Shark Bycatch in U.S. West Coast Swordfish Fisheries

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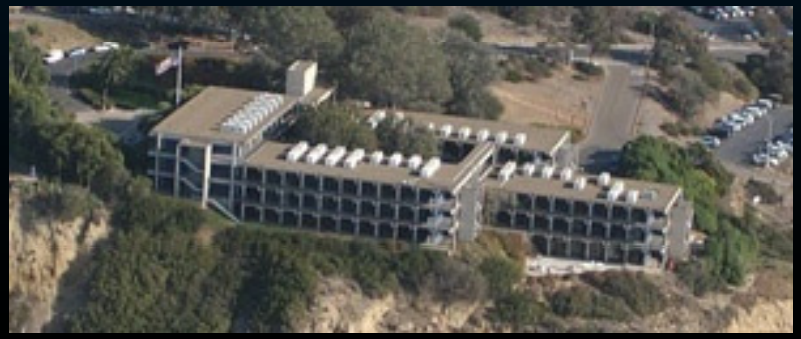


The Fisheries

- Harpoon
  - Rare take of a mako or thresher shark
- Pelagic Drift Gillnet (DGN)
  - Formerly a fishery targeting thresher sharks
  - Thresher, mako and blue shark bycatch is significant (defined as >5 per 100 swordfish caught)
  - Smaller numbers of several other species caught
- Shallow-set Pelagic Longline (SSLL)
  - Blue shark bycatch is significant
  - Smaller numbers of several other species caught

Measures Potentially Affecting Shark Bycatch

- Pelagic Drift Gillnet
  - May 1 to Aug 15, no fishing with 75 miles of coast and no fishing in depths less than 1000 m at all other times (1986; as revised in 1995)
  - 36’ extenders required (1997)
  - OR (1999) and WA (2000) ban thresher targeting and eventually shut down pelagic drift gillnet fishery
  - Aug 15 to Nov 15, no fishing in Turtle Conservation Area (2001)
- Shallow-set Pelagic Longline
  - HI based fishery closed over turtle bycatch concerns (2002)
  - HI based fishery reopens with set limits, circle hook and mackerel-type bait required (2004)
  - CA based fishery closed (2004)

Observer Data on Shark Bycatch

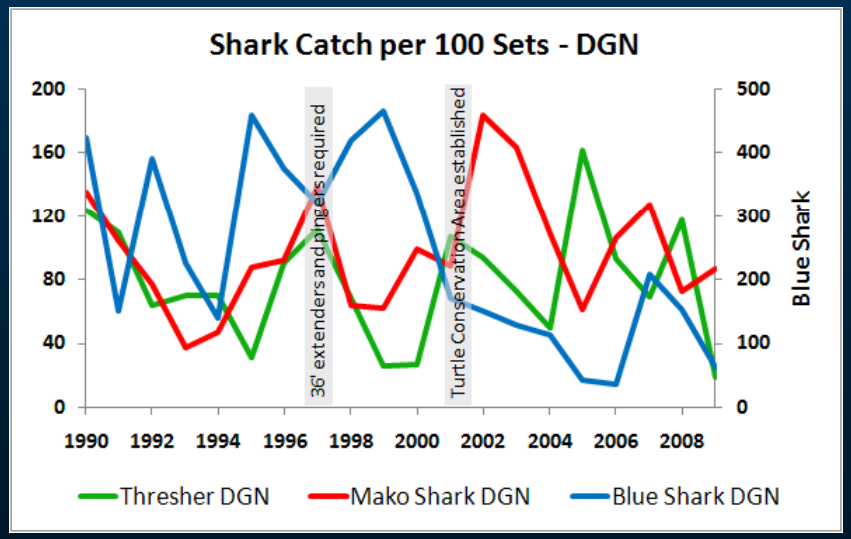
CA/OR Pelagic Drift Gillnet - US EEZ (1990-2009); 8145 observed sets				
Species	Number Caught	Catch/ Target	Percent Retained	Catch/ 100 sets
Shark, Blue	21985	1.27	0.6%	269.92
Swordfish, Broadbill	17364		98.4%	213.19
Shark, Shortfin Mako	7391	0.43	95.6%	90.74
Shark, Common Thresher	6127	0.35	99.3%	75.22
Shark, Bigeye Thresher	636	0.04	77.8%	7.81
Stingray, Pelagic	351	0.02	0.9%	4.31
Shark, Salmon	111	0.01	21.6%	1.36
Shark, Pelagic Thresher	78	0.00	97.4%	0.96
Shark, Smooth Hammerhead	47	0.00	25.5%	0.58
Ray, Pacific Electric	43	0.00	2.3%	0.53
Ray, Bat	20	0.00	0.0%	0.25
Ray, Manta	15	0.00	0.0%	0.18
Ray, Unidentified	11	0.00	9.1%	0.14

