v. Night Depth on 156 TDR Monitored Nighttime Longline Sets, $r=69.04$, $p<<0.001$

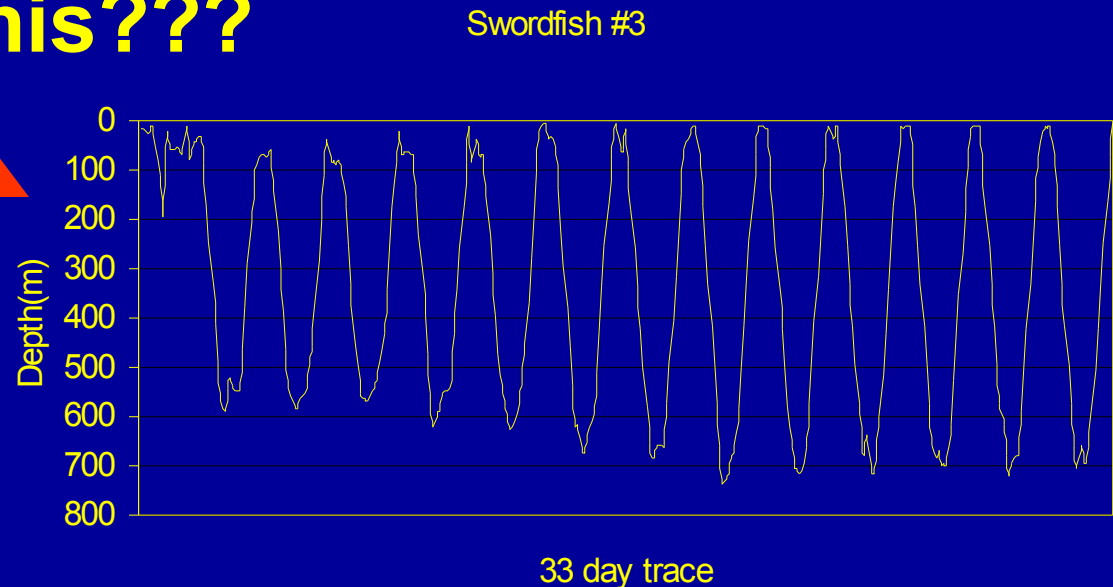


Longline gear can be targeted to specific depths.



PSAT Reporting rates are lower with swordfish than other species

- 2001: 4 of 8 ($\approx 50\%$)
- 2002: 5 of 17 ($\approx 30\%$)
- 2003: 0 of 3 (0%)
- **Because of this???**



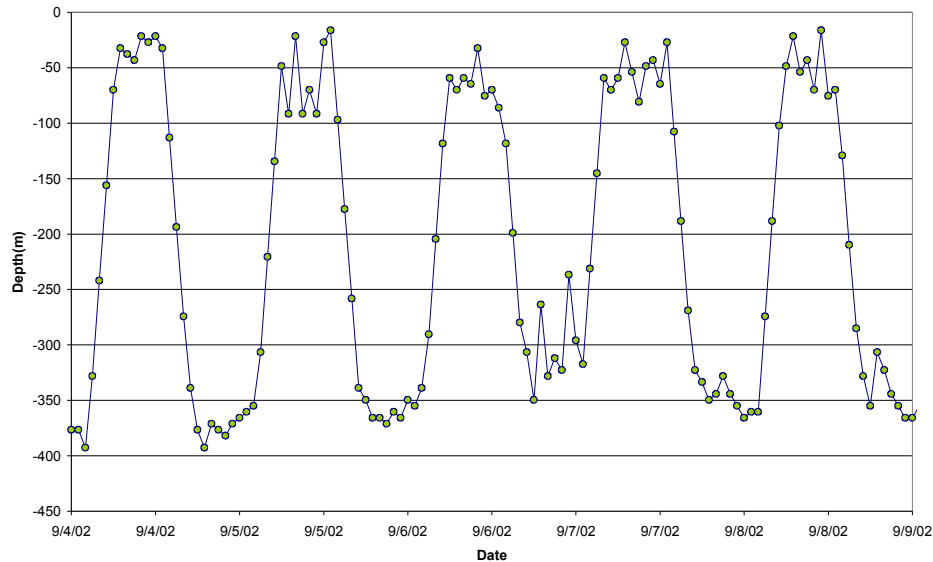
Swordfish #3



33 day trace

Swordfish PSAT reporting rate: 32% (9 of 28)

Bigeye thresher shark



Bigeye thresher shark PSAT reporting rate: 29% (2 of 7)

Tag retention in swordfish is problematic:

Range = 5-190 days,

Average = 58 days

Median = 33 days

None where near the 8-12 month retentions hoped for.

