Advances in Fishing Methods to Reduce Bycatch

Pacific Fishery Management Council

November 2017

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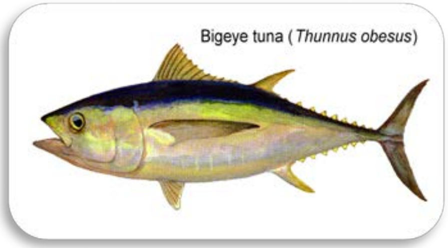


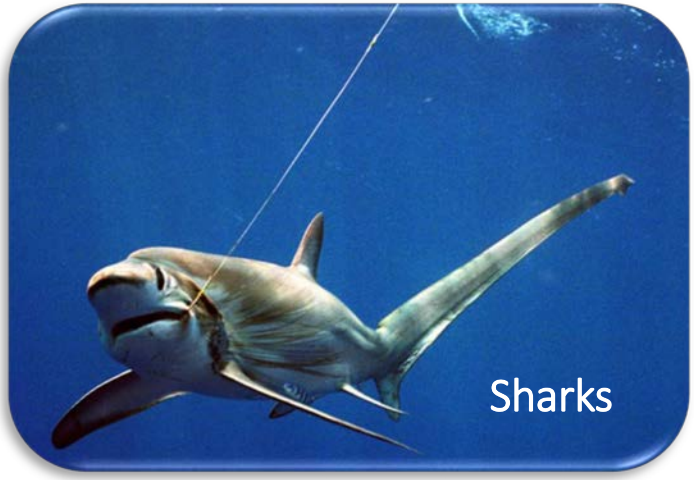
Bycatch

Bycatch, the incidental capture of non-target species (including protected species), occurs when there is spatial and temporal overlap between target and non-target species.

Measured by:

- Rates of interaction
- Survivorship
    - At vessel
    - Post-release

Presentation Overview



frontiers in Marine Science

ORIGINAL RESEARCH
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Sea Turtle Bycatch Mitigation in U.S. Longline Fisheries

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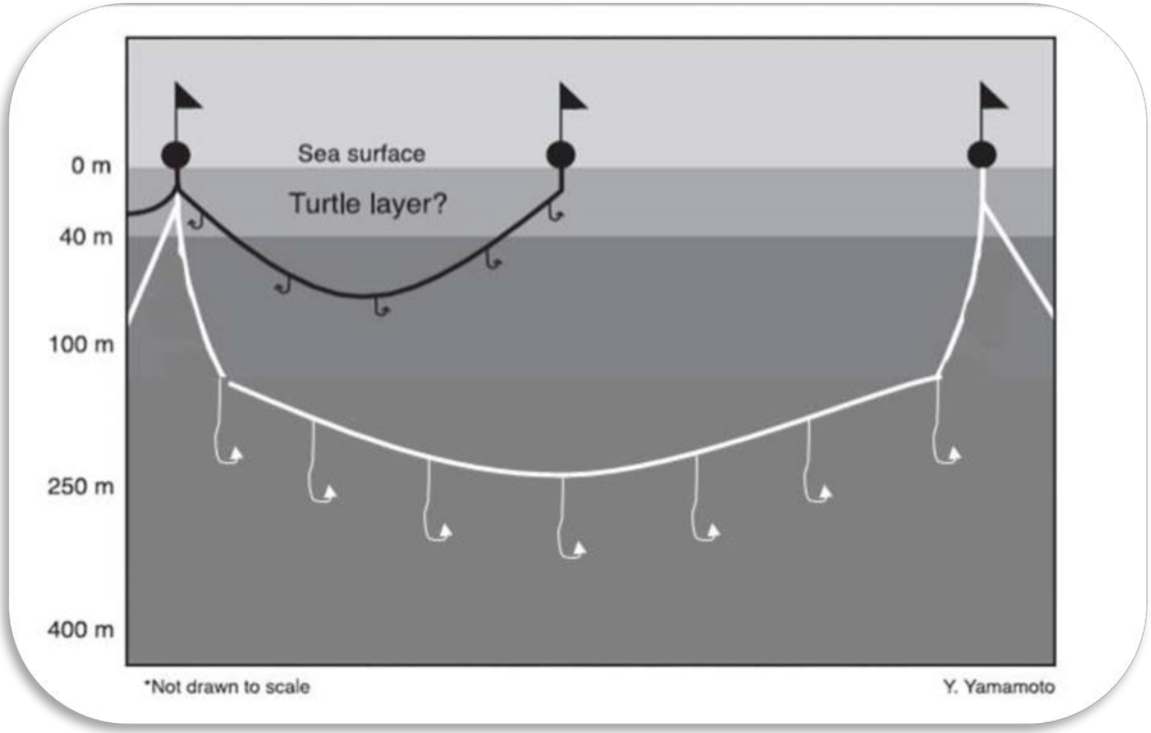
Capture of sea turtles in longline fisheries has been implicated in population declines of loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) turtles. Since 2004, United States (U.S.) longline vessels targeting swordfish and tunas in the Pacific and regions in the Atlantic Ocean have operated under extensive fisheries regulations to reduce the capture and mortality of endangered and threatened sea turtles. We analyzed 20+ years of longline observer data from both ocean basins during periods before and after the regulations to assess the effectiveness of the regulations. Using generalized additive mixed models (GAMMs), we investigated relationships between the probability of expected turtle interactions and operational components such as fishing location, hook type, bait type, sea surface temperature, and use of light sticks. GAMMs identified a two to three-fold lower probability of expected capture of loggerhead and

Sea Turtles and Longline Gear

Shallow Set VS Deep Set



loggerhead and leatherback

olive ridley

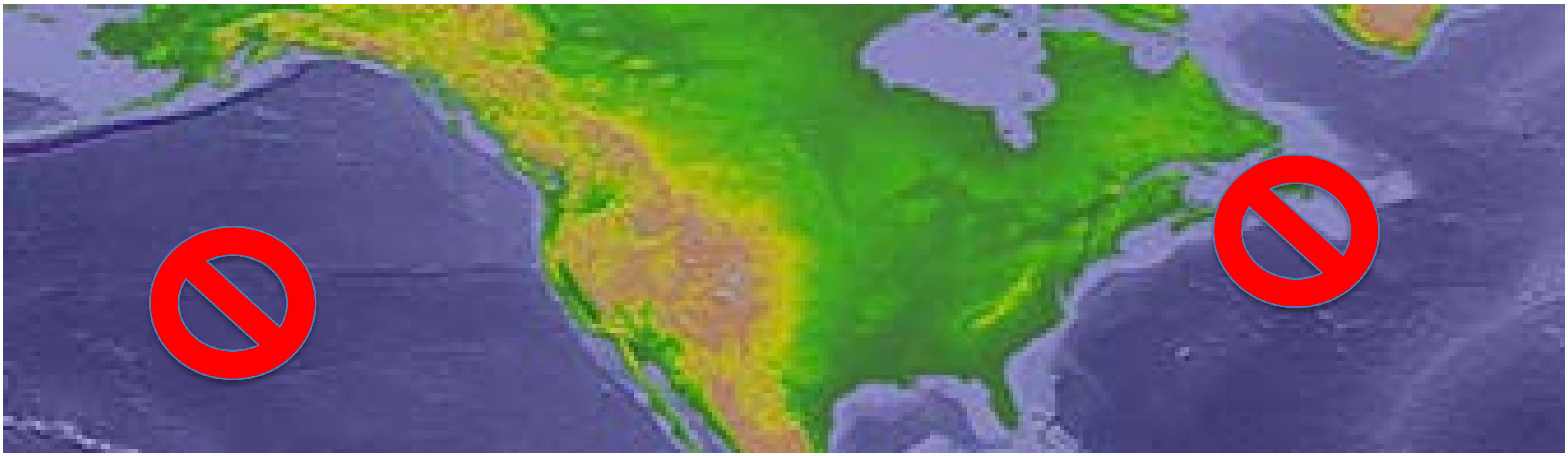
Higher interaction rates, higher survival rates