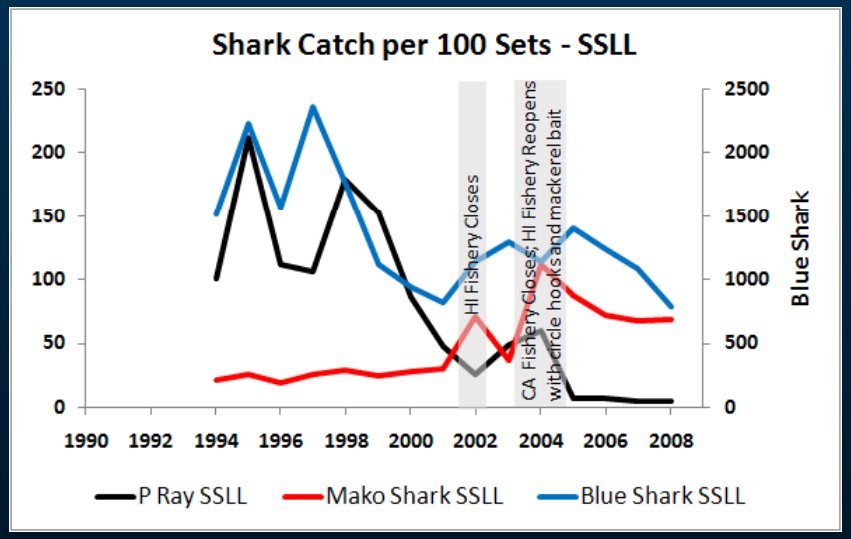
HI/CA SSLL - Temperate High Seas (1994-2008); 9439 observed sets				
Species	Number Caught	Catch/ Target	Percent Retained	Catch/ 100 sets
Swordfish, Broadbill	89454		87.8%	1389.25
Shark, Blue	77191	0.86	0.1%	1198.80
Shark, Shortfin Mako	3857	0.04	11.8%	59.90
Stingray, Pelagic	2512	0.03	5.9%	39.01
Shark, Unidentified	2033	0.02	0.2%	31.57
Shark, Oceanic Whitetip	343	0.00	4.7%	5.33
Shark, Unid. Mako	156	0.00	0.6%	2.42
Shark, Bigeye Thresher	148	0.00	20.3%	2.30
Shark, Salmon	109	0.00	1.8%	1.69
Shark, Crocodile	54	0.00	3.7%	0.84
Shark, Sandbar	38	0.00	5.3%	0.59
Shark, Cookie Cutter	27	0.00	11.1%	0.42
Shark, Silky	23	0.00	0.0%	0.36
Shark, Longfin Mako	20	0.00	20.0%	0.31
Shark, Common Thresher	18	0.00	11.1%	0.28
Shark, Thresher Unid.	14	0.00	0.0%	0.22

Note: Other elasmobranchs rarely caught have included soupfin, prickly, Pacific angel, white, basking, sevengill, megamouth, scalloped hammerhead, sixgill, Galapagos, tiger, bignose, dusky, grey reef, and blacktip sharks, velvet and spiny dogfish, devil rays, California and big skates, and round stingrays.

Provisional observer data from the NMFS SWR and PIR Observer Programs

Nominal Catch Rates – Observed Sets





Provisional observer data from the NMFS SWR and PIR Observer Programs

- Nominal catch of blue sharks in DGN fishery higher prior to 2001
- No obvious trend in nominal catch rates for mako and thresher sharks in DGN fishery

- Nominal catch of blue sharks in SSLL fishery higher prior to 1999
- Nominal catch of mako sharks higher since 2002
- Nominal catch of pelagic rays higher prior to 2001

North Pacific blue shark population status: what do we know?