Nylon heads:

- Retention time: 5-104 days

Metal heads:

- Retention time: 5-190 days

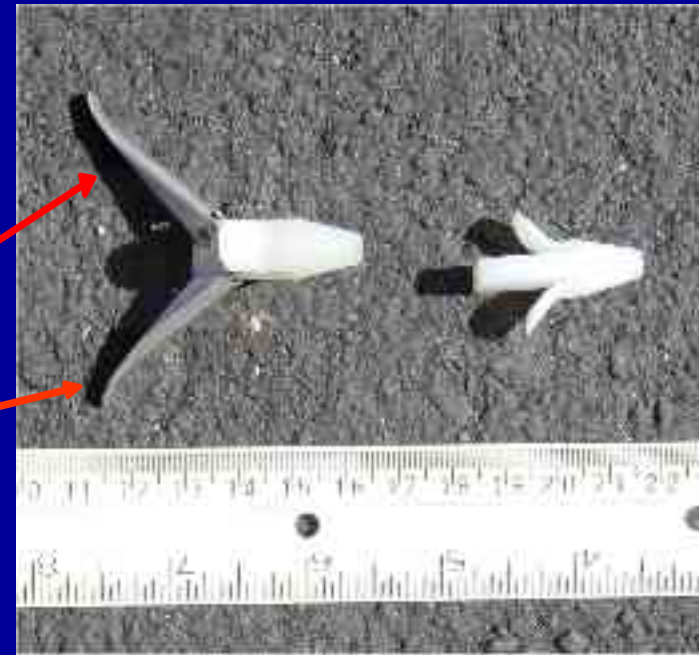


Recent modifications of tag head and tether



Swivel added to reduce torque of tag head in tissue

Speargun barbs added to increase surface areas



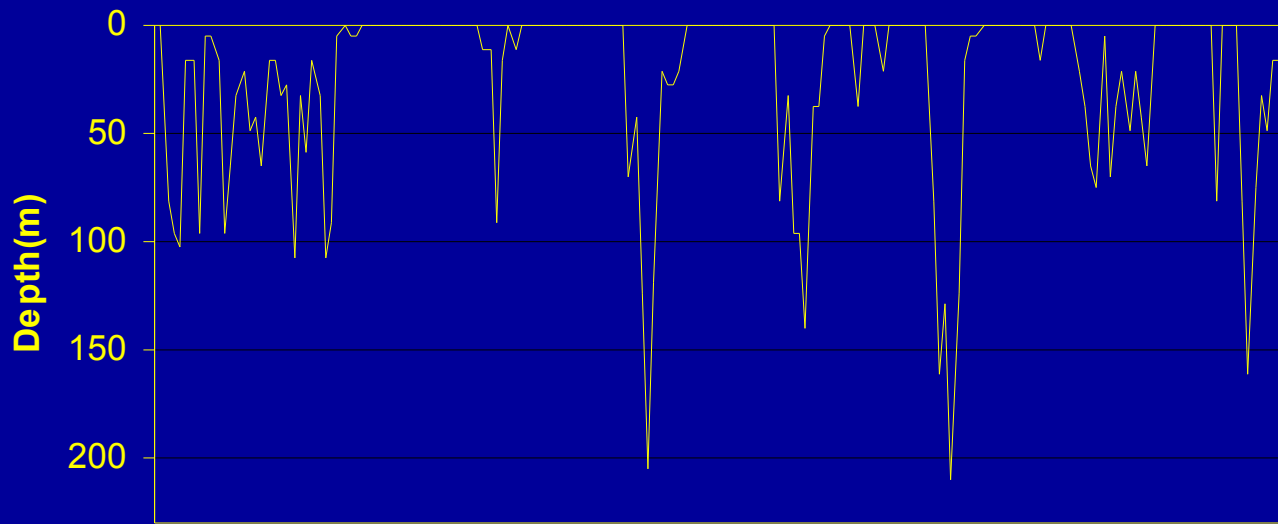
Total time at liberty for all tagged fish = 527 days

Fraction of days at liberty with depth data = 47%

But...