Lower interaction rates, lower survival rates

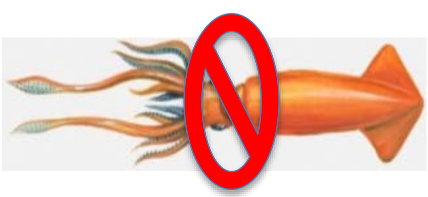
Gilman et al. Reducing sea turtle bycatch in pelagic longline fisheries.2006. *Fish & Fisheries*.7:2-23.

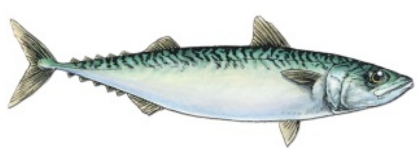
Regulatory Changes

2001: Pacific (HI) & Atlantic shallow set fisheries closed



2004: fisheries re-opened w/ extensive regulations





Watson et al. Fishing methods to reduce sea turtle mortality associated with pelagic longlines. 2005 *Can J Fish & Aq Sci*. 62:965-81.

Hawaii Shallow Set Longline Fishery Regulations

Gear:

- Hook: 18/0 circle 
- Bait: Fish 

Calendar Year 2017

	Leatherback Sea Turtles	Loggerhead Sea Turtles
Annual limit	26	34
Interactions to date	0	7

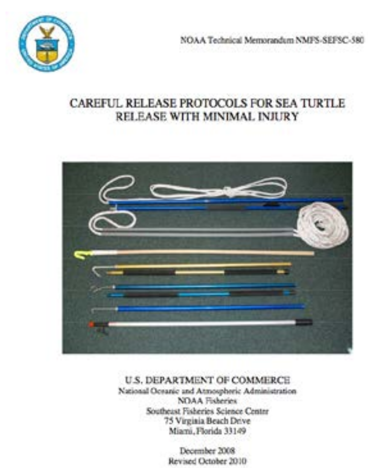
Nov. 16, 2017

Limits & Observer Coverage:

- Hard caps met = closure
- Increased observer coverage (from 20% to 100%)

Education & Safe Handling:

- Skipper trainings
- Safe handling gear on board


NOAA Technical Memorandum NMFS-SEFSC-580

CAREFUL RELEASE PROTOCOLS FOR SEA TURTLE RELEASE WITH MINIMAL INJURY

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NOAA Fisheries
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, Florida 33149

December 2008
Revised October 2010

http://www.fpir.noaa.gov/SFD/SFDturtleint.html

20 Yrs of Observer Data – Before & After Regs

Goals:

- Determine if mandatory use of large circle hooks and finfish bait reduced sea turtle bycatch

- Identify explanatory variables (eg., SST, location, hook, bait) associated with turtle capture risk by using an ecological model
  - Generalized additive mixed model (GAMM)

20 Years of HI LL Observer Data

Observer program managed by NOAA NMFS PIRO

Years:

- Pre-regulation ‘94-’01
- Post-regulation ‘04-’14

15,472 unique sets

20-100% of total annual effort (100% since 2004)

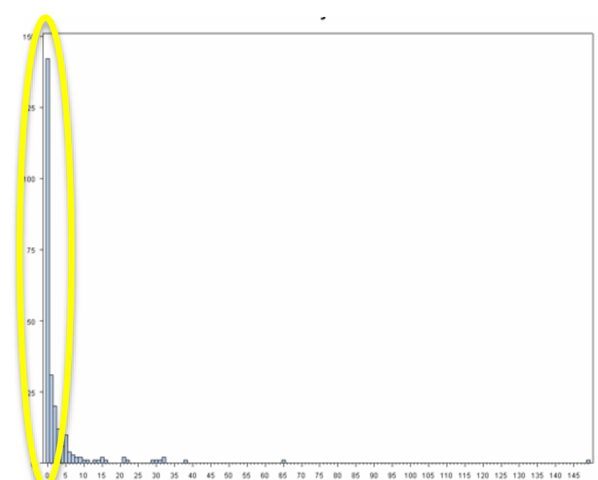
Statistical Challenges – “Rare Events”

Hawaii data:

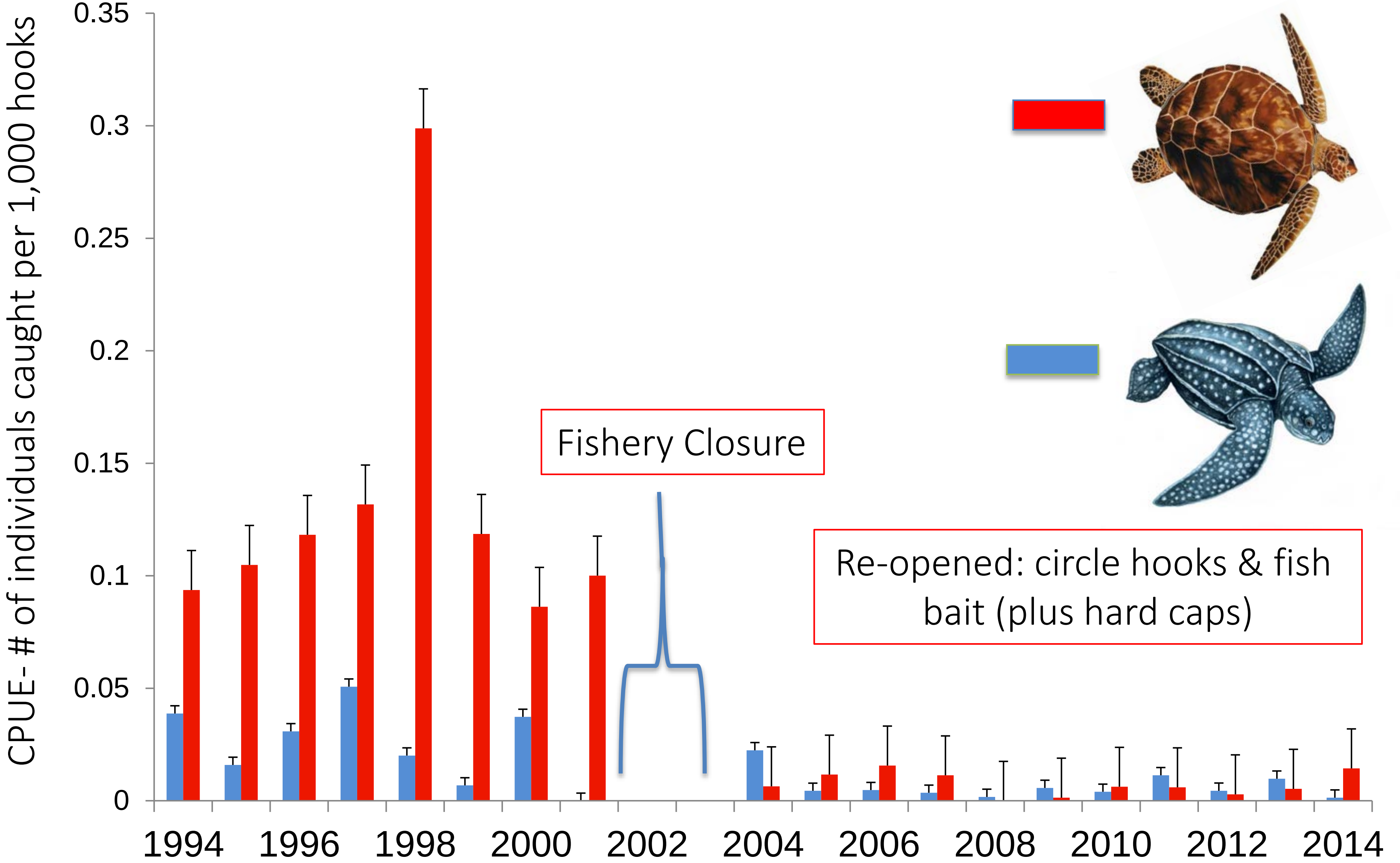
n=222, caught on <2% of sets

n= 105, caught on <1% of sets

Example of “zero inflated” data



Pacific Sea Turtle Catch: CPUE



20 Yrs of Observer Data – Before & After Regs

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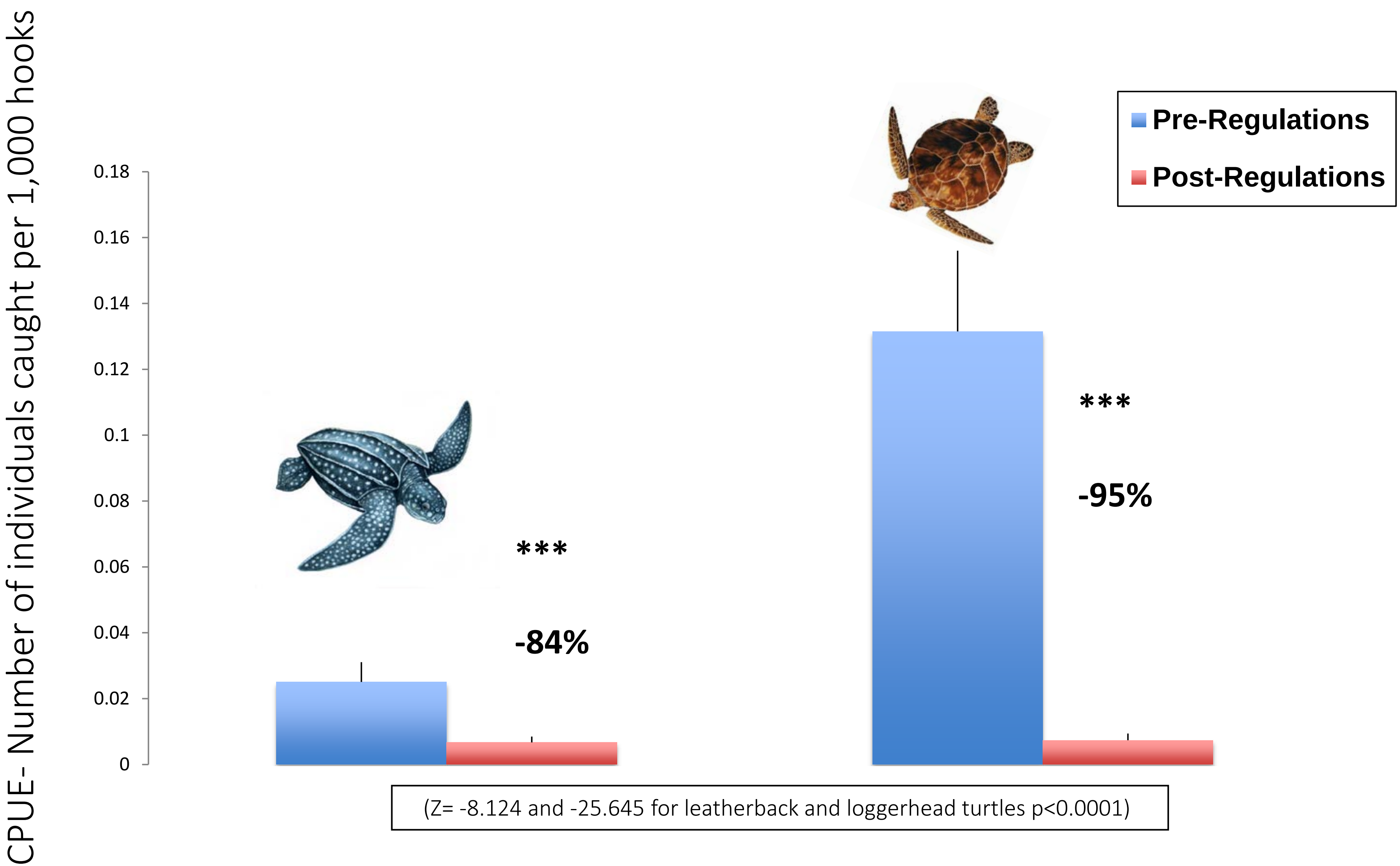
Regulatory Effects on Bycatch Reduction



Swimmer et al. Sea Turtle Bycatch Mitigation in U.S. Longline Fisheries. 2017 *Front Mar Sci* 4: 260