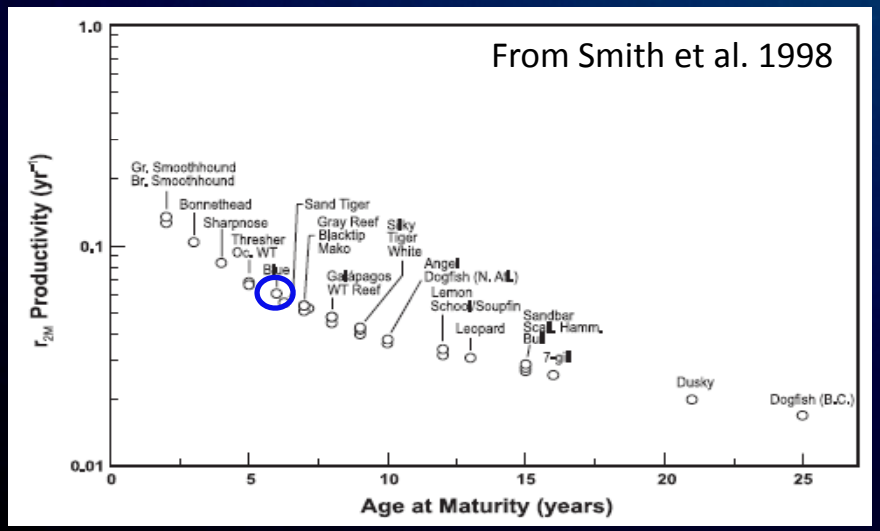
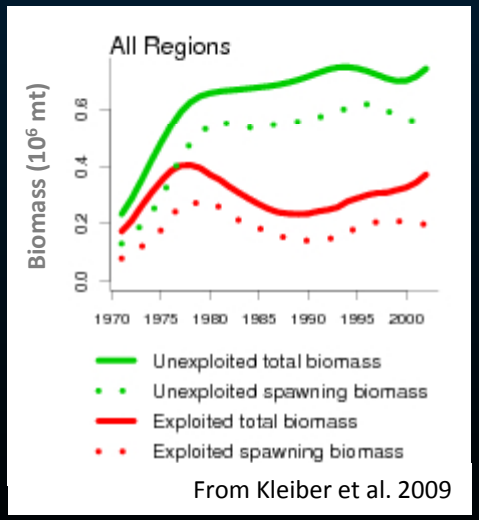


Photo: Mark Conlin

- Productivity considered moderate to high for elasmobranchs (7th of 26 Pacific shark stocks examined) based on relatively low female age at maturity (6-7 years) and high fecundity (4-135 pups/litter)

- North Pacific blue shark assessment (Kleiber et al. 2009)
  - Range of fishery data: N. Pacific international waters (140E to 130W); commercial longline, high seas drift and small mesh drift fisheries
  - Catch/effort time series from the Japan LL fishery
  - Analysis: (1) Bayesian Surplus Production, (2) Multifan-CL
  - Trend: Declines from 70s through 80s with increases in 90s back to early 70s levels, current B above but close to B_{MSY} and current F below F_{MSY}. If increasing LL fishing effort continues, F may approach F_{MSY}.

