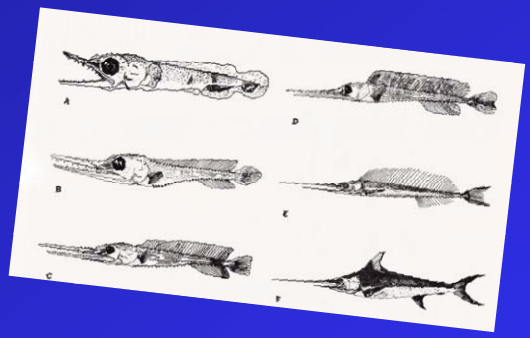
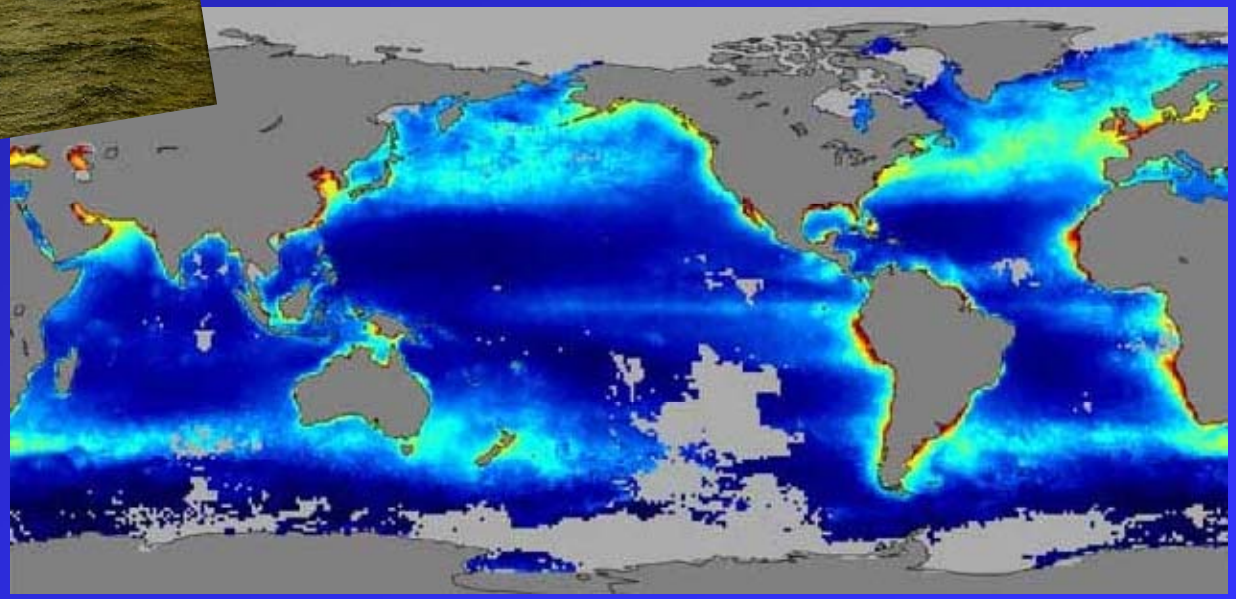
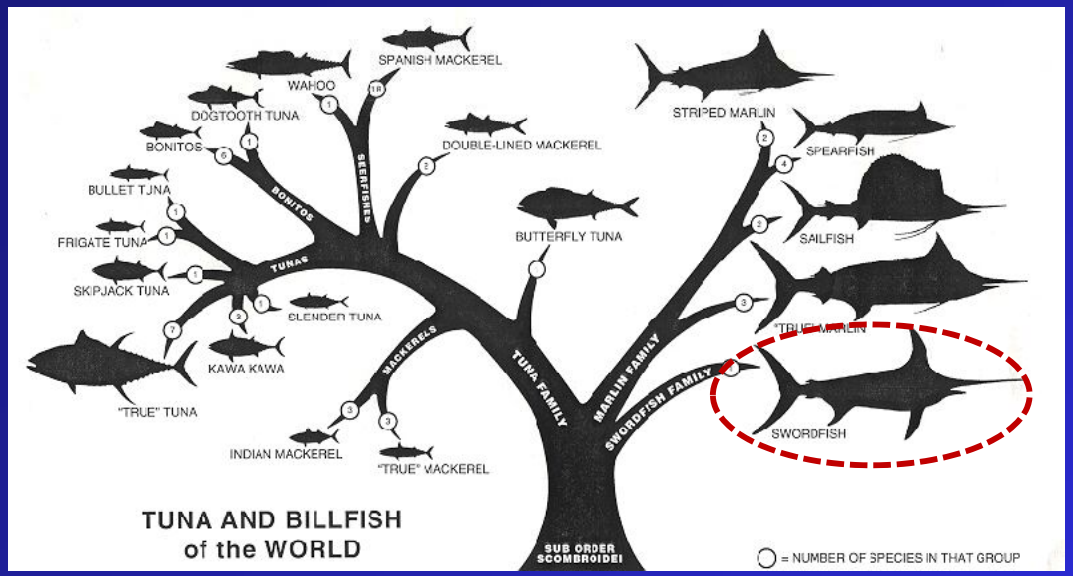
Swordfish
Life History, Habitat and Fisheries overview





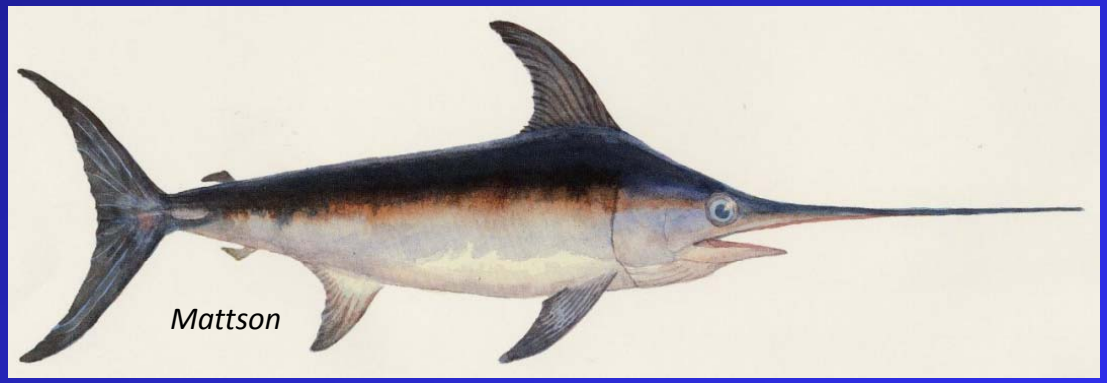
David Itano
Pelagic Fisheries Research Program
University of Hawaii

Life history: general description



Basic life history facts

- Single species worldwide
  - Several independent or semi-discrete stocks
- Long, flattened sword (feeding, aggression)
- No pelvic fins, single caudal keel



Source: FAO and FISHBASE.ORG
Mattson

Life history: general description

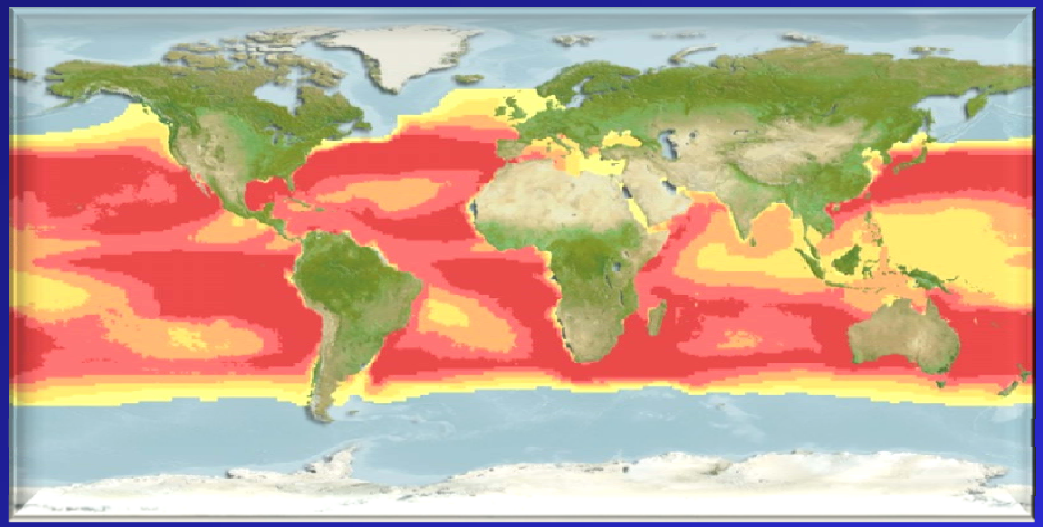
Basic life history facts

- Single species worldwide
  - Several independent or semi-discrete stocks
- Long, flattened sword (feeding, aggression)
- No pelvic fins, single caudal keel
- Max recorded weight 1400 lbs (635 kgs)
  -IGFA All Tackle record 1182 lbs (536 kgs) set in 1955

Source: FAO and FISHBASE.ORG
Mattson

Life history: general description

Global Swordfish distribution



Basic life history facts

- Range ~ 61 N - 50 S
  - Oceanic habitat but can be coastal
- Preferred temp 64° - 72° F
  - Can tolerate 41° - 81° F (5-27°C)
- Surface to > 2000 ft (can be rapid)
  - Typically *deep day/shallow night*

submersible Alvin
WHOI

Deep-sea submersible R/V Alvin was attacked by a swordfish while diving at greater than 2200 ft (670 m)

Archival tag data also indicate diving behavior to extreme depths.