20 Yrs of Observer Data – Before & After Regs

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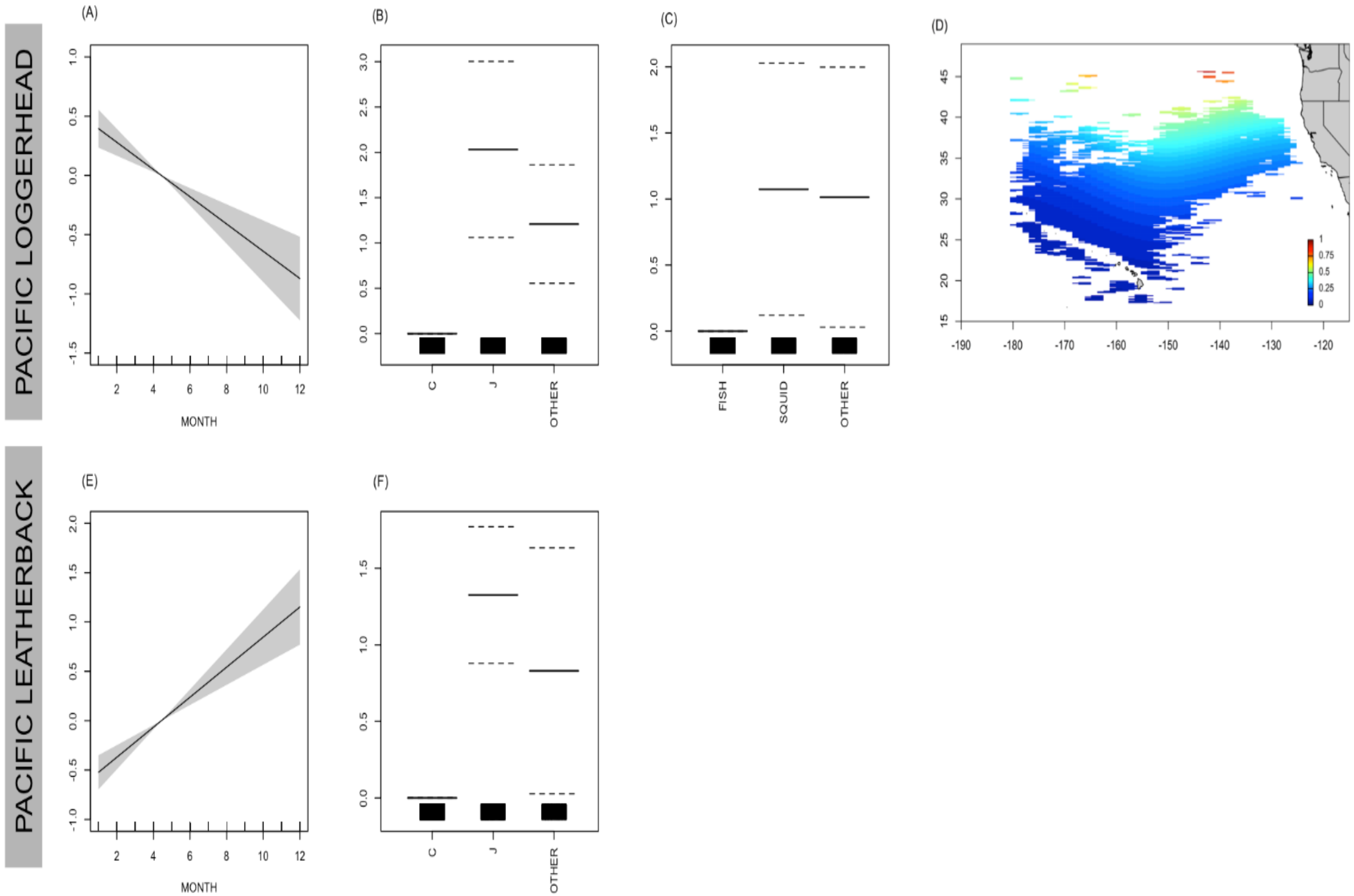
Explanatory Variables Using Ecological Models

Models account for interacting factors that influence sea turtle catch;

Predictive models, such as GAMMs, are used to forecast outcomes, such as risk of capture;

Models confirmed that catching a turtle is not a random event; rather, a capture event is influenced by environment and gear.

GAMM Results

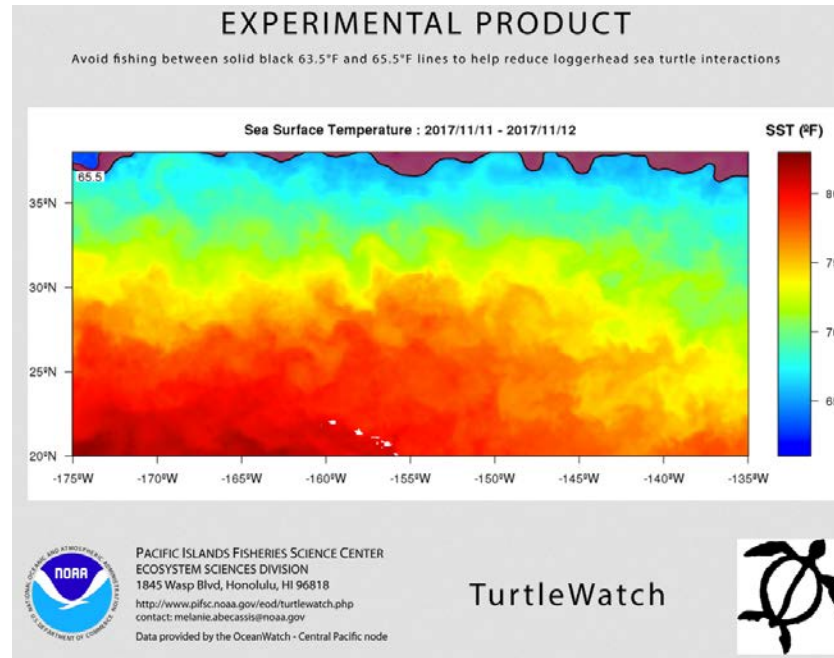


Factors associated with lower catch risk for both species are circle hooks, fish bait and factors associated with location, SST and month

Swimmer et al. Sea Turtle Bycatch Mitigation in U.S. Longline Fisheries. 2017 *Front Mar Sci* 4: 260

Real Time, Dynamic Management: “TurtleWatch”

- Online map
- real time (3 day avg.) SST & ocean currents
- predicted location of waters preferred by loggerhead turtles
- For fishers and managers to assist with decision making - reduce sea turtle interactions.
- More recent publication specific to leatherback turtles.



Howell et al. TurtleWatch: a tool to aid in the bycatch reduction of loggerhead turtles in the Hawaii-based pelagic longline fishery. 2008. Endang Species Res.5:267–278.
Howell et al. Enhancing the TurtleWatch product for leatherback sea turtles, a dynamic habitat model for ecosystem-based Management. 2015. Fish Oceanogr. doi:10.1111/fog.12092

Sea Turtle Survivorship

<u>At vessel survival depends on:</u>

- Gear characteristics
- Severity of injury

<u>Post-release survival depends on:</u>

- Severity of injury
- Safe handling
  - (e.g. use a dip net)
- Amount of gear removed

Ryder et al. Report of the Marine Turtle Workshop on Longline Post-Interaction Mortality. 2006. US Dep Commerce, NOAA Tech Memo, NMFS-F/OPR-29.
Swimmer, Y et al. Post-release mortality estimates of loggerhead sea turtles caught in pelagic longline fisheries based on archived satellite data and hooking location. *J. of Aquatic Conservation: Marine and Freshw Ecosystems*. DOI: 10.1002/aqc.2396.