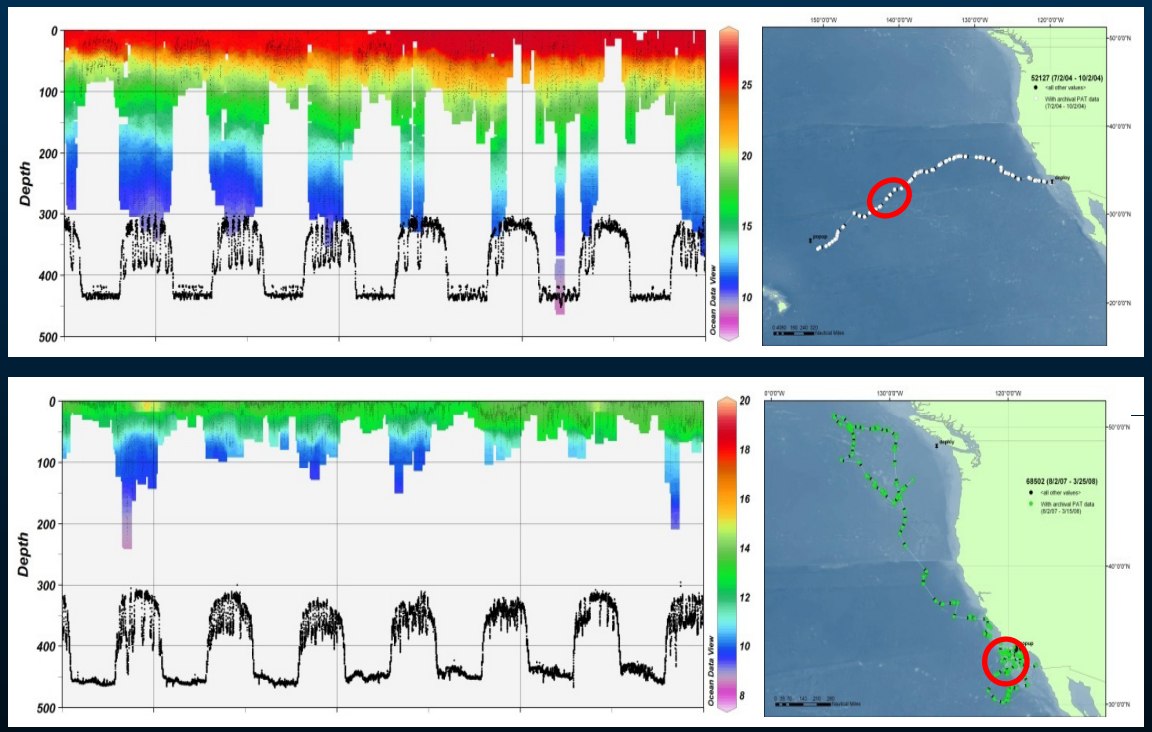


From Kleiber et al. 2009

Blue shark susceptibility in west coast fisheries?

Vertical Habitat Use: 34 PSAT tagged sharks

Max Depth	812 m
Daily Max Depth	443 ± 146 m
Time <50 m	76%
Time >200 m	6%



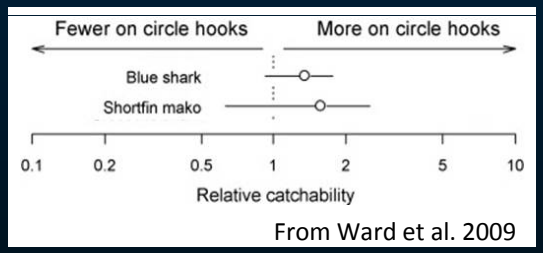
Blue shark vertical habitat overlaps with DGN and SSLL gear.

36’ extenders in the DGN fishery may provide some refuge for blue sharks near the surface at night.

Horizontal Habitat Use

- In HI SSLL fishery, SST fronts and lunar phase have greater effect on swordfish catch rates; SST has greater effect on blue shark catch (Bigelow et al. 1999).
- Preliminary analyses of DGN data indicate spatial patterns in high blue shark abundance relative to high swordfish abundance (SLUTH project)
- Nominal catch rates higher before the closure north of Point Conception

Other Considerations



From Ward et al. 2009

- Circle hooks do not consistently affect catch rates of blue sharks (most studies show increase; e.g. Watson et al. 2005)
- Bait type may be more important than hook type (catch rates higher with squid bait; e.g. Yokota et al. 2009)
- U.S. swordfish fishers do not want to catch blue sharks and avoid areas with high blue shark abundance
- Most (>90%) blue sharks are released alive from the SSLL fishery, whereas ~65% of DGN caught blue sharks are discarded dead

Shortfin mako shark population status: what do we know?