DeMartini et al. 2007
FISHBASE.ORG
Woods Hole Oceanographic Institute

Life history: growth and biology

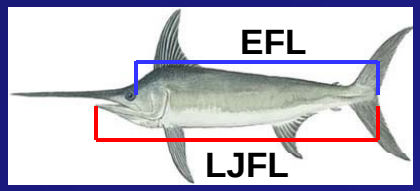
Michael Lerner, 1940 Peru/Chile Expedition

Basic life history facts

- Rapid initial GROWTH,
  - females larger, grow faster
  - Nearly all SWO > 300 lbs are female
  - Can at times segregate by sex
  - Females more common in cooler waters
- MIGRATE seasonally
  - Feeding, reproduction, optimal water temperature profiles
- FEEDING is opportunistic
  - Fish, squid, deep scattering layer (DSL)
  - Diet may differ from LL baits

➢ Max age ~15+ years
  - Ageing by anal fin ring counts

Source: FAO and FISHBASE.ORG
Hyde et al. 2005
IGFA



Life history: size/age at maturity

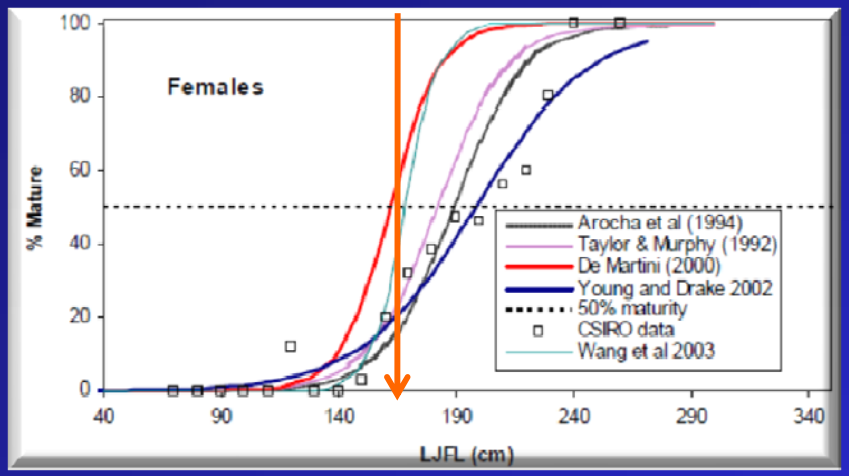


Figure 1: L^{50} maturity for female swordfish from several studies

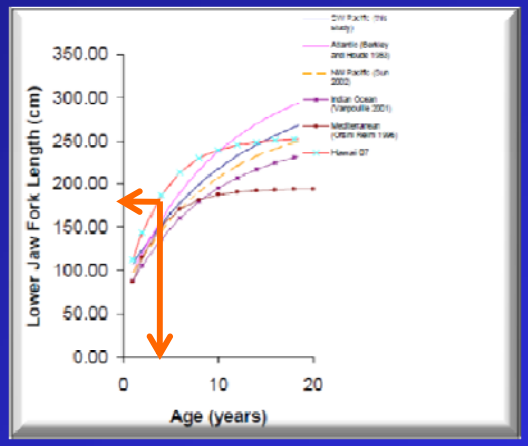


Figure 2: LENGTH at AGE of swordfish from several studies

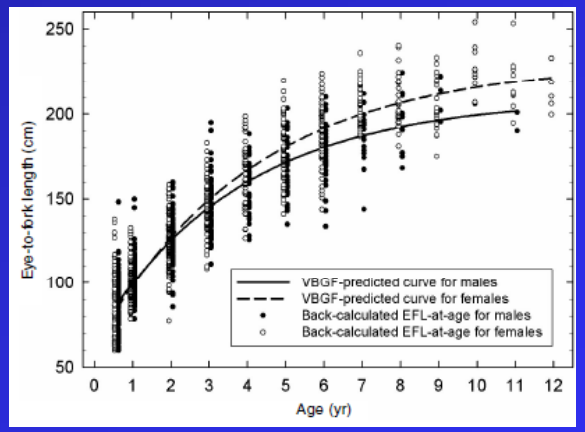


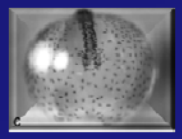
Figure 3: Eye Fork LENGTH at AGE of male and female swordfish from Hawaii shallow-set longline fishery

Basic life history facts

- Size at maturity - many differing estimates
- Good support for DeMartini et al. (2000)
  - L^{50} Male: 40 in EFL (102 cm)
  - L^{50} FEMALE: 57 in EFL (144 cm)
- Age at female L^{50} maturity
- (DeMartini et al. 2007)
  - ~4 years
- Characterized by
  - **Rapid growth**
  - **Early maturity**

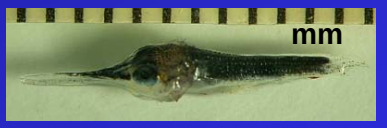
Figures 1, 2: Young et al. 2008. WCPFC-SC4-BI-IP-2
Figure 3: Dimartini et al. 2007

Fertilized egg

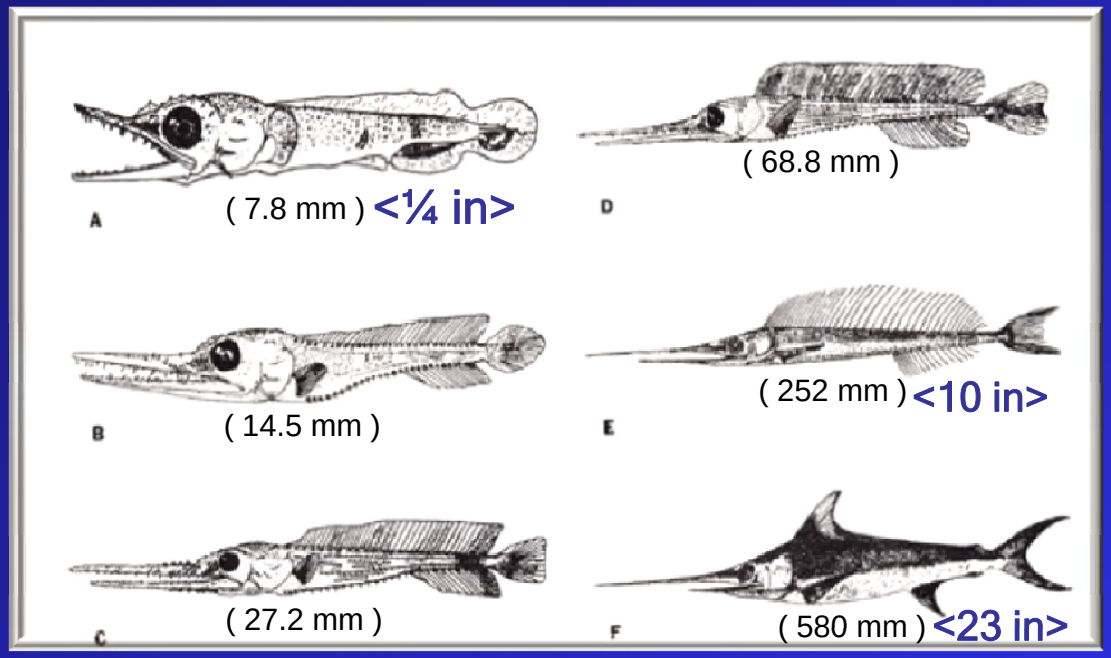


| 1.6 mm |

Life history: reproductive biology



10 mm juvenile



Basic life history facts

- Broadcast spawners in surface waters
  (ideal 73°-75°F, 23°-24°C)
- High fecundity (millions of eggs/spawn)
  - Solitary pairing of males and females
- Larvae hatch at 4 mm
- Spawning throughout year in tropics
  - Spring/summer in temperate regions

Hyde et al. 2005
Jones 1962; Arata 1954; Nakamura et al. 1951
NOAA Fisheries, Pacific Islands Fisheries Science Center

Life history: adaptive physiology

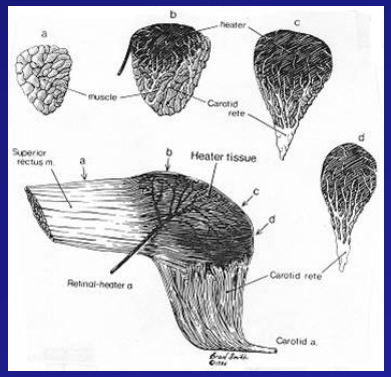


Figure 1: Superior rectus muscle (eye), modified for heat retention

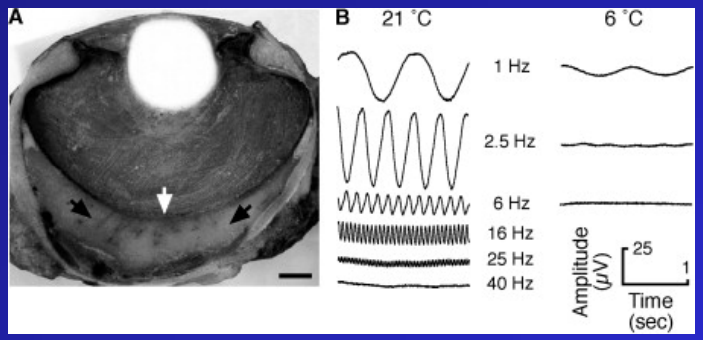


Figure 2: Swordfish eye showing fatty layer that insulates warm blood from heater organ to supply retina resulting in increased retinal response by temperature

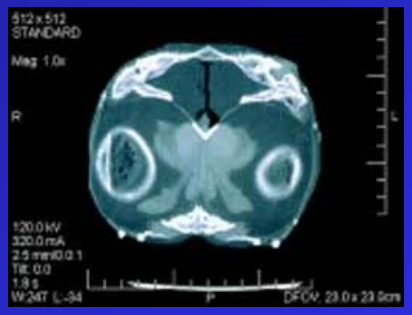


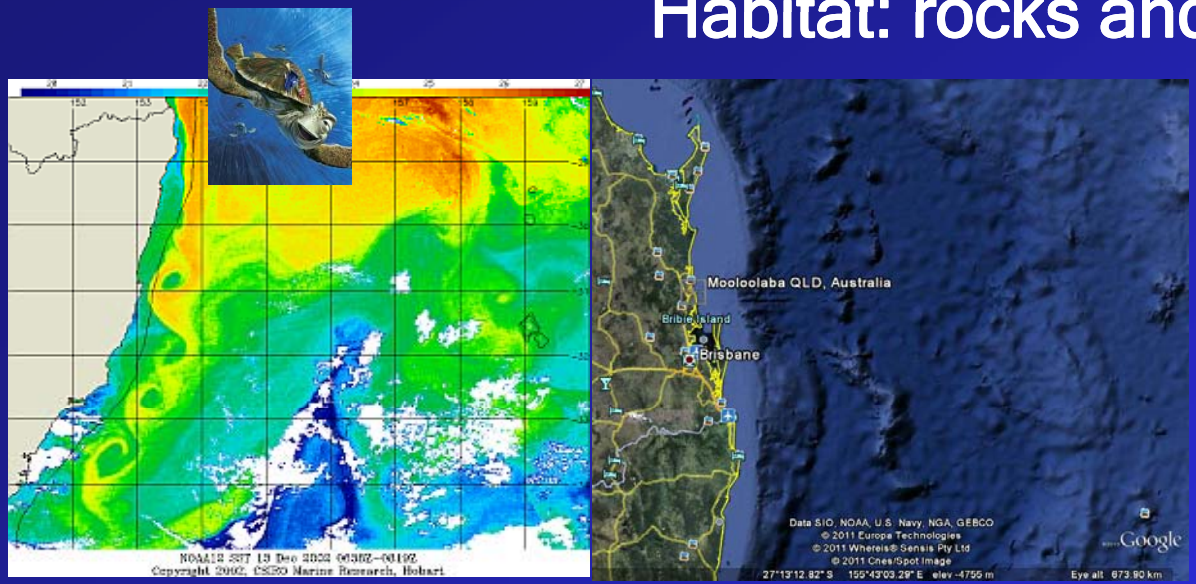
Figure 3: Differential temperatures in the brain and eyes of a swordfish