Fraction of days at liberty with geolocations = 11%

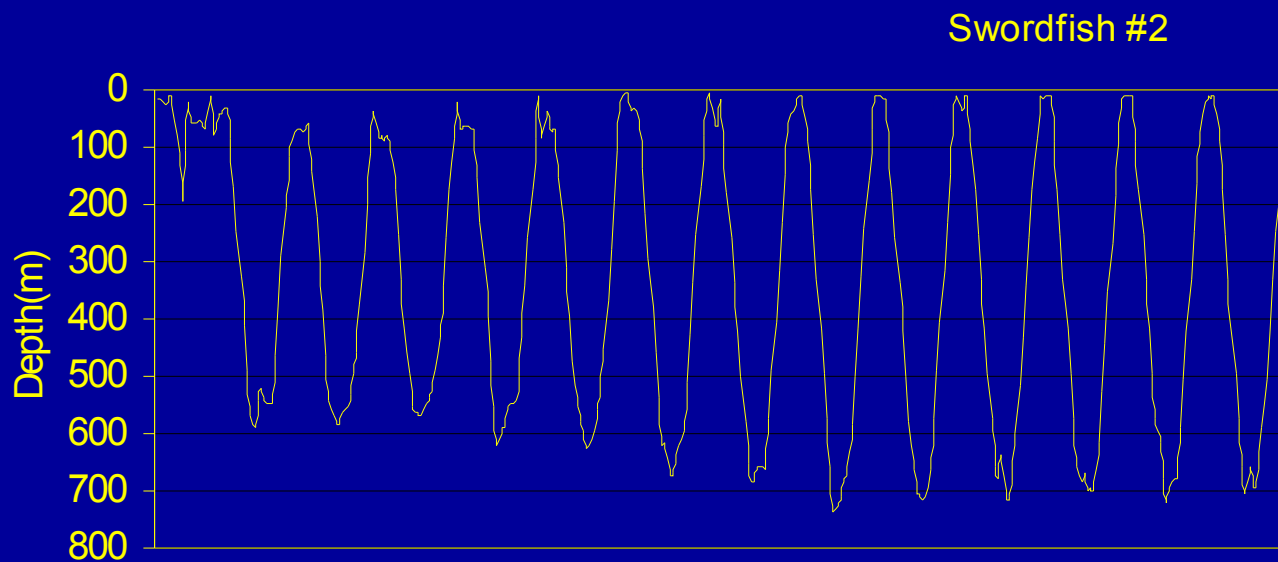




14 day trace

Swordfish #3

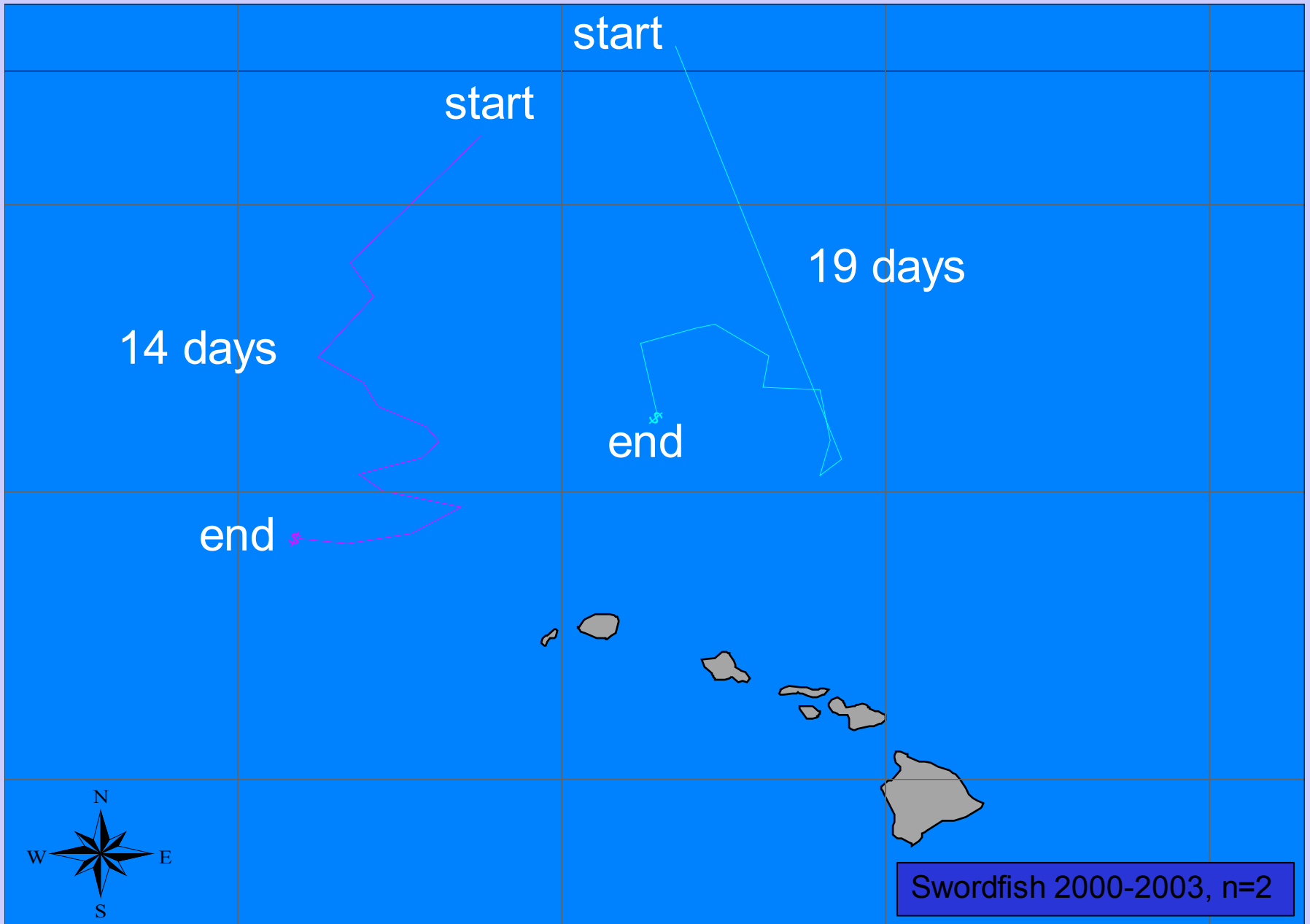
= Geolocations