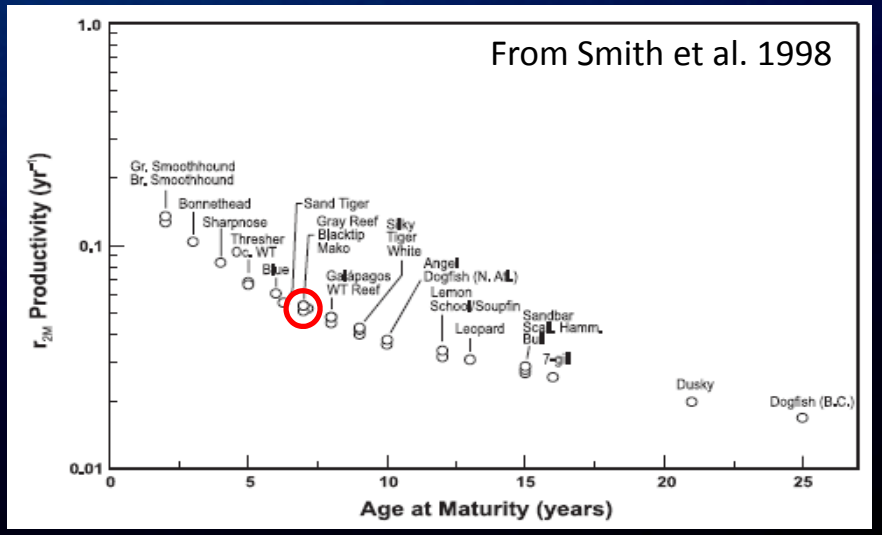


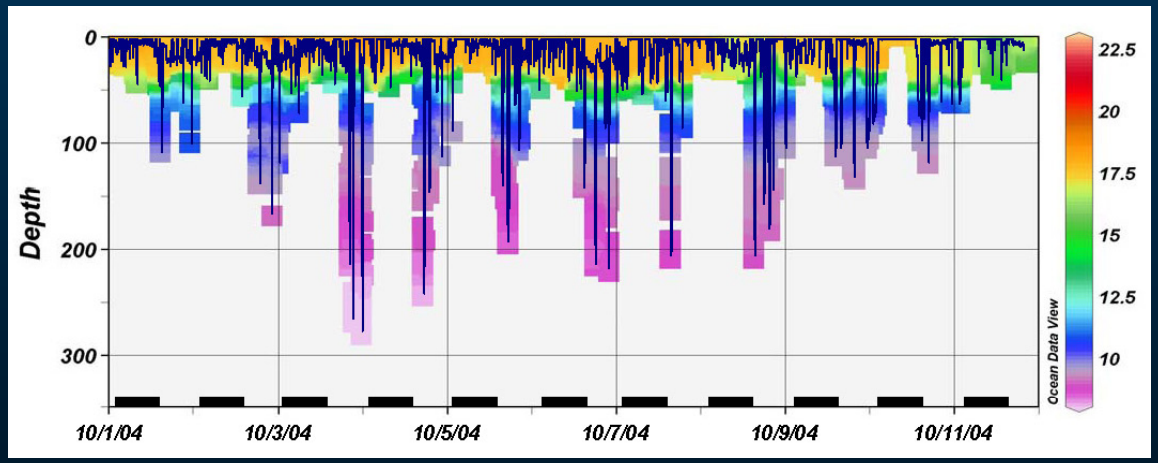
Photo: Mark Conlin

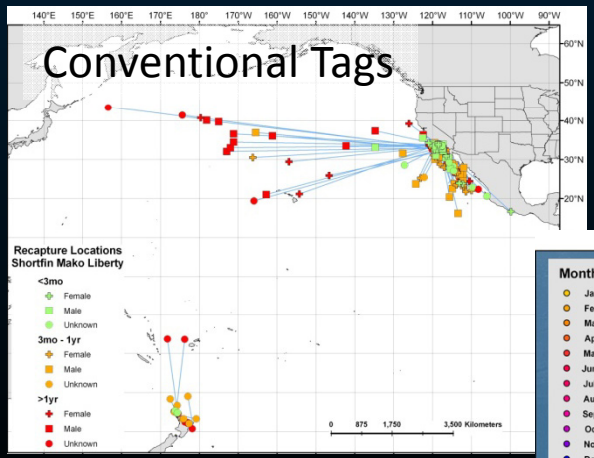
- Productivity considered moderate for elasmobranchs (11th of 26 Pacific shark stocks examined) based on relatively low fecundity (4-16 pups/litter) and female maturity of 7-8 years; productivity much lower if female maturity assumed to be 20+ years.
- Northwest Pacific shortfin mako assessment (Chang and Liu, 2009)
  - Range of Fishery Data: limited to NW Pacific off Eastern Taiwan; commercial longline predominantly
  - Analysis: Yield-per-Recruit and Virtual Population Analysis (VPA)
  - Results: the stock off Taiwan may be overexploited; Biomass and observed size in the fisheries are declining and fishing mortality exceeds most overfishing reference points
- PFMC Fishery Management Plan (PFMC and SWFSC 2004)
  - Trends in catch and CPUE in CA/OR DGN fishery stable
  - Sustainable harvest guideline established at 150 mt
  - Updated quantitative analyses needed

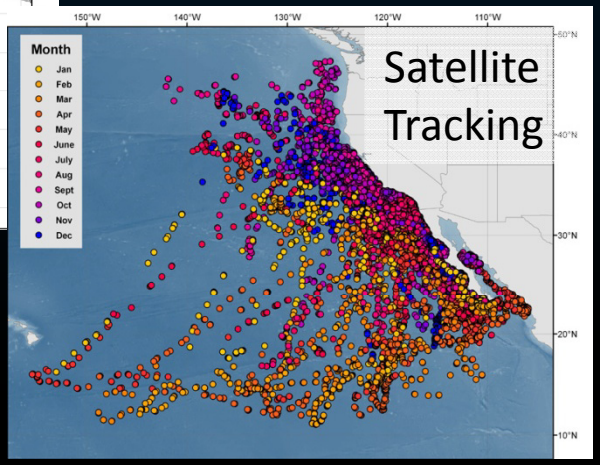
Mako shark susceptibility in west coast fisheries?