Sea Turtle Safe-Handling Gear and Techniques

Presentation Overview

*Not always bycatch

Blue Sharks (*Prionaces glauca*)

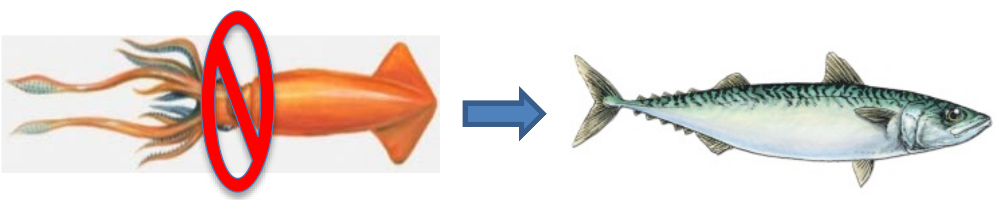
- Most commonly caught shark in both the deep and shallow-set longline sectors
- East of the 140°W, blue sharks represent ~80% of total shark catch for both fisheries by species

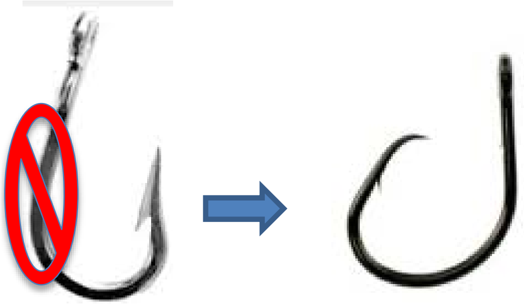
NOAA observer data

Impacts of Sea Turtle Regulations on Sharks

Remember:

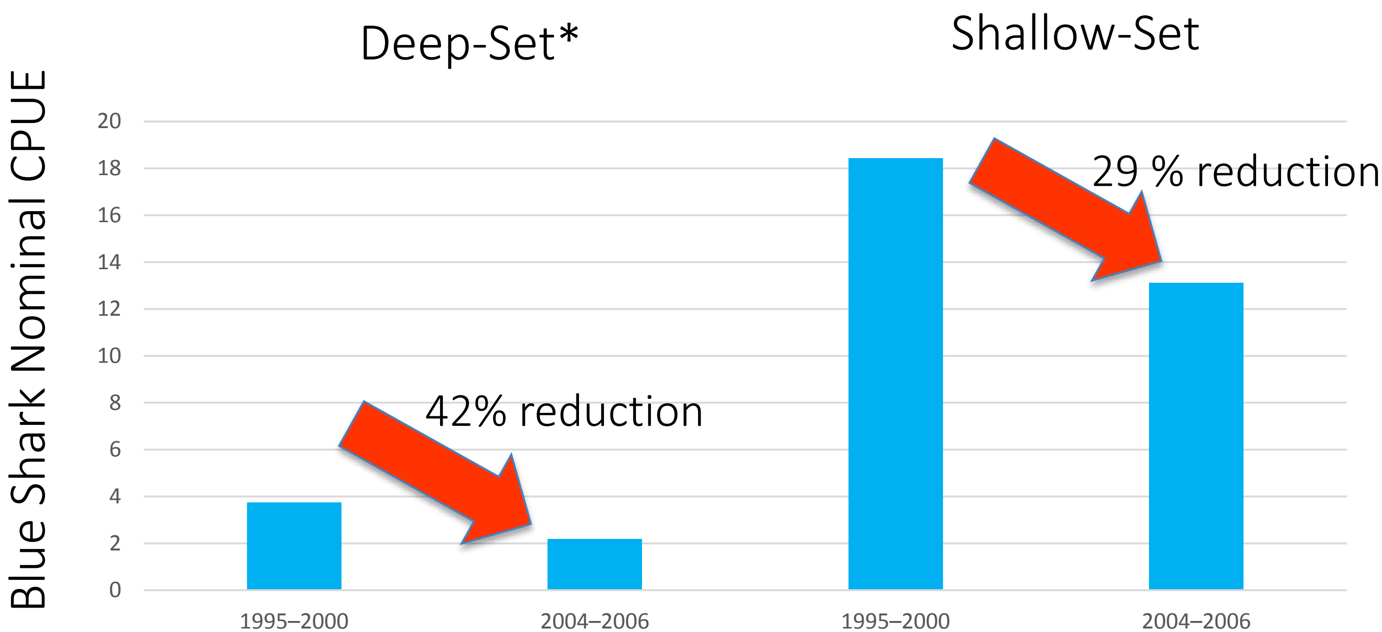
- 2004 the HI SSLL fishery re-opened
- shift from J hooks and squid bait to circle hooks and finfish bait
- means to reduce turtle bycatch and mortality.





Impacts of Sea Turtle Regulations on Sharks

Blue sharks



* Mostly finfish after 2004, not mandatory

Walsh WA, Bigelow KA, Sender KL. Decreases in shark catches and mortality in the Hawaii-based longline fishery as documented by fishery observers. Marine and coastal fisheries: Dynamics, management, and ecosystem science. 2009 Oct 1:270-82.

Impacts of Sea Turtle Regulations on Sharks

Reduced catch rates: Hooks or bait?

- High variability in catch rates with circle hooks
  - Godin et al. (2012) compared the results from 23 studies, many including blue sharks.
- Results suggest it is the change in bait

Regardless: Take home = shift to circle hooks and finfish bait reduced mortality of blue sharks in the HI LL fisheries.

Godin AC, Carlson JK, Burgener V. The effect of circle hooks on shark catchability and at-vessel mortality rates in longlines fisheries. Bulletin of Marine Science. 2012 Jul 1;88(3):469-83.

Potential Options to Reduce Shark Catch

Deterrents

- Electro-positive metals
- Magnets

Variable results, expensive, and at current state of technology not a viable option[1,2,3]