Specialized development for deep-diving behavior

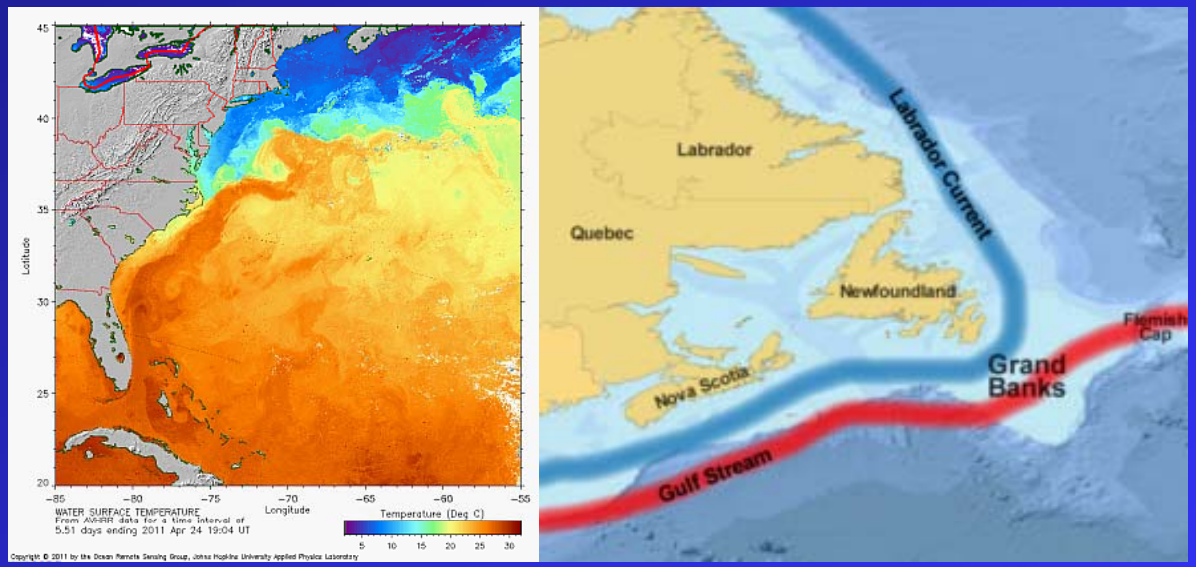
- Swordfish possess specialized **brain and eye heater organs** that promote efficient hunting and feeding at depth
- Blood from carotid artery is warmed via a **countercurrent heat exchanger** and insulated by fatty tissue within the eye
- Swordfish can maintain brain and eye temperatures between 66° - 82° F (19-28C)
  - Can represent a 10 °- 15°C increase above surrounding water

Carey 1982
Figure 1: Brill
Figure 2: Fritsches et al. 2005
Figure 3: Schwab 2002

Habitat: rocks and water



East Australia Current + West Wind Drift / Mooloolaba Grounds (seamounts)



Labrador Current + Gulf Stream / Georges Bank, Grand Banks

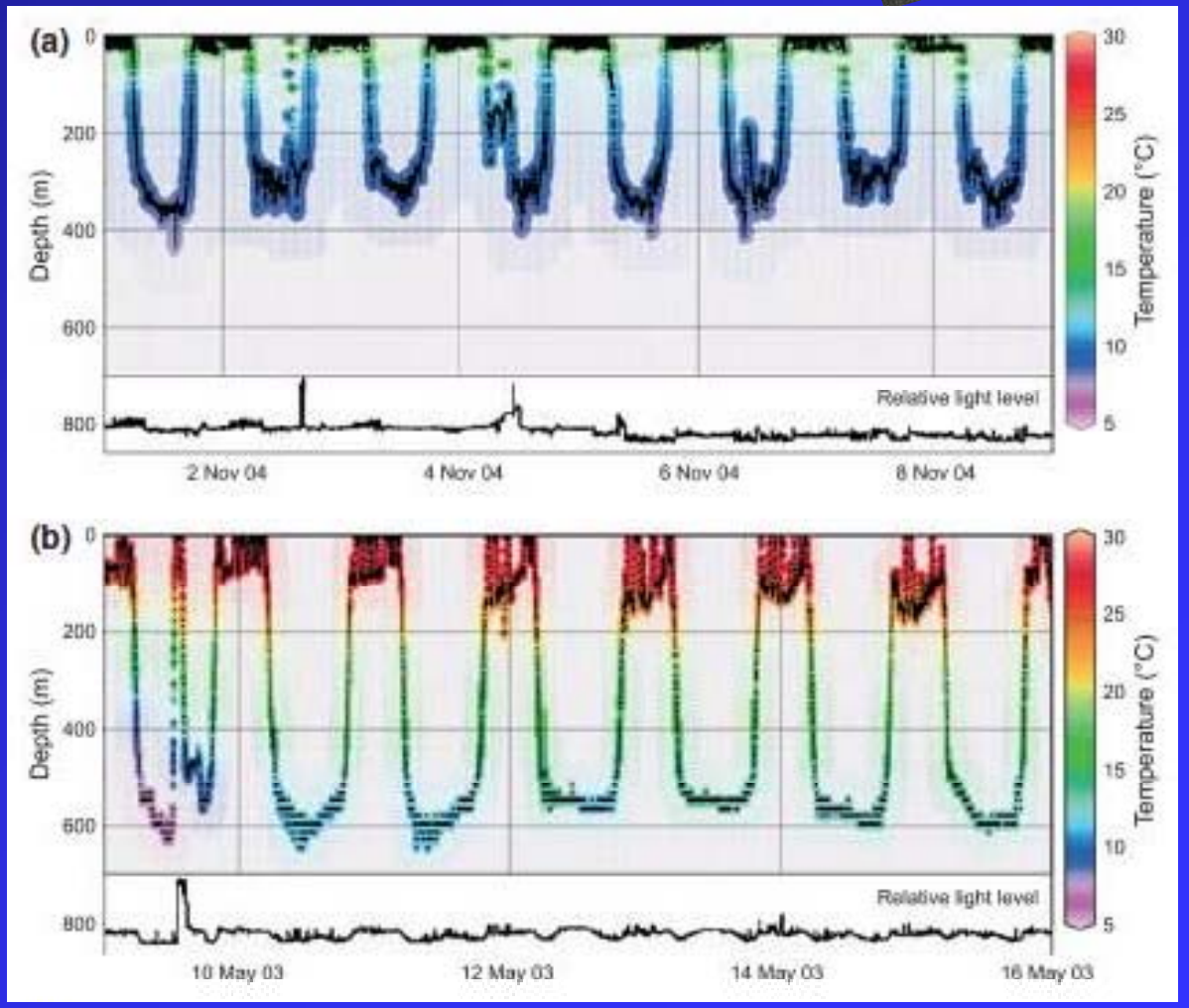
Habitat preferences

- Underwater features
  - banks
  - Seamounts
  - Continental shelves
- Convergence zones
  - Where warm currents meet cool nutrient-rich waters
  - Can be Oceanic or Coastal
- Frequent productive areas with high prey abundance

Source: CSIRO, NASA, SeaWifs

Habitat: vertical behavior (how deep and when)

Use of “popup” satellite archival tags



Daytime depth range appears to be determined by a combination of:

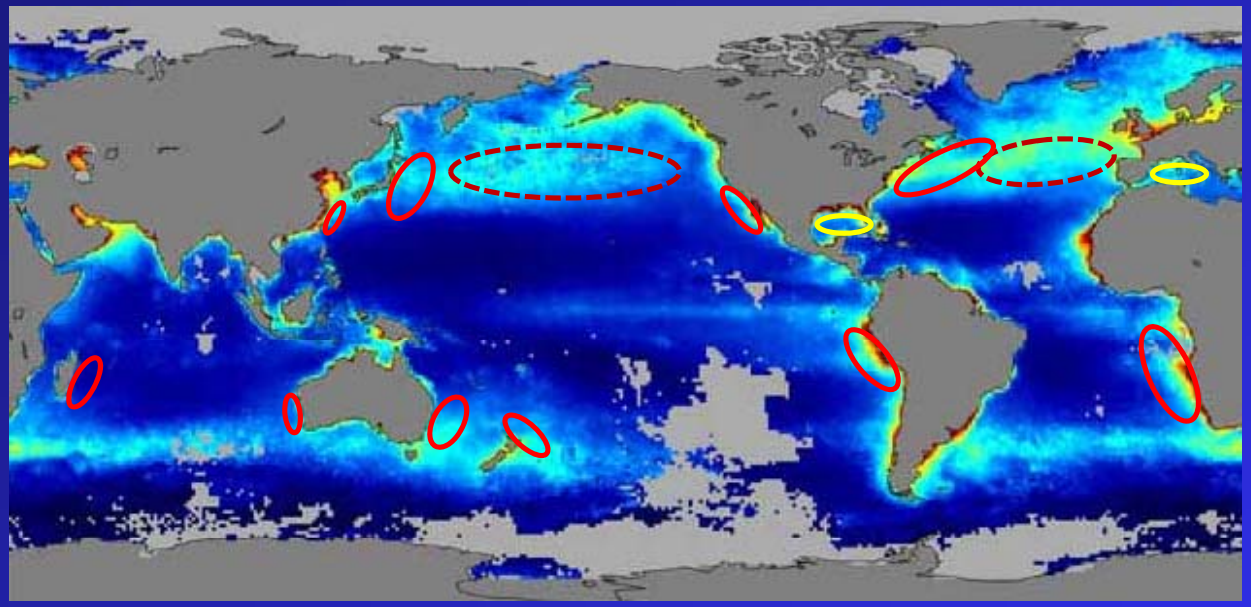
1) Temperature at depth
2) Oxygen concentration at depth
3) Water clarity