Vertical Habitat Use: 21 PSAT tagged sharks

Max Depth	556 m
Time <50 m	89%
Time >200 m	0.7%

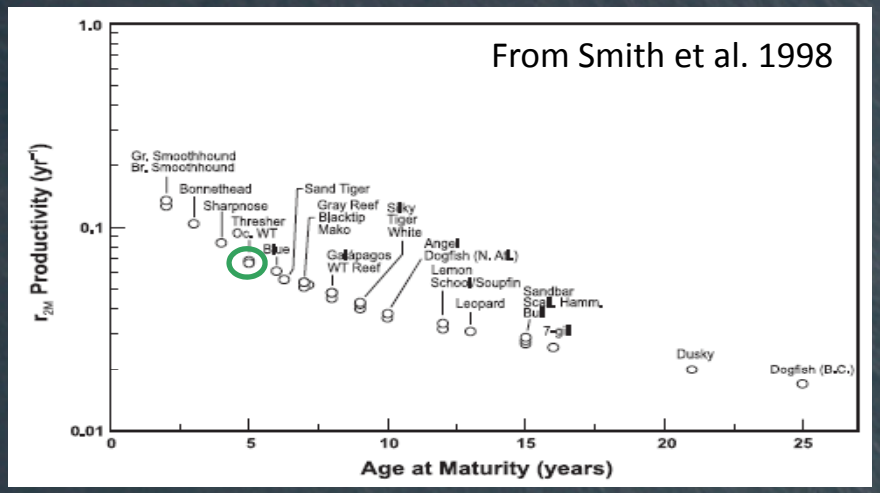






Vertical and horizontal overlap with DGN and SSLL fisheries high.

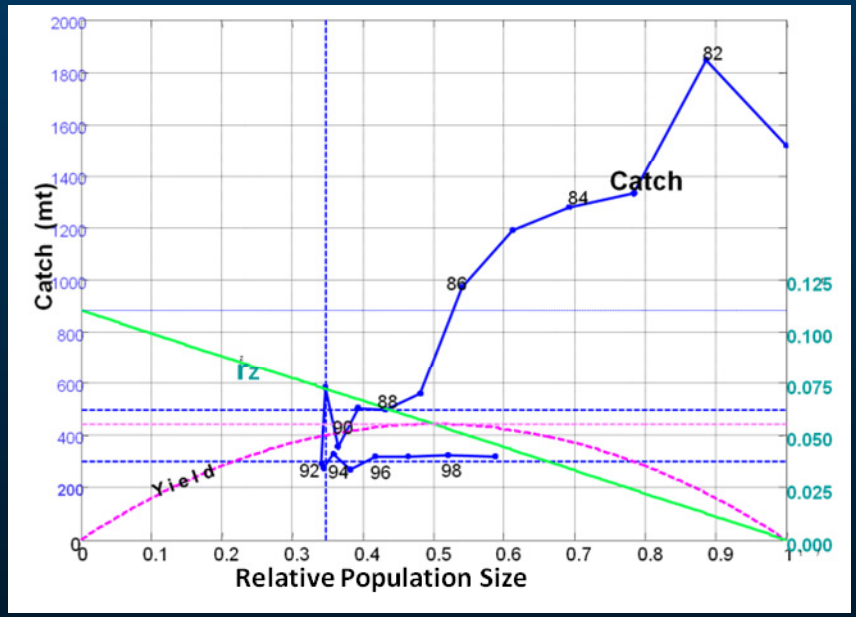
36’ extenders in the DGN fishery may provide some refuge near the surface at night.



Thresher shark population vulnerability and status: what do we know?