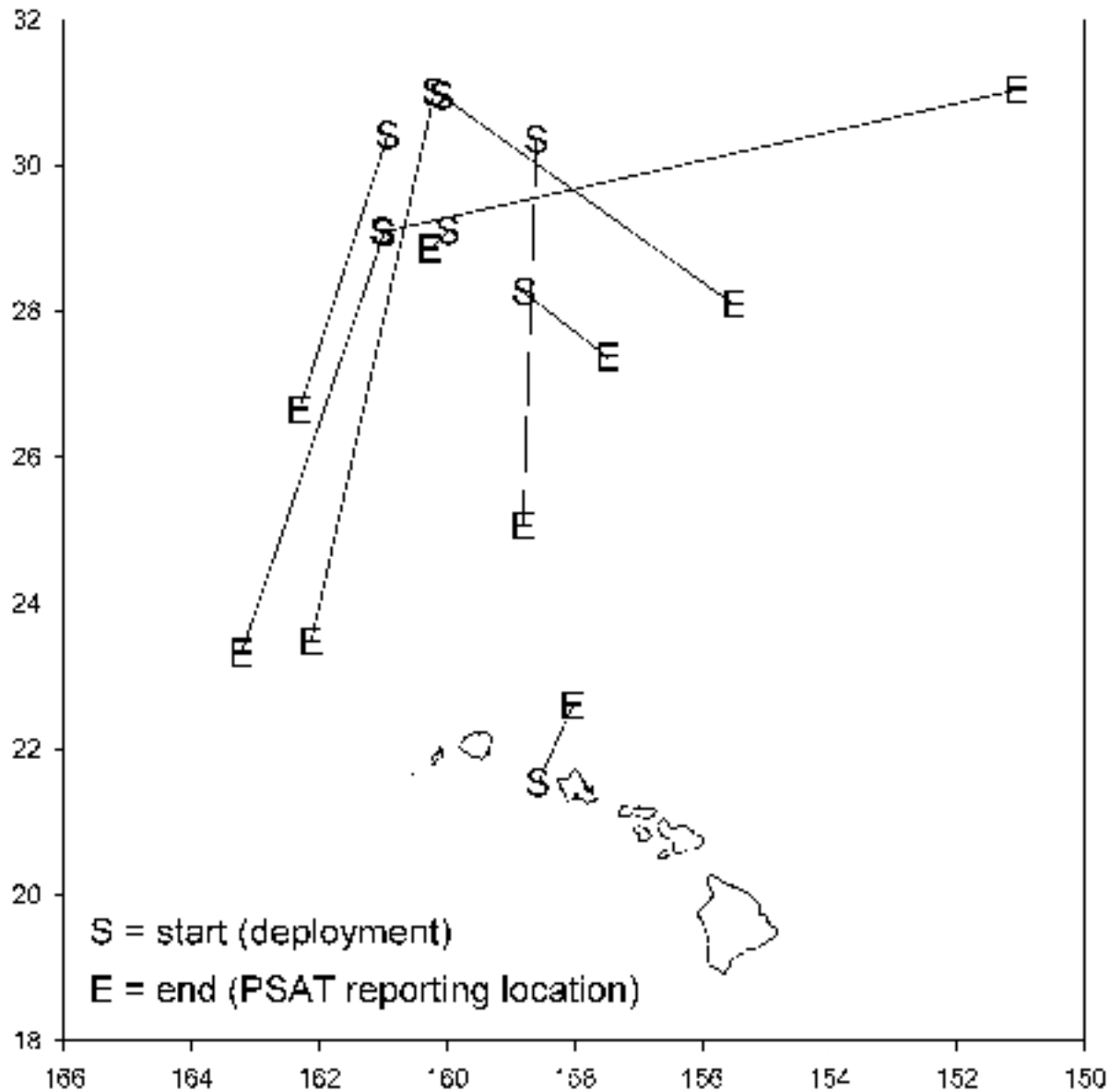


33 day trace

Swordfish #2

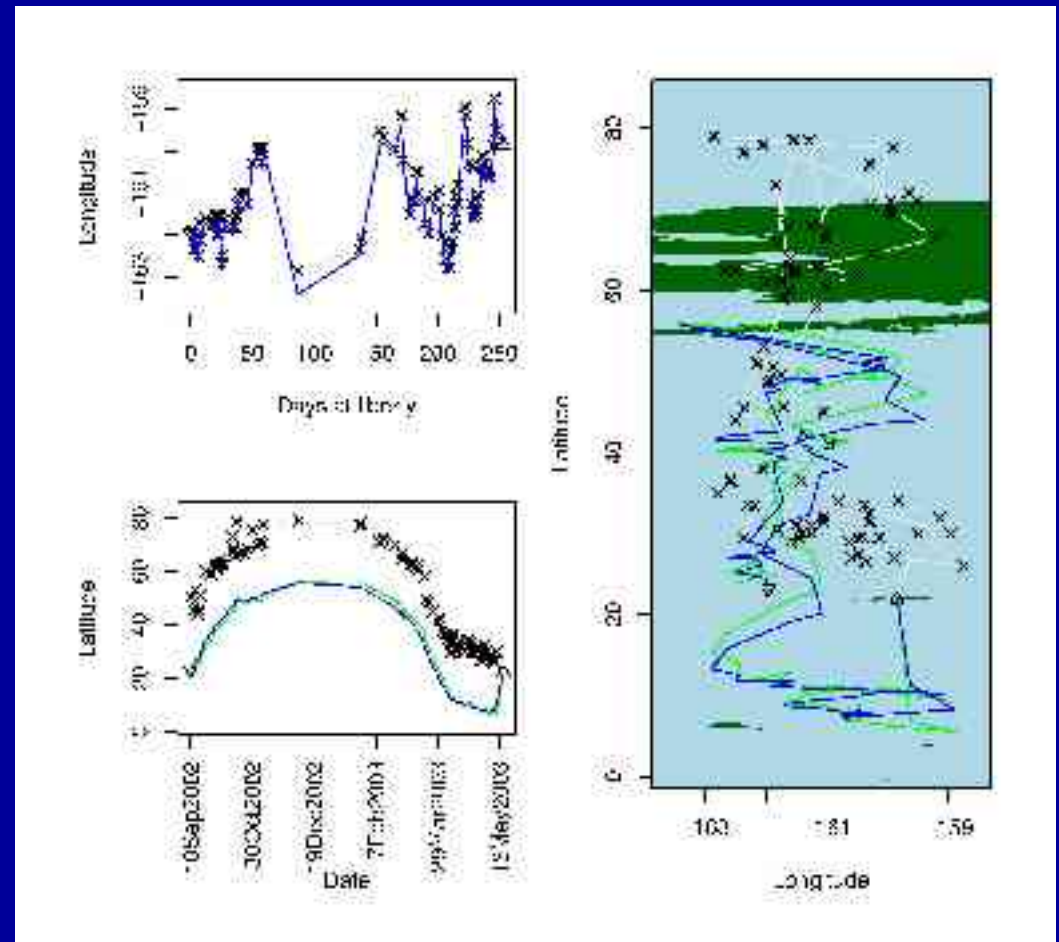
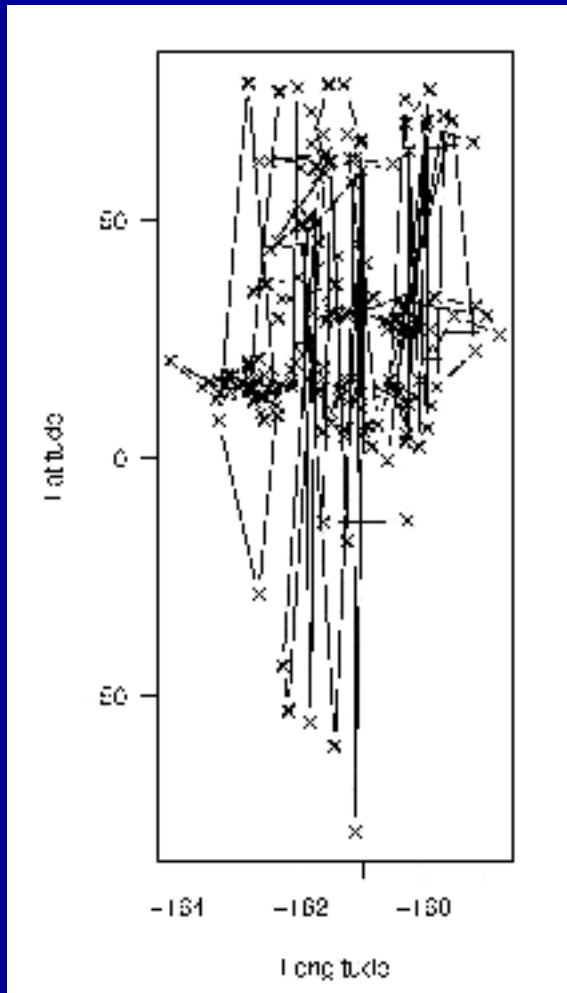
= No geolocations