… as fish remain at a constant daytime light level that determines depth of deep scattering layer (food)

Figures: Brill
Dewar et al. 2011

Habitat: oceanic & coastal areas

Net Primary Productivity and Fisheries



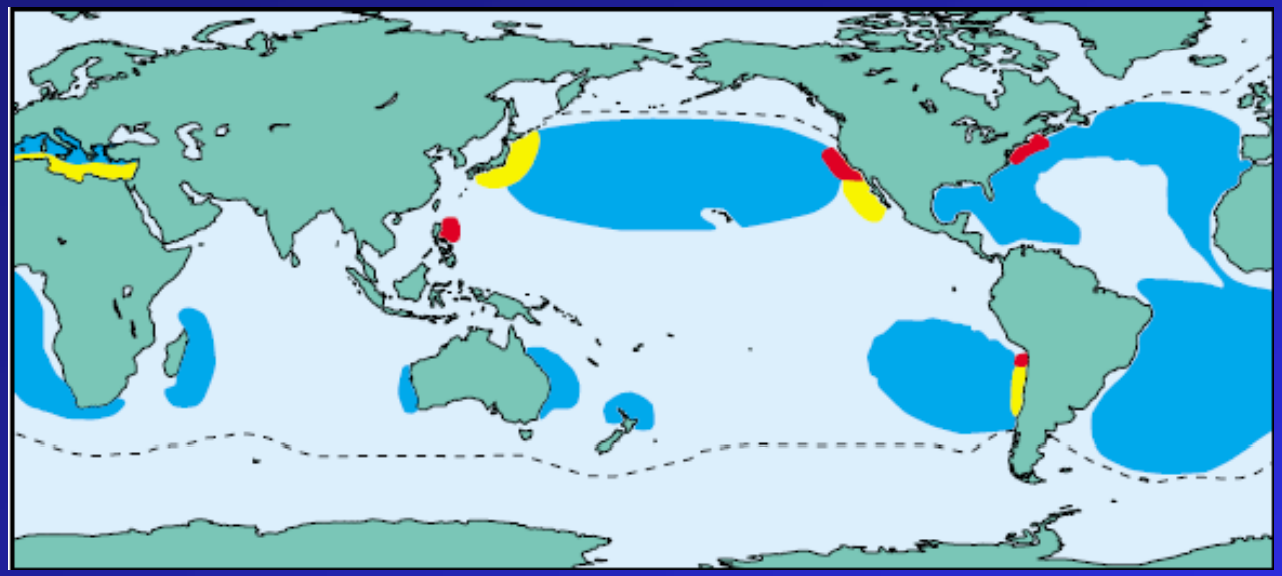
Swordfish Fisheries occur in:

- Oceanic frontal zones (dashed red ovals)
- Enriched seas (yellow ovals)
- Coastal areas (red ovals)
  - Warm/Cold mixing of currents
  - Coastal upwelling
  - Seamounts and shelf structure

Figure source: NASA

Swordfish Fisheries: gear types

Gear types and regions



Swordfish taken by:

- Harpoon (RED)
- Driftnet (YELLOW)
- Targeted Longline (BLUE)

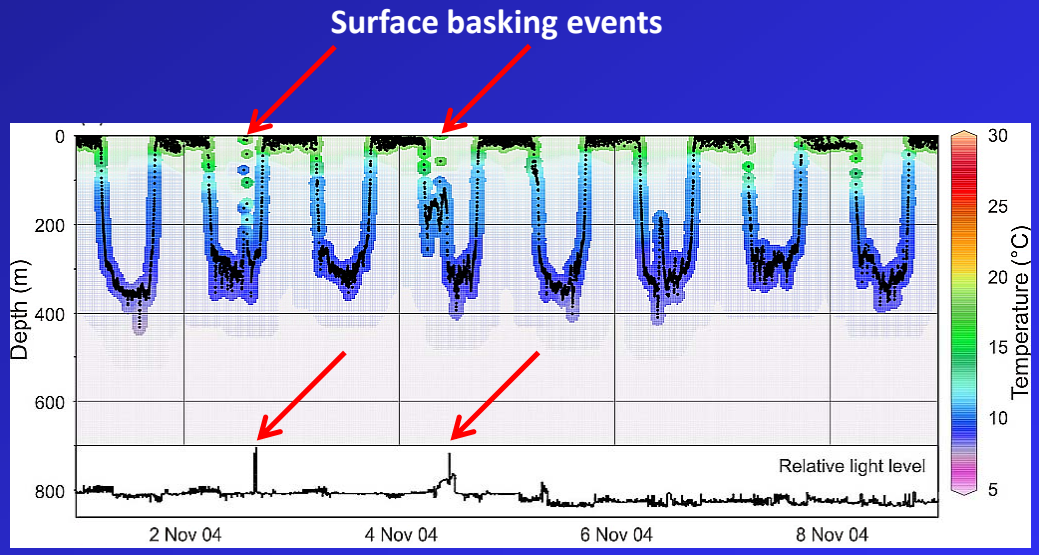
~100,000 metric tonnes (mt) per year

About 50% of all swordfish landings are taken as non-Target catch in tuna targeted longline fisheries

Figure source: Ward 2000. PFRP Vol 5: No 4
Data table: FAO

Swordfish Fisheries: Harpoon

Swordfish "finning" behavior



Temperature (color coded), depth and light levels of swordfish off California from PAT tag data

Harpoon fisheries:

- Exist where swordfish "bask" in calm, coastal waters near deep cold, nutrient rich waters
- Swordfish bask to recover from deep diving behavior, to:
  - Warm up
  - Recover from low Oxygen levels
- Basking only occurs in certain regions of the world

Dewar et al. 2011

Swordfish Fisheries: Harpoon

Swordfish "stick" boats

Mediterranean swordfish harpoon boat

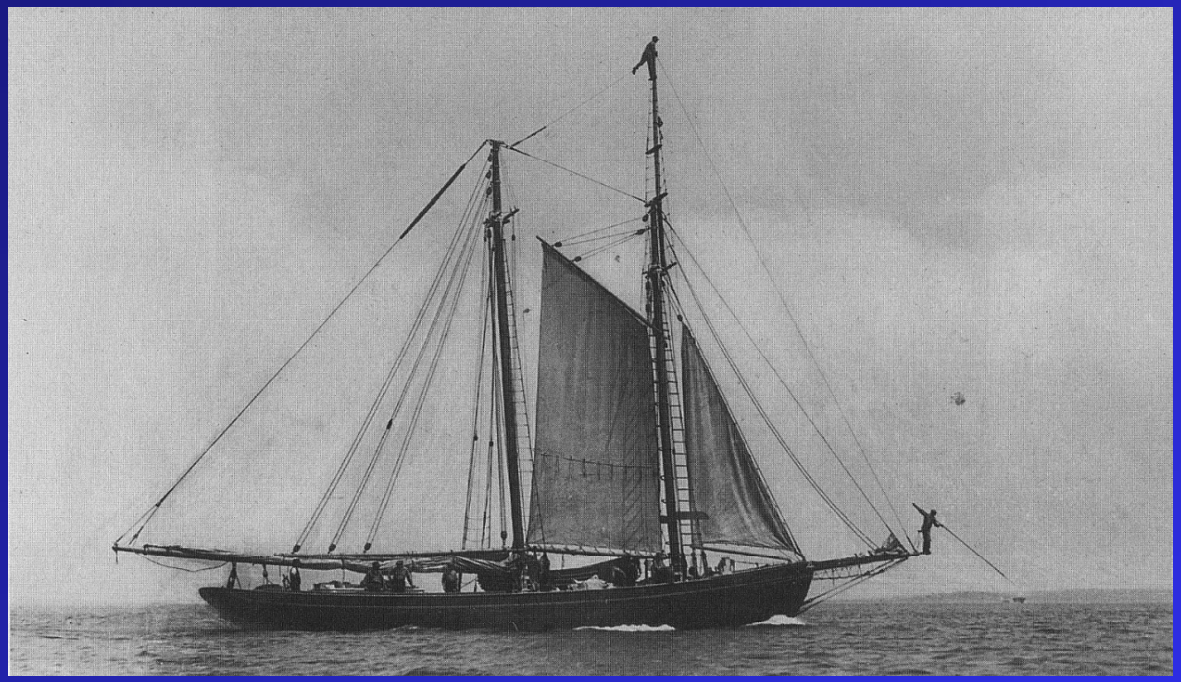
Harpoon fisheries:

- Harpoon fisheries exist in:
  - Mediterranean: since ~ 1000 BC
  - US New England: mid 1800s
  - Nova Scotia: early 1900s
  - US west coast: early 1900s
- Other harpoon fisheries
  - Taiwan
  - Chile/Peru

ISC / PIFSC
Image: S. Smith & J. Forbes

Swordfish Fisheries: Harpoon

Swordfish "stick" boats



Schooner rigged New England swordfisherman, circa 1920

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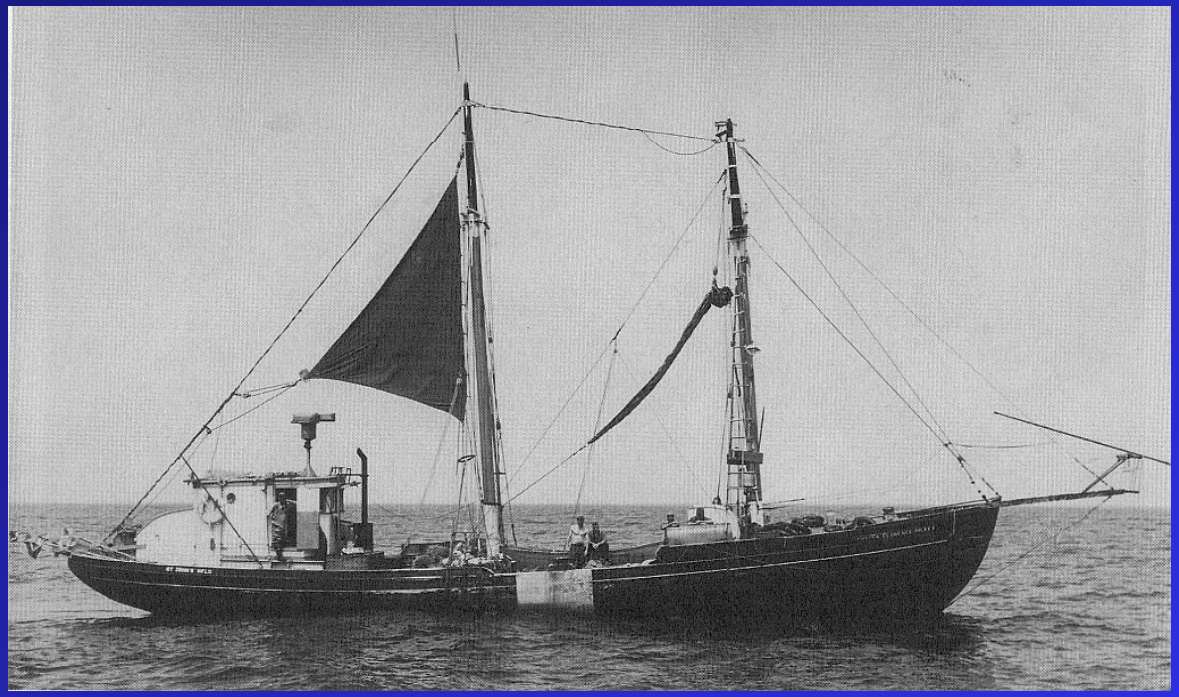
Swordfish Fisheries: Harpoon