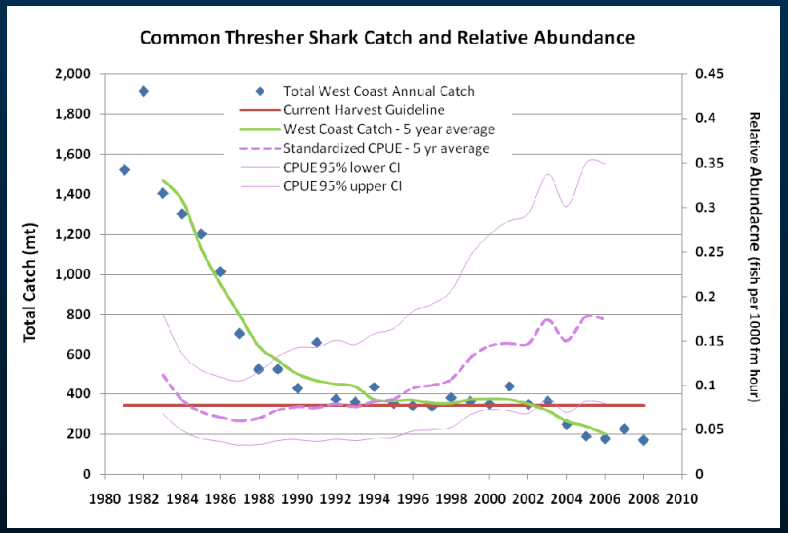
Photo: Ann Coleman

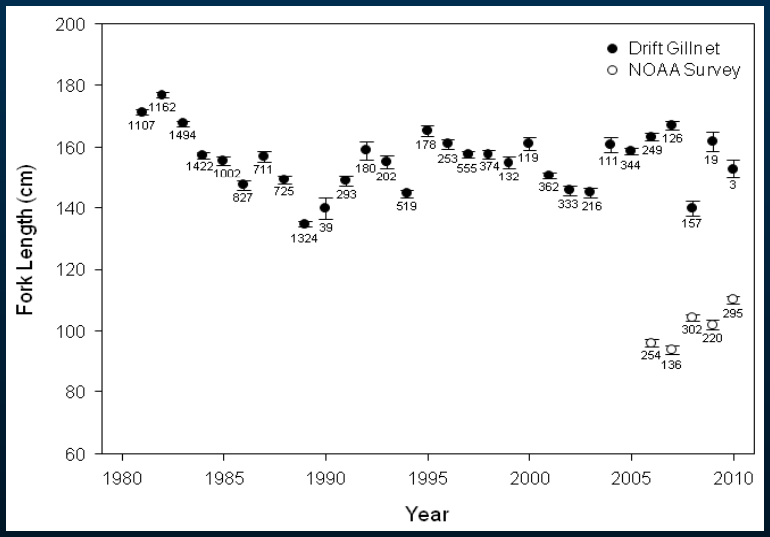
- Productivity considered high for elasmobranchs (5th of 26 Pacific shark stocks examined) based on relatively low female age at maturity (5 years) and rapid growth.



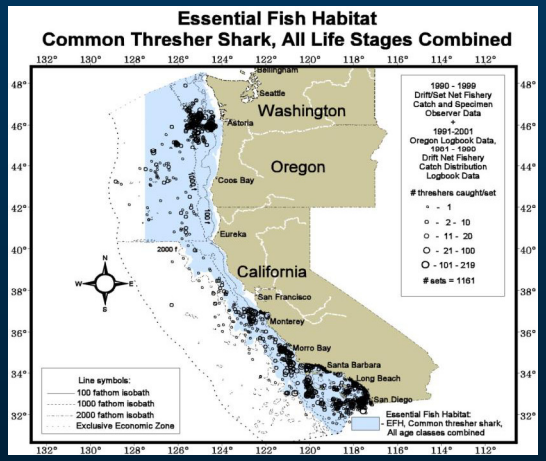
- PFMC Fishery Management Plan (PFMC and SWFSC 2004)
  - 1981-99 catch vs. relative abundance decline stopped in 1991-93
  - Relative population size increased after 1992 at catches of between 300-500 mt
  - Local MSY estimated at 450 mt based on the productivity (r_z) and yield curve
  - Harvest guideline set at a precautionary Optimal Yield = 0.75 x MSY = 340 mt because of greater vulnerability of pelagic sharks
  - 1999 biomass was above B_{MSY} and F was below F_{MSY}