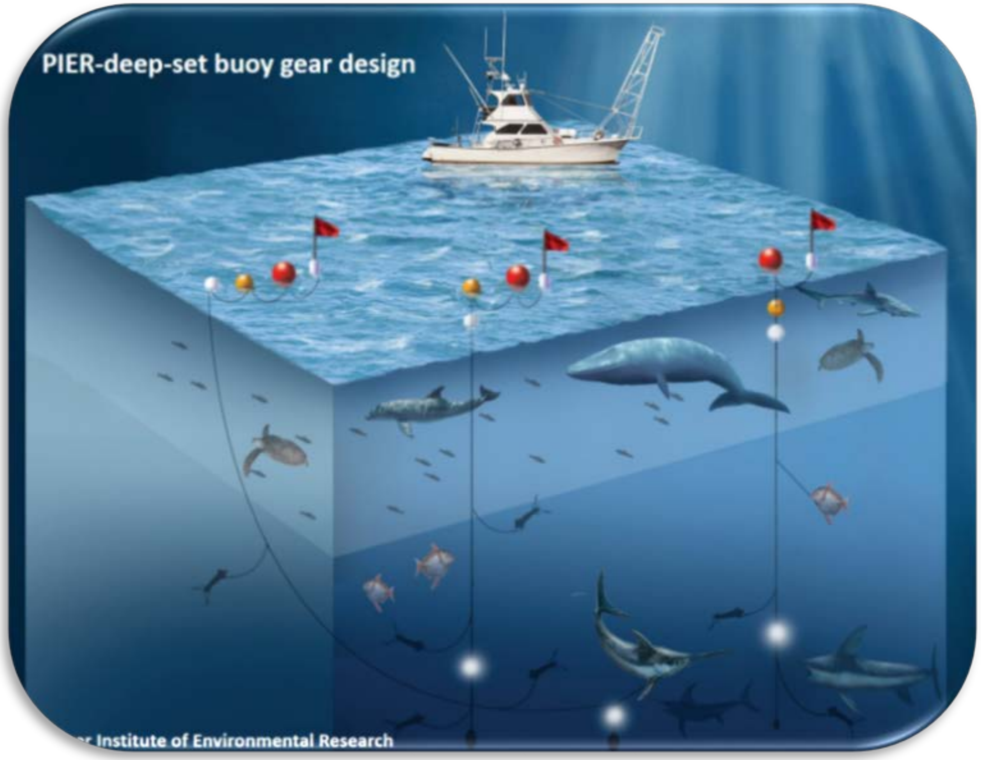
Fish where sharks are not

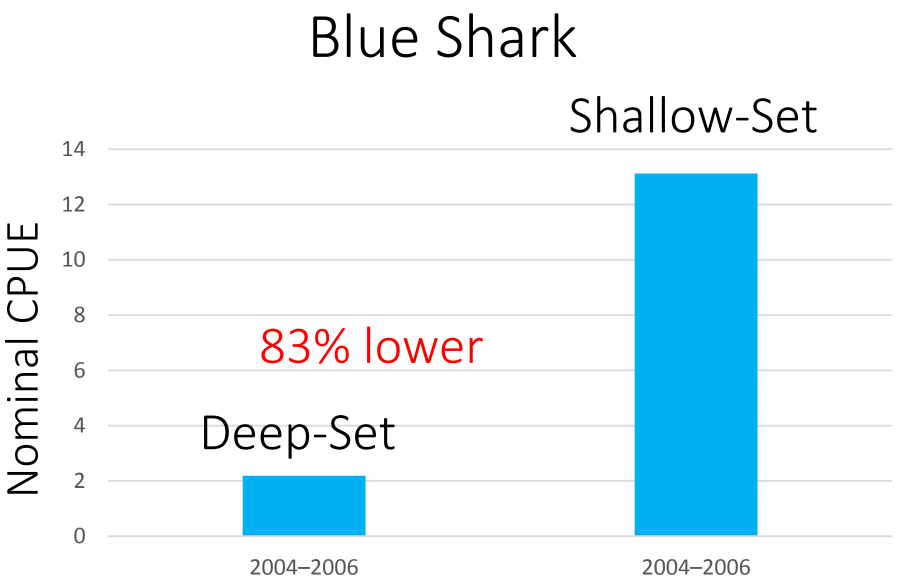
- Vertically
- Geographically (EcoCast)

1.Wang JH, McNaughton L, Swimmer Y, Wang JH. Galapagos and sandbar shark aversion to electropositive metal (Pr–Nd alloy). InShark Deterrent and Incidental Capture Workshop 2008 Apr 10 (pp. 28-32).
2.Hutchinson M, Wang JH, Swimmer Y, Holland K, Kohin S, Dewar H, Wraith J, Vetter R, Heberer C, Martinez J. The effects of a lanthanide metal alloy on shark catch rates. Fisheries Research. 2012 Nov 30;131:45-51.
3. Curran D. Shark Catch in Pelagic Longline Fisheries: A Review of Mitigation Measures. WCPFC-SC10-2014/EB-IP-11. Western and Central Pacific Fisheries Commission, Kolonia, Federated States of Micronesia; 2014 Aug 6.

Fish Where Sharks are Not

Removal of shallow hooks suggest potential to reduce epipelagic shark catch





Walsh WA, Bigelow KA, Sender KL. Decreases in shark catches and mortality in the Hawaii-based longline fishery as documented by fishery observers. Marine and coastal fisheries: Dynamics, management, and ecosystem science. 2009 Oct 1:270-82.
Beverly S, Curran D, Musyl M, Molony B. Effects of eliminating shallow hooks from tuna longline sets on target and non-target species in the Hawaii-based pelagic tuna fishery. Fisheries Research. 2009 Mar 31;96(2):281-8.

Circle Hooks and Post-Release Survival

Circle Hooks and Post-Release Survival

At-vessel mortality:

- 35% lower at vessel mortality with circle hooks [1]
- 96% that swallowed hooks were pulled up dead [2]

Post-release mortality: [2]

- 0 healthy sharks died
- ~33% of injured sharks died
- J hooks cause more injury

Increased at vessel survival with *larger* circle hooks:

- survival 79% on larger Circle hooks (16/0) vs 67 % [3]

1.Godin, Carlson, Burgener. The effect of circle hooks on shark catchability and at-vessel mortality rates in longlines fisheries. 2012 Bull. of Mar. Sci; 88(3):469-83.
2. Campana, Joyce, Manning. Bycatch and discard mortality in commercially caught blue sharks *Prionace glauca* assessed using archival satellite pop-up tags. 2009 Marine Ecology Progress Series; 387:241-53.
3. Curran, Beverly. Effects of 16/0 circle hooks on pelagic fish catches in three South Pacific albacore longline fisheries. 2012 Bull. of Mar. Sci; 88(3):485-97.

Gear Options to Reduce Mortality

<u>Leader Material – Monofilament (instead of wire)</u>

- Sharks can bite through monofilament leaders and facilitate an early release[1, 2] - although results across studies are not always consistent [3].
- Regardless, monofilament leaders are mandated in a number of fisheries.
- Some suggestion that Santos et al recently found significant decrease (31%) in blue shark catch with monofilament leaders.

1. Ward P, Lawrence E, Darbyshire R, Hindmarsh S. Large-scale experiment shows that nylon leaders reduce shark bycatch and benefit pelagic longline fishers. Fisheries Research. 2008 Apr 30;90(1):100-8.
2. Santos MN, Lino PG, Coelho R. Effects of leader material on catches of shallow pelagic longline fisheries in the southwest Indian Ocean. Fishery Bulletin. 2017 Apr 1;115(2):219-33.
3. Curran D. Shark Catch in Pelagic Longline Fisheries: A Review of Mitigation Measures. WCPFC-SC10-2014/EB-IP-11. Western and Central Pacific Fisheries Commission, Kolonia, Federated States of Micronesia; 2014 Aug 6.

Handling Options – Increase Post-Release Survival

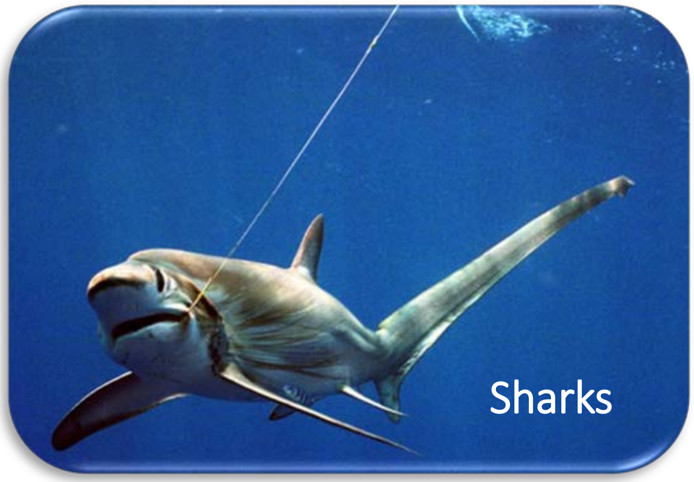
Condition on release is dependent on handling and gear removal

Optimal:

- leave shark in water
- minimize trailing gear (cut line as close to hook as possible)
- remove hook if possible
- work with fishers on hook removal/ line cutters to ensure efficiency and safety

1. Hutchinson unpublished data
2. http://www.issfguidebooks.org/downloadable-guides/skippers-guide-longline-english
3. Curran D. Shark Catch in Pelagic Longline Fisheries: A Review of Mitigation Measures. WCPFC-SC10-2014/EB-IP-11. Western and Central Pacific Fisheries Commission, Kolonia, Federated States of Micronesia; 2014 Aug 6.