Swordfish "stick" boats



Canadian swordfish harpoon boat out of St Johns, Newfoundland

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  - Nova Scotia: early 1900s
  - US west coast: early 1900s
- Other harpoon fisheries
  - Taiwan
  - Chile/Peru

ISC / PIFSC
Gibson 1998

Swordfish Fisheries: Harpoon

Swordfish "stick" boats

Typical California swordfish harpoon boats, Catalina Island

Harpoon fisheries:

- Harpoon fisheries exist in:
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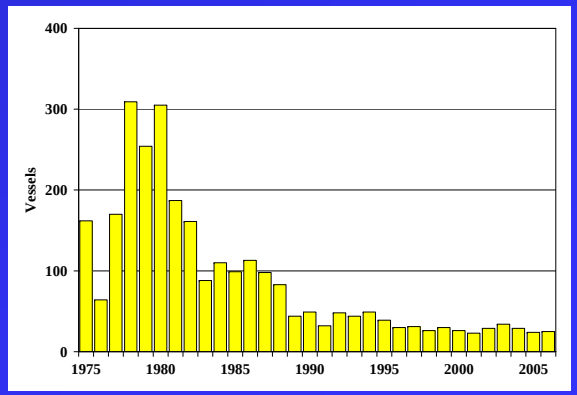


Number of California Harpoon boats

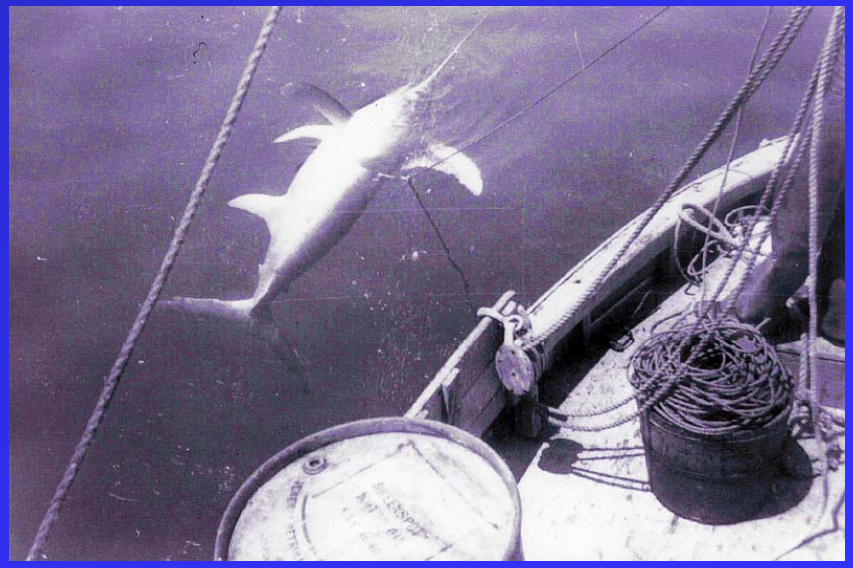
ISC / PIFSC
George Williams II

detachable dart

Swordfish Fisheries: Harpoon

Harpoon method:

- Harpoon fitted w detachable dart
- Approach by vessels with long bow plank
- Fish is struck, dart detaches
- Tows ¼" line with floats
- Fish boated and dressed



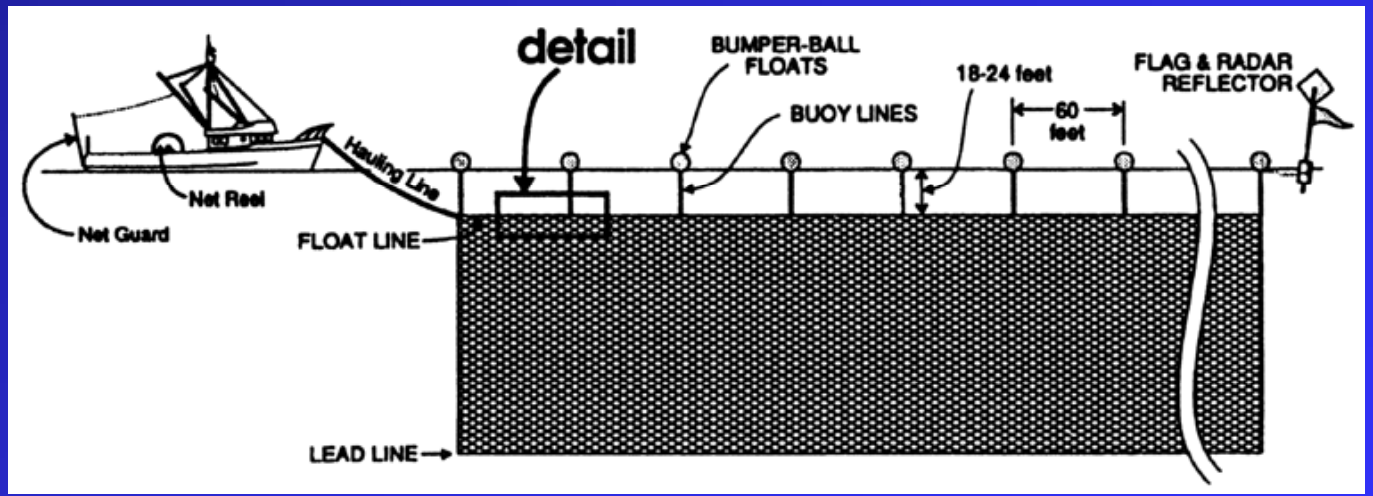
The Hull Truth
Gibson 1998
T. Giacalone

Swordfish Fisheries: Gillnet

California drift gillnet fishery

Large mesh gillnet:

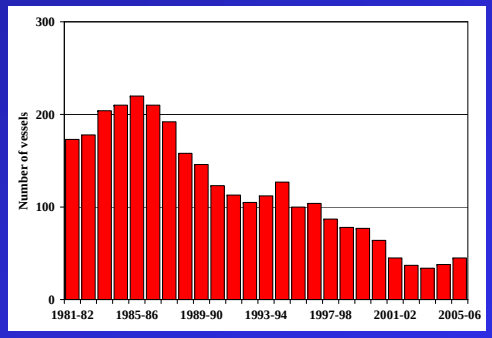
- Began in late 1970s. Mainly San Diego to Cape Mendocino
- Target Swordfish, common thresher and shortfin mako shark
- Swordfish targeted in SCB from ~May – December, peak catches in Oct – Nov.



Hanan et al. 1993. CDFG

Swordfish Fisheries: Gillnet

California drift gillnet fishery



Number of California Drift Gillnet boats

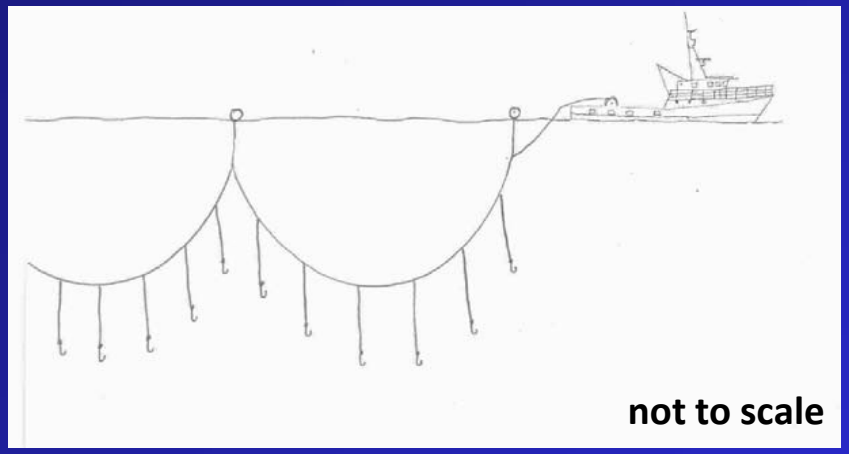
Large mesh gillnet:

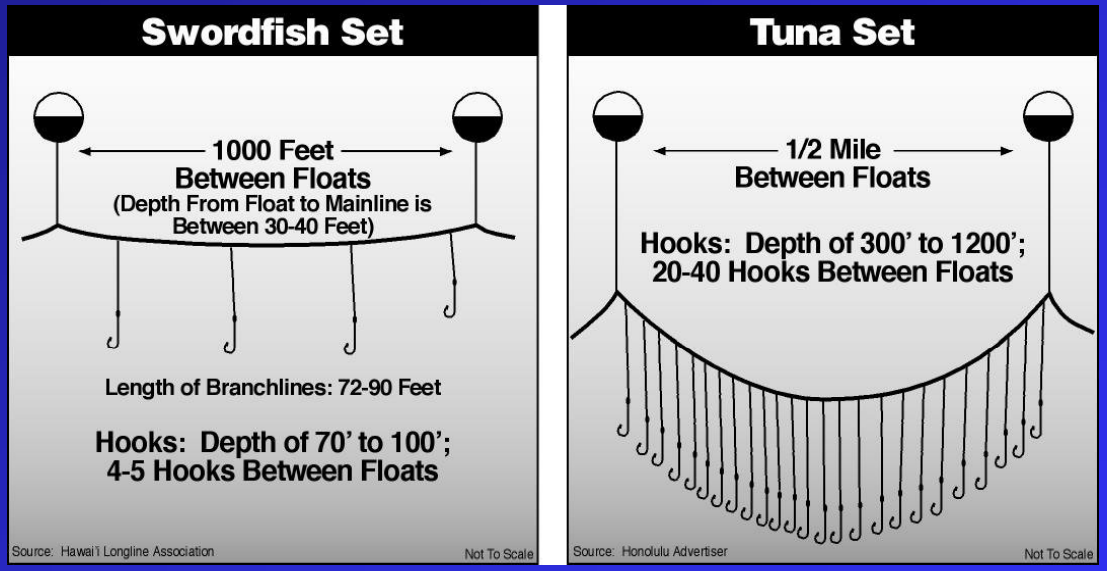
- Vessels 35 – 65 ft
- Gillnets 800 to max 1000 ft
- Stretched mesh size 18-21”
- Peak effort 1985-86 @ 220 vessels
- Decreased to 41 and 35 vessels in 2008, 2009
- Landings peaked in 1985 @ 2990 mt and down to 405 and 249 mt (08-09)