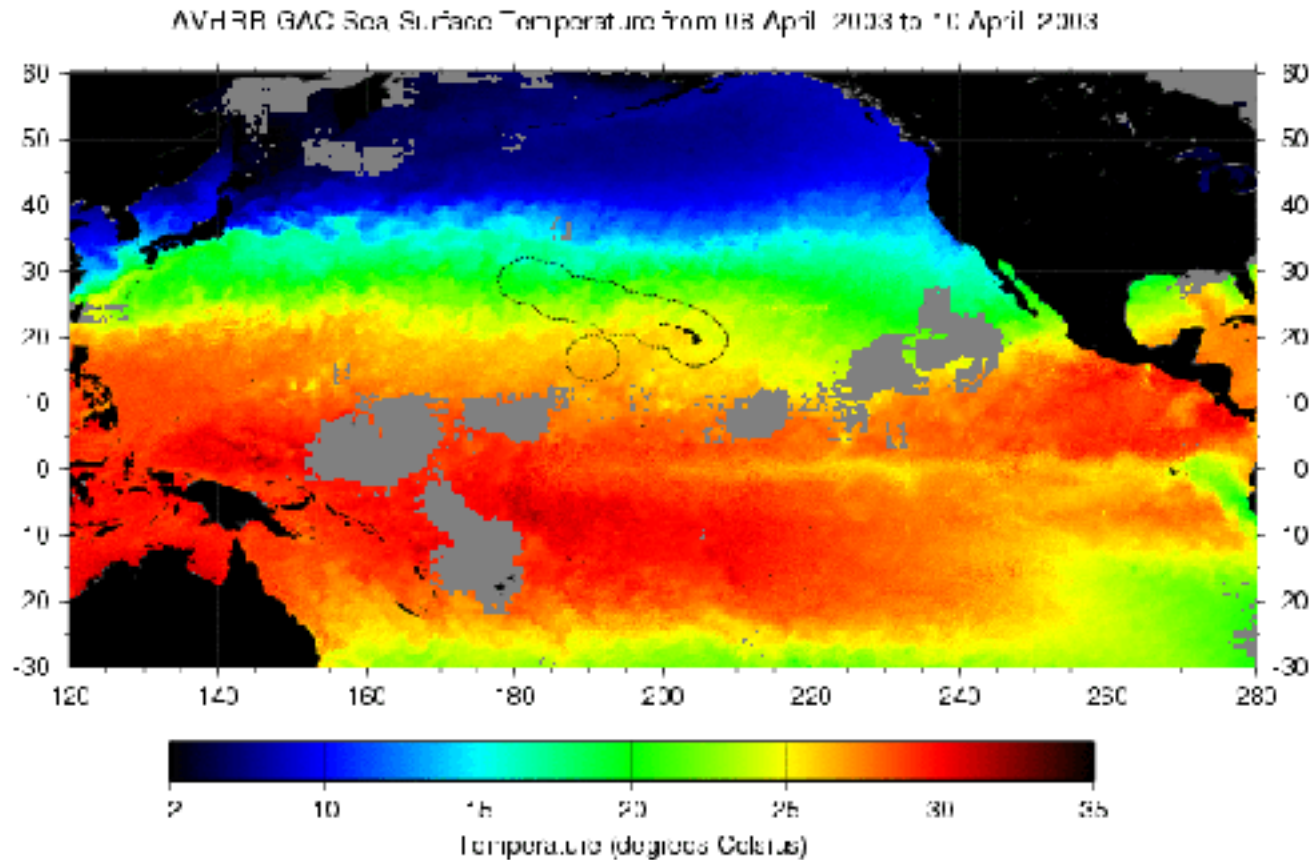
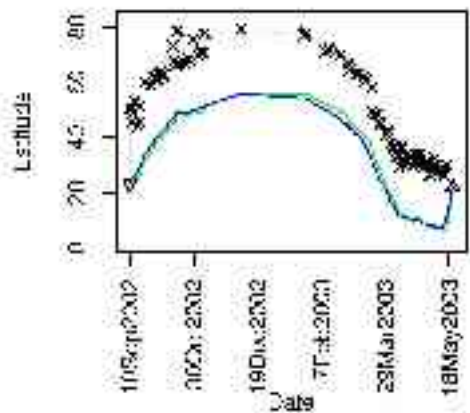
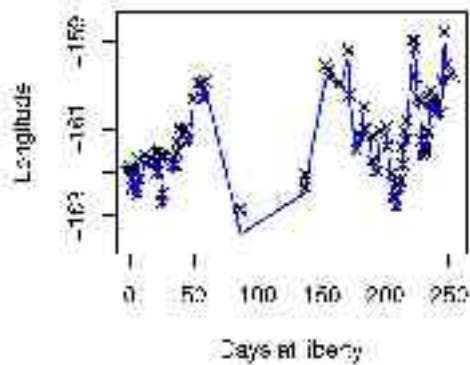
Swordfish PSAT
deployment and
reporting locations