Presentation Overview

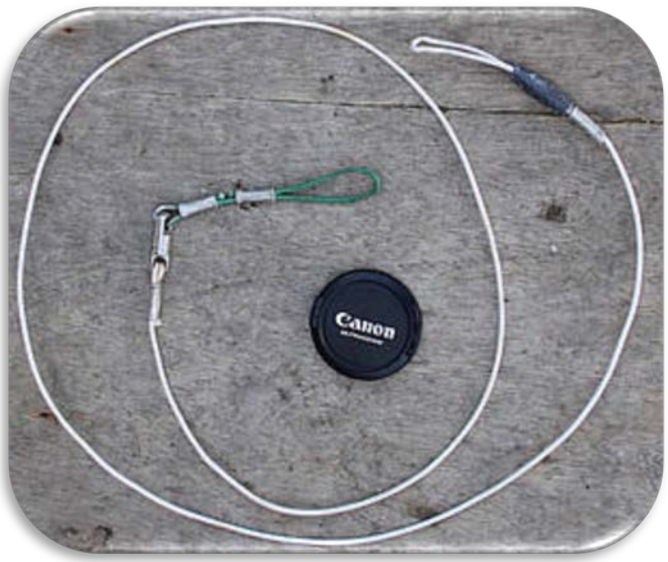


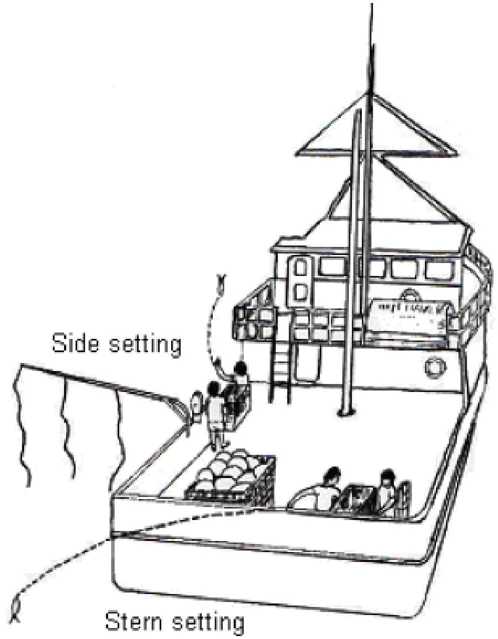
Seabird Bycatch Mitigation Measures

Hawaii regulations differ based on:

- deep vs. shallow set fishing
- location of fishing (N or S of 23^{o})

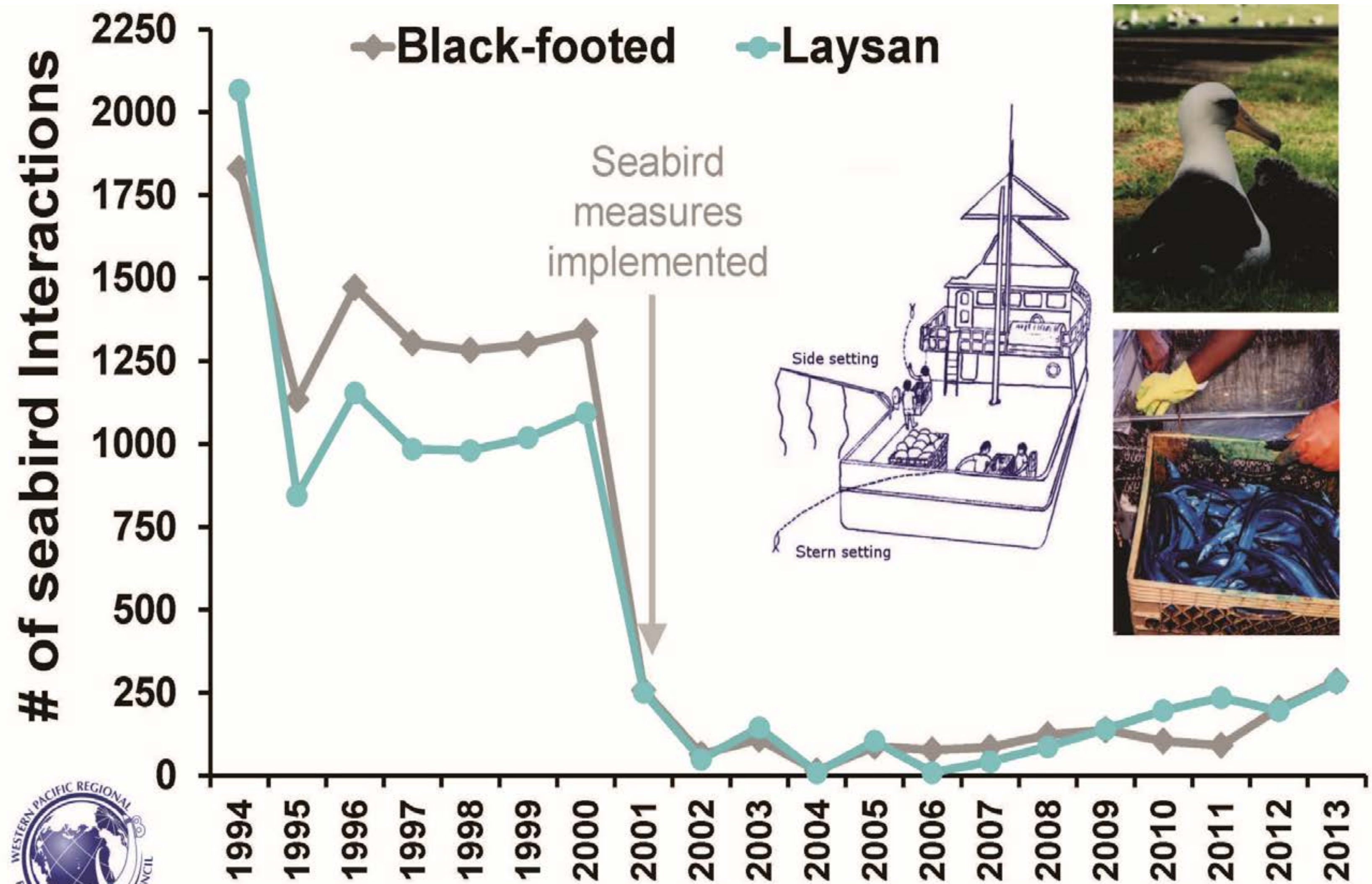
Fishers are given choices amongst suite of options





Gilman, Brothers, Kobayashi. Principles and approaches to abate seabird by-catch in longline fisheries. 2005 Fish & Fisheries 6 (35–49)

Seabird Interactions in HI Fisheries



Note: Total interactions from 1994 to 2004 are estimates from available bycatch data recorded from a small portion of all trips. Data since 2004 combine estimated interactions from the deep-set (tuna) fishery and actual interactions from the shallow-set (swordfish) fishery.
Side setting image: Gilman et al. 2003.