- Subject to NOAA observers
- Subject to seasonal and spatial closures
- Use of longer buoy lines and acoustic pingers to reduce bycatch

Swordfish Fisheries: Longline - US Domestic

Swordfish longline gear





Shallow-set longline gear

- Set monofilament mainline at night, shallow, no line shooter
- Set only 3 - 5 hooks between floats
- Often use light devices or chemical light sticks on baited branchlines

Hanan et al. 1993. CDFG

Swordfish Fisheries: Longline - US Domestic

Swordfish longline fisheries

~2000 mt / year for all US fisheries combined

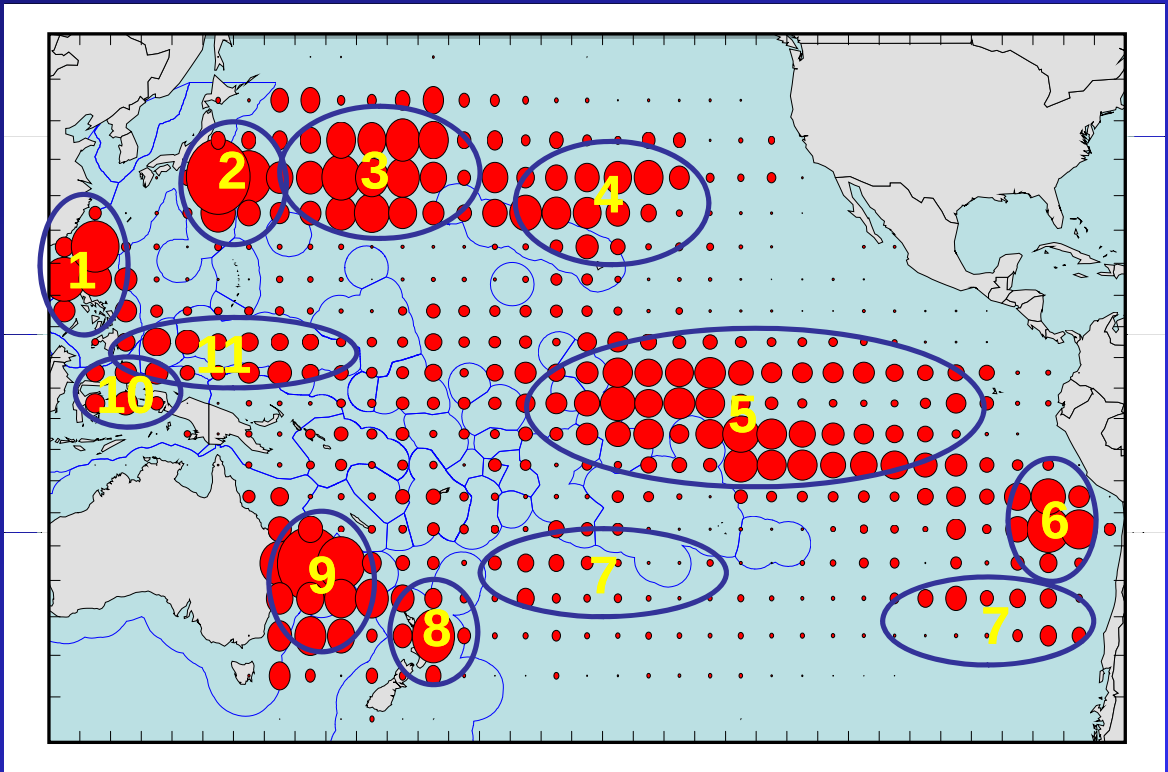
US LL Swordfish landing fleets

- Atlantic
  - Distant-water: N and S Atlantic
  - Mid-Atlantic + New England: swordfish and bigeye
  - South Atlantic: NC to E Florida
  - Caribbean: tuna and swordfish
- Gulf of Mexico
  - Yellowfin tuna and swordfish
- California
  - Prohibited inside US EEZ
  - Episodic relocation of Hawaii fleet
  - *Single California-based vessel currently operating outside EEZ targeting tuna*
- Hawaii
  - Tuna: deep daytime set
  - Swordfish shallow night set

Images: NOAA Fisheries PIRO

Swordfish Fisheries: Longline – Pacific International

Swordfish longline catch (1995 – 2005)*



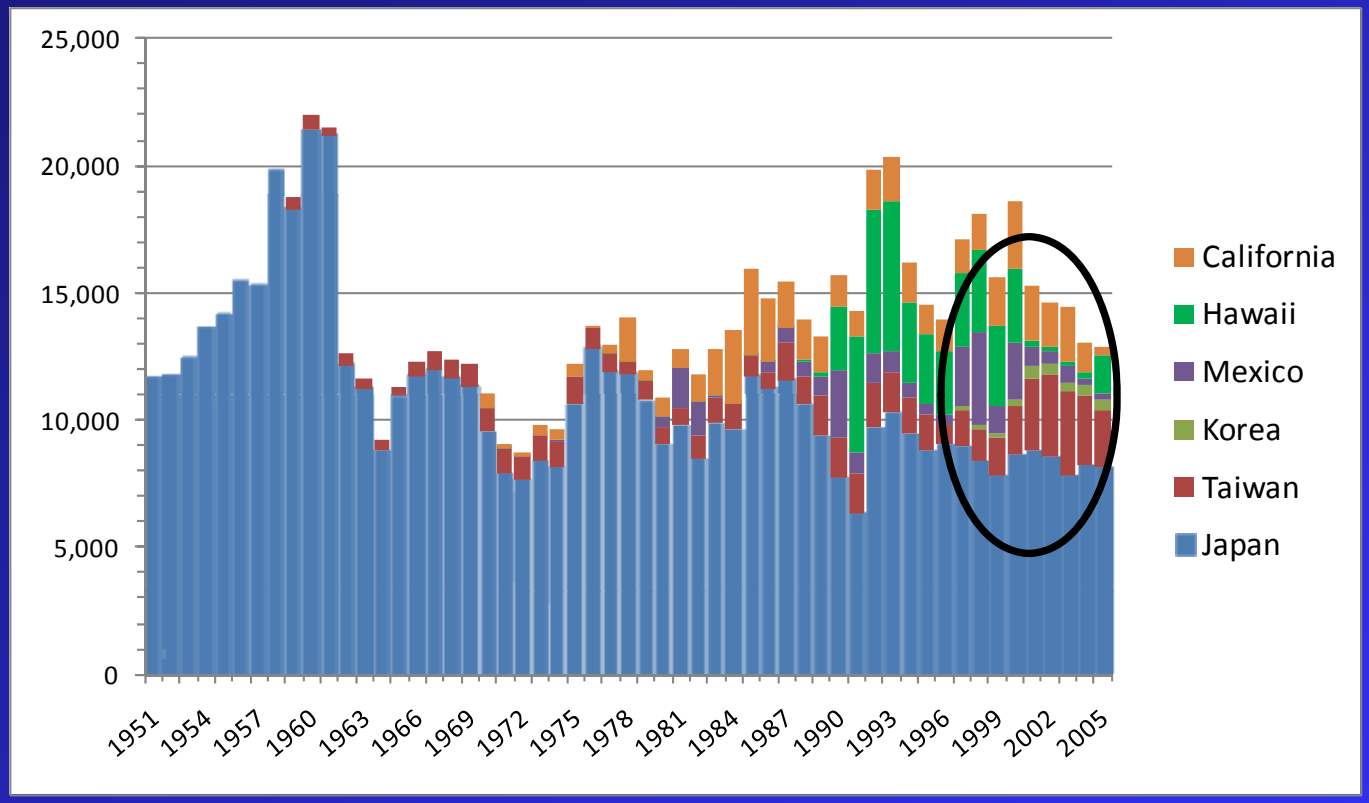
Major swordfish LL fleets

1) Taiwan domestic
2) Japan domestic
3) Japan/Taiwan targeted and non-target tuna
4) Hawaii
5) International non-target catch to bigeye LL fleets
6) Japanese distant-water, targeted
7) Spanish
8) New Zealand domestic, target and non-target tuna
9) Australia domestic, target and non-target tuna
10) Indonesian domestic
11) Taiwan (Davao based) and Pacific-islands based (foreign and domestic)