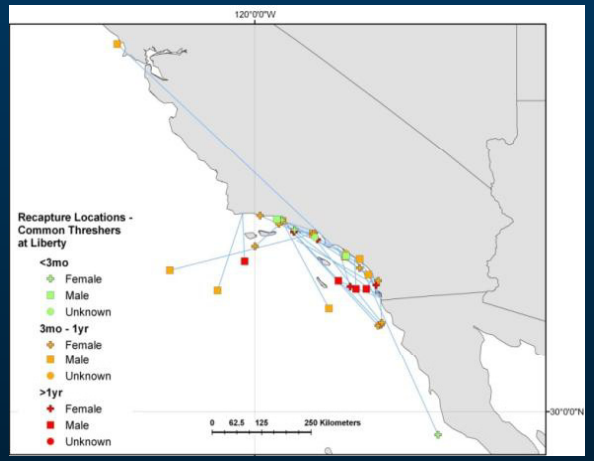
Recent Fishery Data Trend Analyses

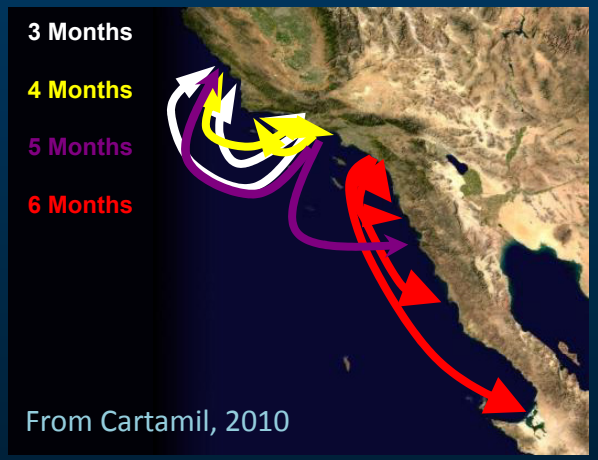




- Catch, size and CPUE declines evident in 1980's following heavy exploitation of the "new" drift gillnet fishery
- Regulations and a preference for swordfish reduced effort on threshers after mid 1980
- Both CPUE analyses and size frequency trends suggest that the population is increasing since the early 1990s

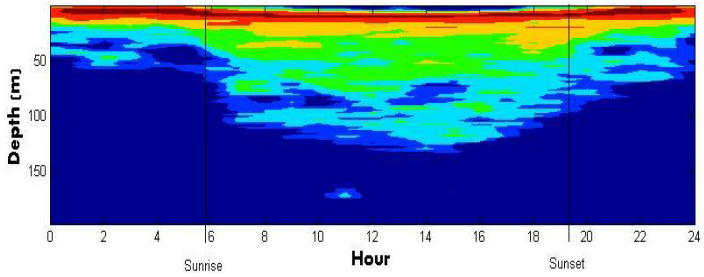






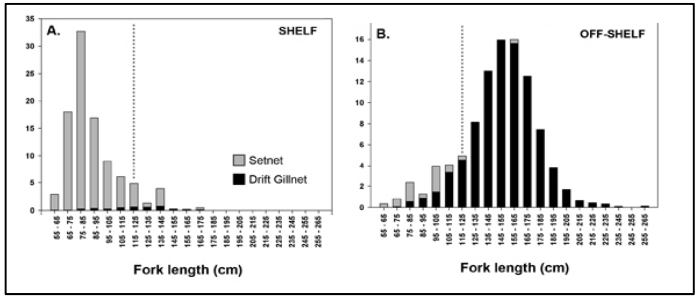
- Horizontal movements predominately confined to U.S. and Mexico West Coasts where vertical and horizontal overlap with DGN gear occurs
- Closure within 75 nmi of coast reduced thresher catch, and notably of pupping females
- 36’ DGN extenders may provide some refuge near the surface at night

Vertical movements overlap with the DGN fishery offshore



From Heberer et al. 2010

DGN fishery catches few neonates and young juveniles



From Cartamil et al. 2010

Summary

- Blue, mako and thresher shark bycatch in the DGN fishery is significant
- Makos and threshers are utilized, while blue sharks are discarded
- Blue shark bycatch in the SSLL is high, but mako shark bycatch is low and common threshers are rarely taken in the SSLL fishery
- U.S. west coast mako and thresher harvests are considered sustainable based on recent trends in catch, effort and size data
- North Pacific blue shark population is above MSY and fishing pressure is below F_{MSY}
- Sharks in general are highly vulnerable to fishing pressure due to slow growth, low fecundity and late maturation, thus careful monitoring and timely assessments are warranted
- Further research into alternate hook and bait types is needed
- Examining fine-scale movement patterns and associations with environmental features may reveal habitat use differences between swordfish and sharks to identify areas to avoid to reduce shark bycatch