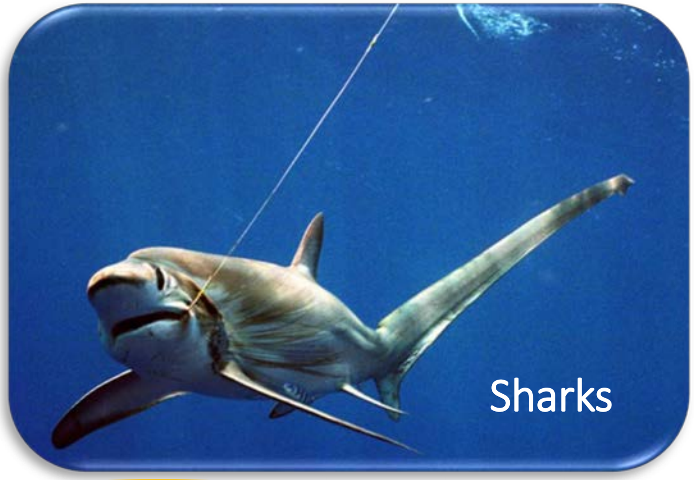
wpcouncil.org

Efficacy of Seabird Mitigation Techniques

Study[1]	Treatment	Contact rate	Contact reduction (%)	Capture rate	Capture reduction (%)
McNamara *et al.* (1999)	Control[2]	32.8 (265.7)[3]		2.23 (18.0)	
Hawaii longline swordfish gear	Blue-dyed bait	7.6 (61.6)	77	0.12 (17.5)	95
	Towed buoy	16.1 (130.4)	51	0.26 (6.8)	88
	Offal discards	15.7 (124.7)	53	0.32 (2.3)	86
	Streamer line	15.7 (127.2)	52	0.47 (6.6)	79
	Night setting			(0.60)[4]	97[4]
Boggs (2001)	Control[2]	7.60 (313.5)[3,5]			
Hawaii longline swordfish gear	Blue-dyed bait	0.43 (20.5)[5]	94		
	Streamer line	1.82 (93.4)[5]	76		
	Additional 60 g weight at bait	0.61 (25.0)[5]	92		
Gilman *et al.* (2003a)	Control[2]	0.61 (75.93)		0.06 (4.24)	
Hawaii longline tuna gear	Underwater setting chute 9 m	0.03 (1.85)	95	0.00 (0.00)	100
Boggs (2003)	Control[2]	0.78 (27.1)		0.058 (2.0)	
Hawaii longline swordfish gear	Night setting	0.053 (4.8)	93	0.0013 (0.11)	98
	Night setting and blue-dyed bait	0.01 (0.98)	99	0.00 (0.00)	100
Gilman *et al.* (2003b),	Underwater setting chute 9 m	0.30 (5.0)		0.03 (0.6)	
Hawaii longline swordfish gear	Blue-dyed bait	2.37 (64.9)		0.08 (1.8)	
	Side-setting	0.08 (1.9)		0.01 (0.2)	
Gilman *et al.* (2003b),	Underwater setting chute 9 m	0.28 (10.3)	82[6]	0.05 (1.7)	38[6]
Hawaii longline tuna gear	Underwater setting chute 6.5 m	0.20 (5.6)	87[6]	0.01 (0.5)	88[6]
	Blue-dyed bait	0.61 (23.8)	60[6]	0.03 (1.2)	63[6]
	Side-setting	0.01 (0.1)	99[6]	0.00 (0.0)	100[6]

Gilman et al 2005

Presentation Overview

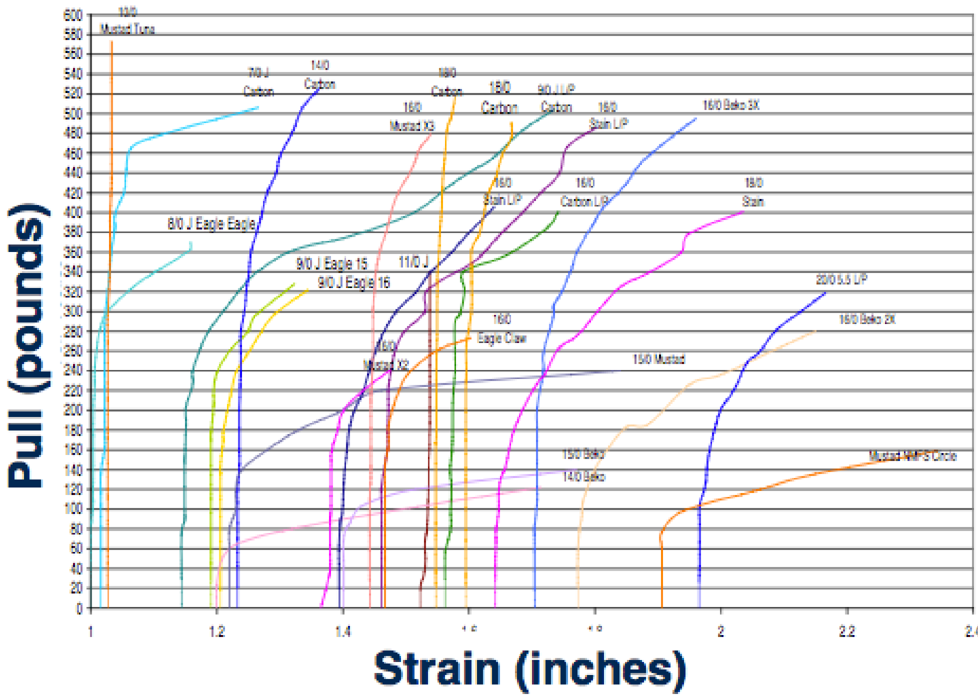


Marine Mammal Bycatch Mitigation

- Real time fleet communication (while at sea)
- Weak hooks (exploit different strengths of target and bycatch species)

Gilman et al. Fleet Communication to abate fisheries bycatch. 2006 Marine Policy Volume 30: 360-364

Weak Hooks



Example of a hook straightened by a FKW

<u>Weak hooks (4.5mm)</u>

- Strong enough to retain target species
- Weak enough to be straightened by a large marine mammal (e.g. FKW)

Bigelow et al. Catch Rates with Variable Strength Circle Hooks in the Hawaii-Based Tuna Longline Fishery. 2012. Bull Mar Sci(3):425 -447.

Bycatch and Mortality Can Be Managed

All Taxa
safe-handling
dynamic management

Sea Turtles
large circle hooks
finfish bait
hook depth

Seabirds
side setting
night setting
tori lines / streamers
weighted branch lines

Sharks
circle hooks
finfish bait
monofilament leaders
release methods

Marine Mammals
weak hooks
fleet communication