PSAT attached to GPS-equipped drifter buoy -- Kalman Filter Analysis



Maps provided by Anders Neilsen and John Sibert

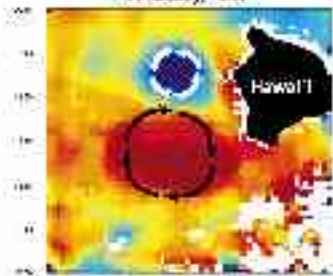
Sea surface temperature data can be used to correct latitude, but only where there is “sufficient” SST gradients.



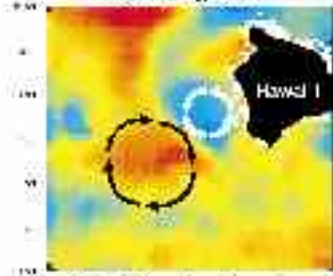
Sea Surface Temperature

QDES-11 (NOAA)

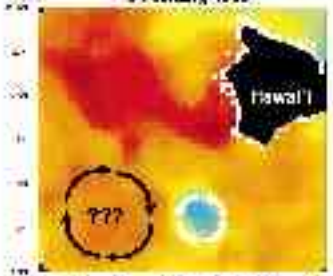
1 February, 1995



3 February, 1995



8 February, 1995



National Marine Fisheries Service
The United States
NEEDS Coastal Ecosystem Program
Hawaii Regional Office



Phytoplankton Chlorophyll

SeaWiFS (Orbimage Inc., and NASA)