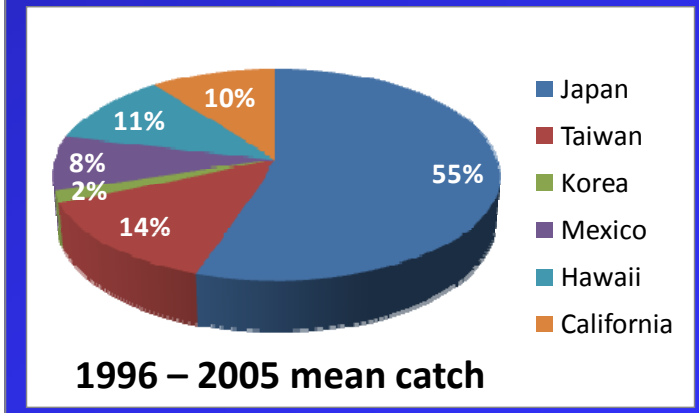
*does not include US West Coast data

Swordfish Fisheries: North Pacific International

Swordfish targeting fleets: All Gear Types combined



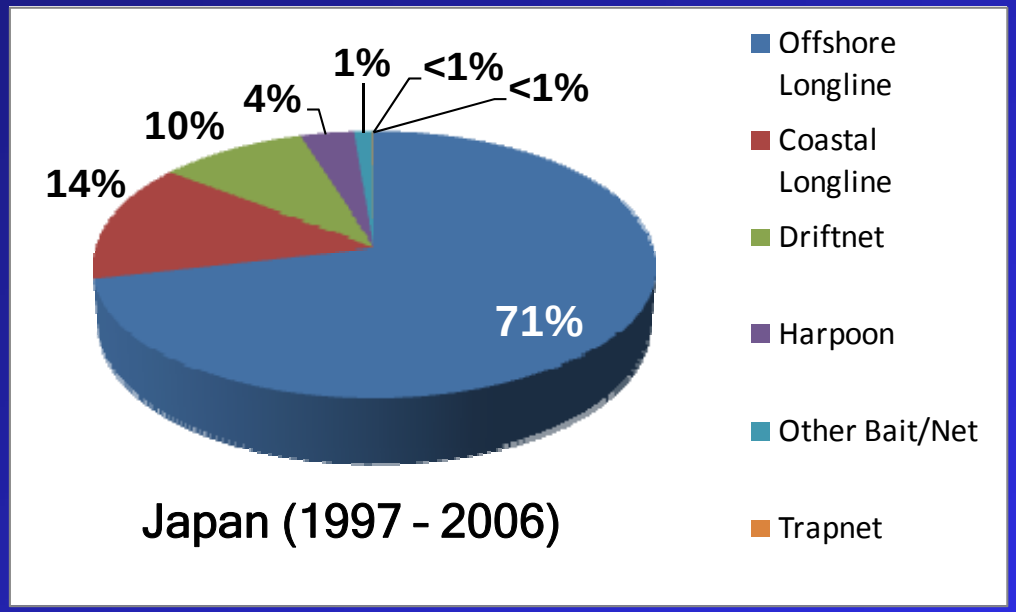
North Pacific Swordfish Catch by Flag 1951 – 2005 (mt)

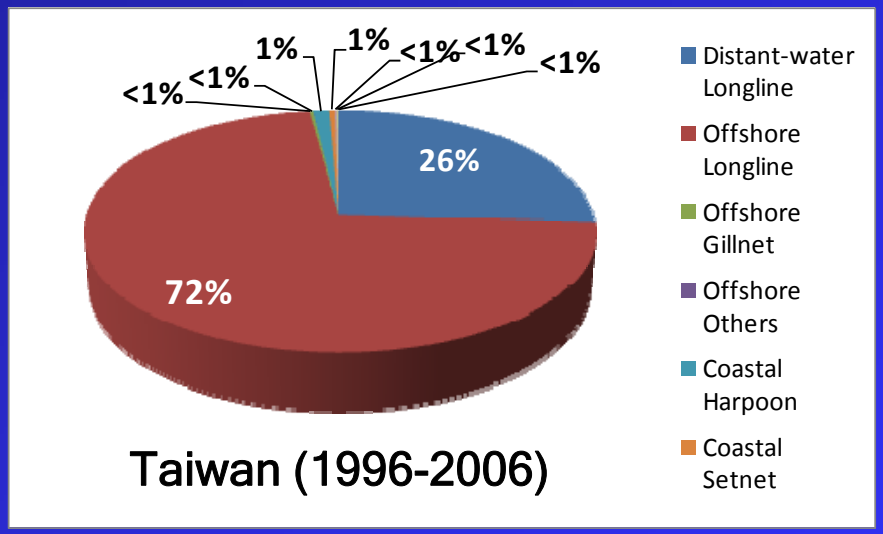


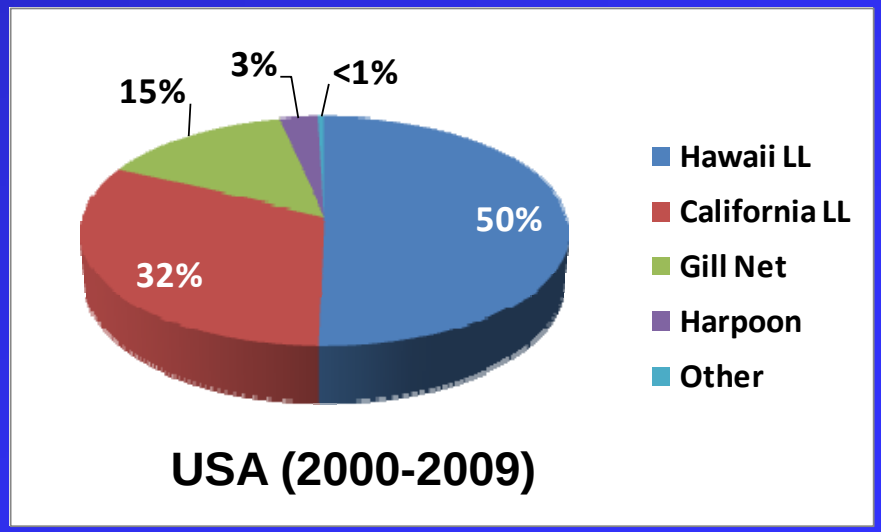
1996 – 2005 mean catch

Swordfish Fisheries: North Pacific Gear types

Swordfish langings by gear type





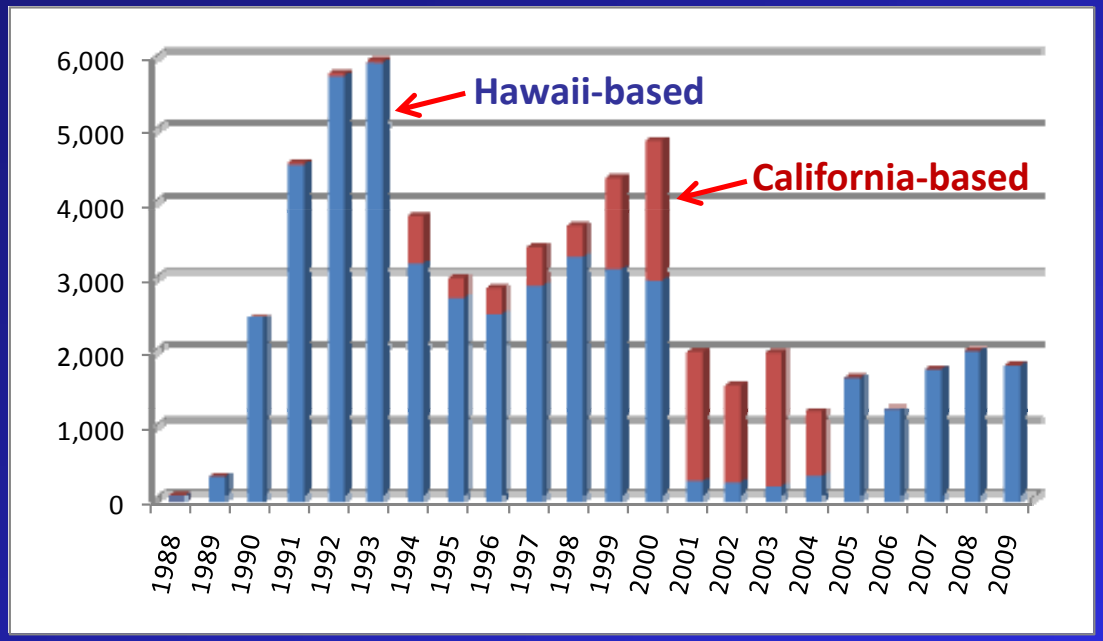


10-year aggregate catches by Flag and gear type

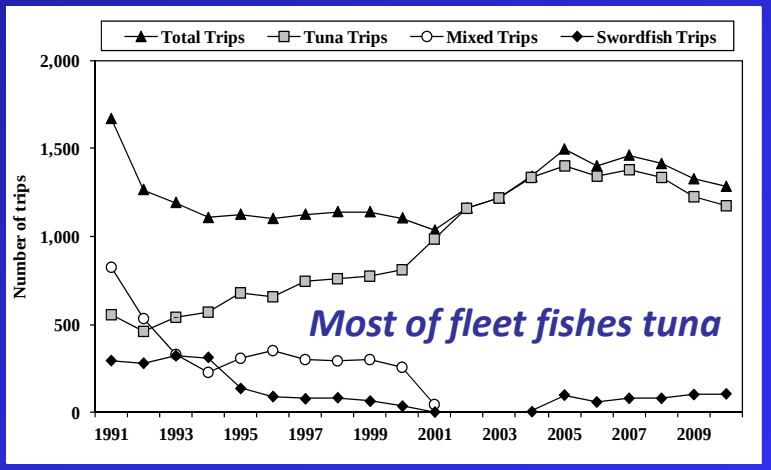
•Data ranges vary due to data availability but are representative of recent effort by flag

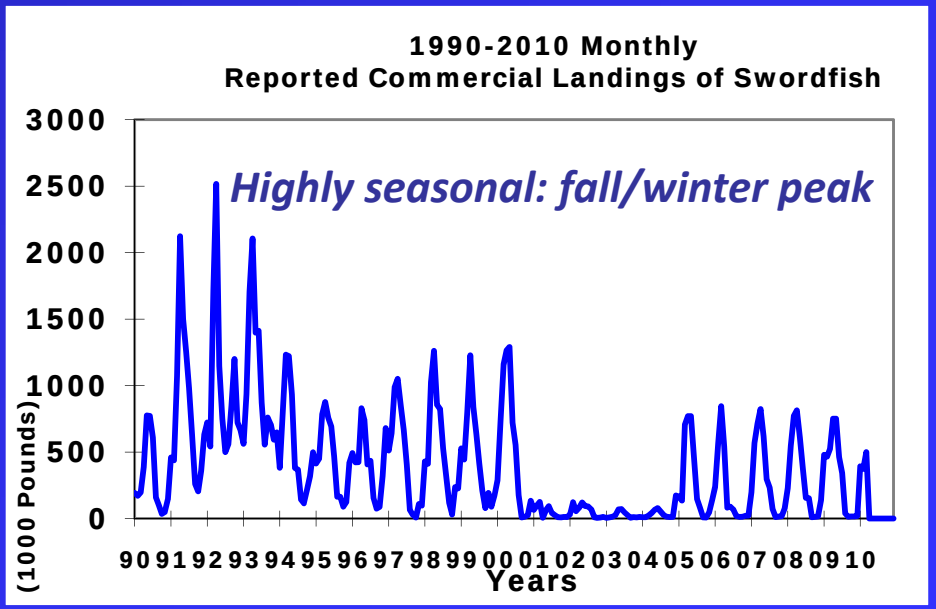
Swordfish Fisheries: Longline: USA

Hawaii and West Coast catch



US West Coast Longline swordfish landings 1988 – 2009 (mt)