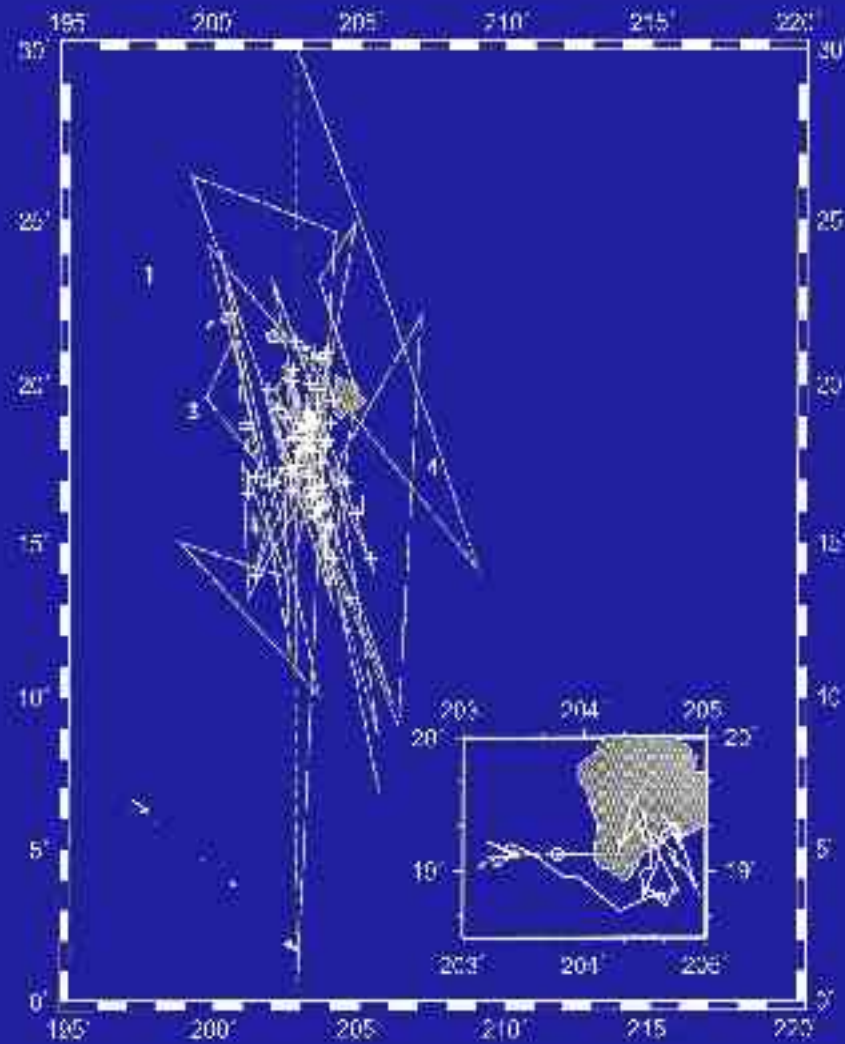
7 February - 9 February, 1995



10 February - 17 February, 1995



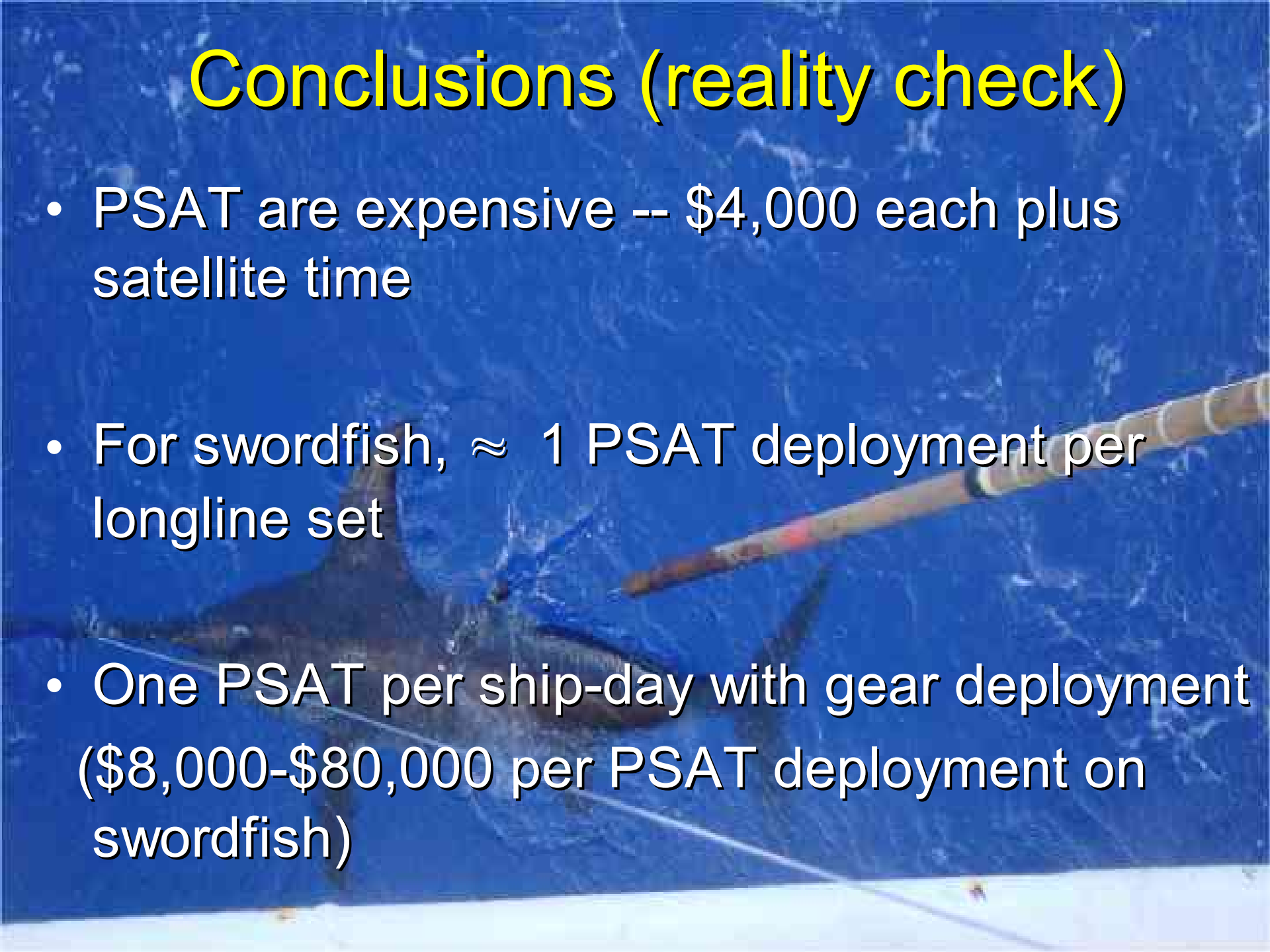
Movements of bigeye tuna carrying archival tag