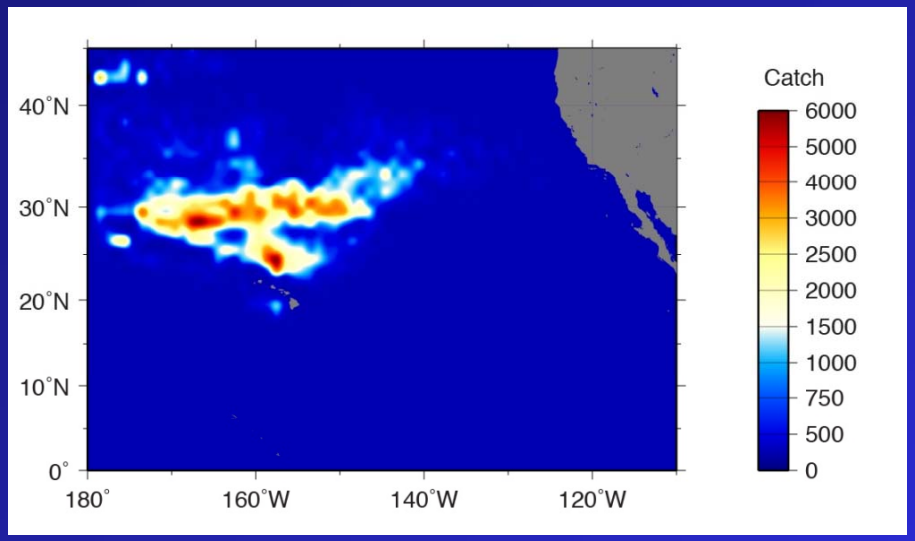


Report of 10th ISC Plenary Session 2010
Pelagics Annual Report 2010, PIFSC (draft)

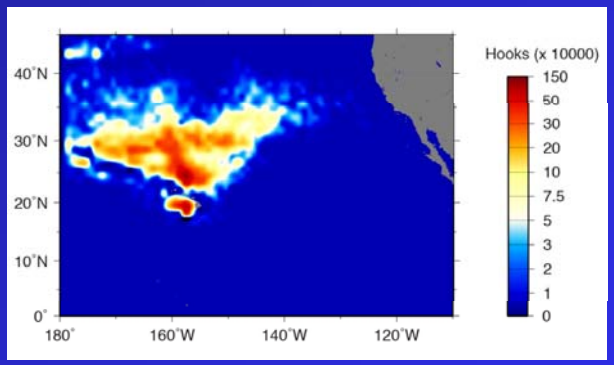
Swordfish Fisheries: Longline - US Hawaii fleet

Swordfish catch and effort

1991 - 2010

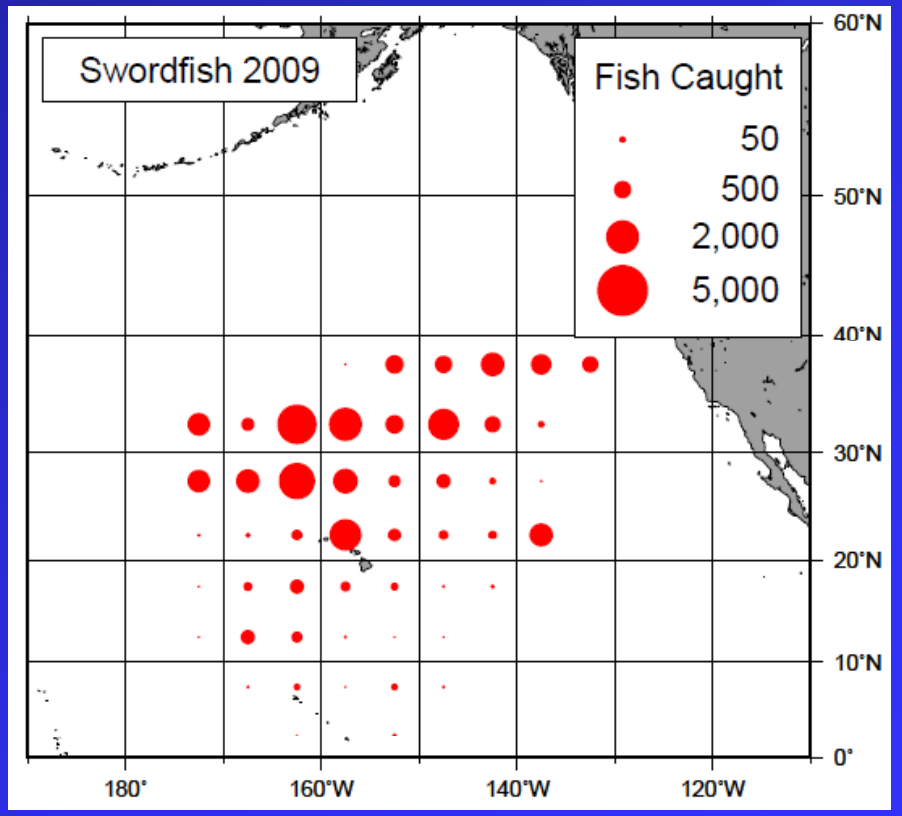


Total catch in numbers of swordfish



Total Effort in number of hooks

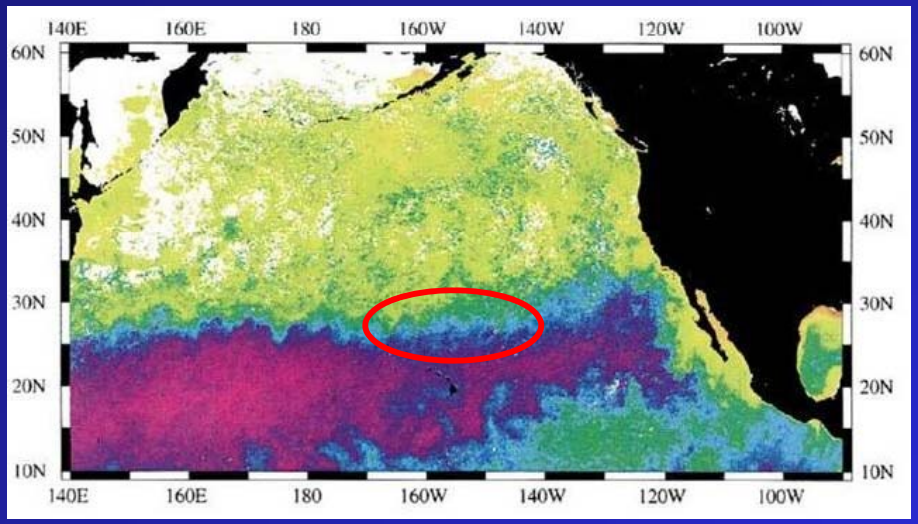
Hawaii and California-based 2009



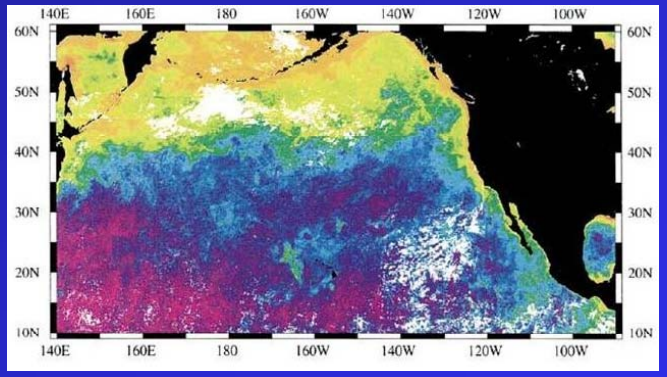
NOAA Fisheries/PIFSC

Swordfish Fisheries: Oceanic habitat

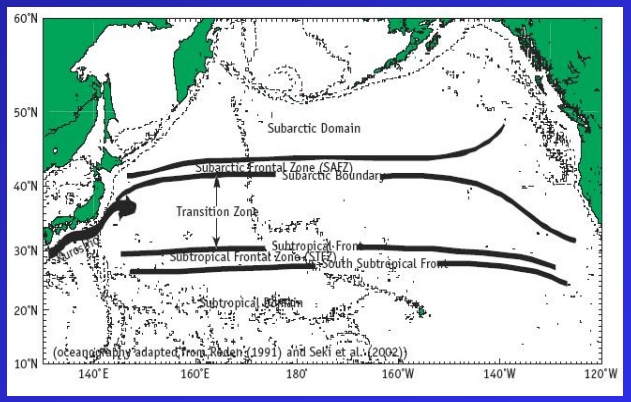
Swordfish: North Pacific Transition Zone



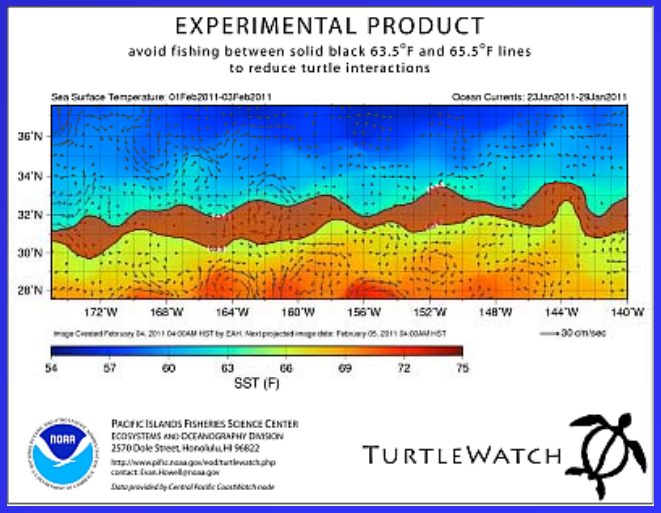
Surface chlorophyll densitiy (February 1998)



Surface chlorophyll densitiy (August 1998)



Subtropical Front: 32°-34 ° N
South Subtropical Front: 28°-30° N



Concentrates swordfish, albacore, pomphret, squid, birds and sea turtles

Polovina et al. 2001
Seki et al. 2002
NOAA Fisheries/PIFSC

Take home messages

1) Characterized by rapid growth and early maturity
   - good species for fisheries
2) Adapted to hunt and feed in cold, deep waters. Bask in some areas but not every day
3) Location and depth distribution (day/night) can be predicted based on productivity and local environmental factors
4) Most swordfish are taken by longline gear at night
5) Swordfish concentrate in productive areas also used by seabirds, squid and sea turtles
6) The Fishery is currently managed on the basis of a maximum of 17 loggerhead or 16 leatherback sea turtle interactions/year after which the fishery closes for the year

Jay Lagemann
The Swordfish Harpooner