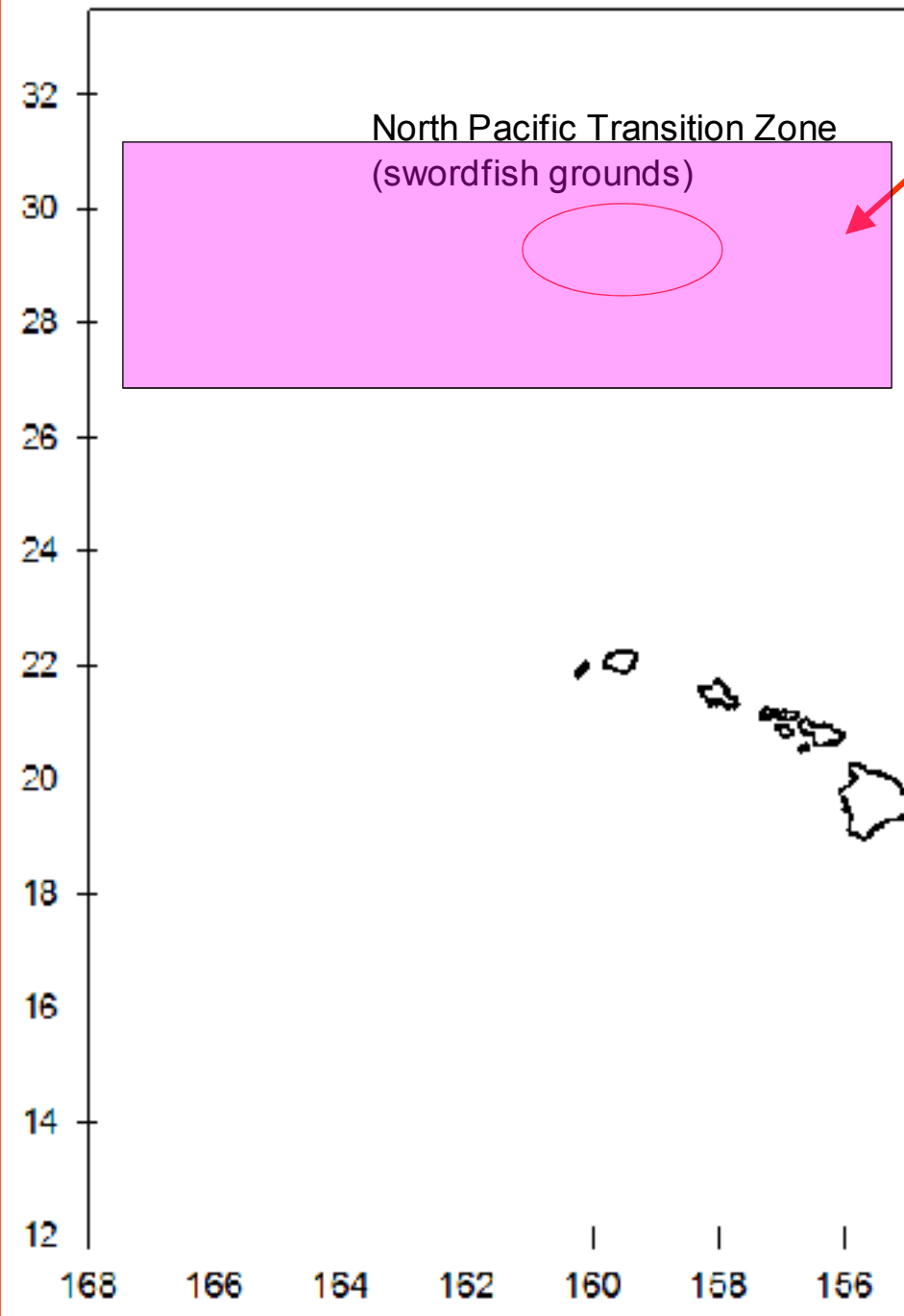
Conclusions (reality check)

- PSAT reliability and attachment issues remain for all species
- Failure modes remain unknown (unknowable?)
- Design – test, redesign – retest cycle is often a year

Conclusions (reality check)

- PSAT are expensive -- \$4,000 each plus satellite time
 - For swordfish, \approx 1 PSAT deployment per longline set
 - One PSAT per ship-day with gear deployment (\$8,000-\$80,000 per PSAT deployment on swordfish)
- 
- A photograph of a swordfish being hoisted by a longline set on a boat deck. The fish is dark and sleek, with its long, pointed snout visible. The longline is a thick, light-colored rope that runs across the deck. The background is a bright blue sky.

Nasty Weather Zone



PSATs:

2001: 8 deployed, 4 reported
2002: 17 deployed, 5 reported
2003: 3 deployed, 0 reported
2004: ?????

Conclusions (reality check)

Geoposition estimates based on light levels (i.e., times of sunrise, sunset, and local noon) have wide scatter

Mathematical filtering technique (Kalman filter) and SST correlations offer promise, but...

Correlations with mesoscale oceanographic or geographic features remain tenuous

Conclusions (reality check)

- PSATs providing data on broad range of species.
- Data is repetitive (confirmative?) of what is already known.
- **Depending on your questions, PSATs may well be your last method of choice!**