Catchability in Hawaii and American Samoa tuna longline fisheries: effects of different circle hook sizes

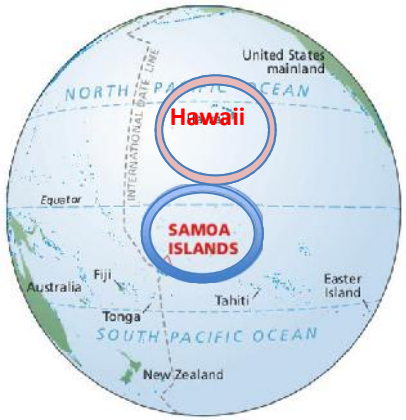
WCPFC SC14 EB 06

Keith Bigelow & Yonat Swimmer

NOAA, NMFS

Pacific Islands Fisheries Science Center

Honolulu, Hawaii USA



- *The Commission tasked SC14 to evaluate the expected effects of several potential sea turtle management scenarios,*

  -Eg., use of large circle hooks, finfish bait

- *The evaluation should focus on expected effects on sea turtle interactions and on target and other bycatch species catch rates;*

- *SC and TCC would then provide any appropriate advice or recommendations to WCPFC15 with respect to improving CMM 2008-03.*

WCPFC: Sea Turtle Conservation Management Measure: CMM 2008-03

CMM 2008-03: CCM's with longline vessels that fish for swordfish in a "shallow-set" (<100m) manner shall:

Employ or implement at least one of the following three methods to mitigate the capture of sea turtles in the Convention Area:

i. Use only large circle hooks, which are fishing hooks that are generally circular or oval in shape and originally designed and manufactured so that the point is turned perpendicularly back to the shank. These hooks shall have an offset not to exceed 10 degrees.

ii. Use only whole finfish for bait.

iii. Use any other measure, mitigation plan, or activity that has been reviewed by the Scientific Committee (SC) and the Technical and Compliance Committee (TCC)

Updates on Commission Tasks

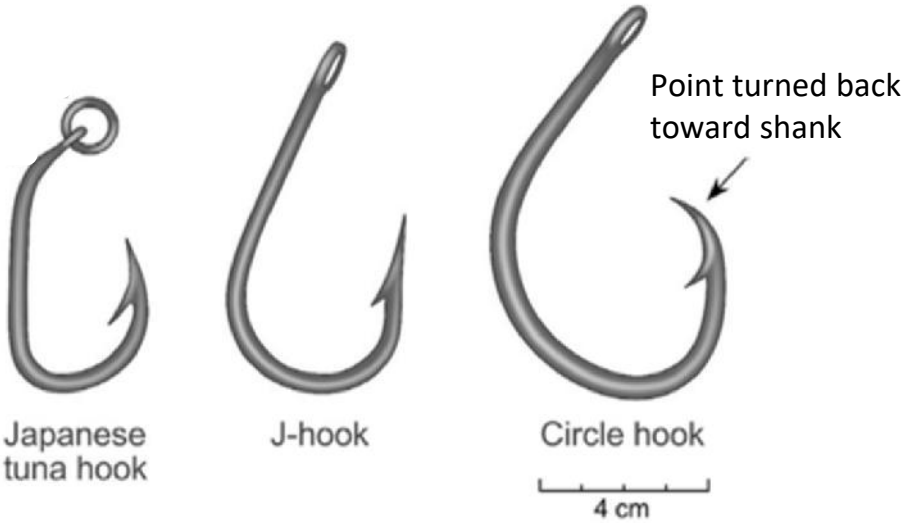
- Effects of sea turtle mitigation measures on sea turtles in the Pacific:

—Analysis of Hawaii's shallow-set fishery targeting swordfish after regulations were put in place;

—Results of ABNJ workshops (2016) regarding factors that influence sea turtle bycatch in the Pacific Ocean;

- Evaluation of catchability effects due to hook size in Hawaii and American Samoa tuna fisheries for both retained and bycatch (discarded) species.

Hook Types, Hook Sizes



Source: Reinhardt et al.2017

15/0

Circle Hook Size	Minimum Width (cm)
13/0	*3.5*
14/0	*3.8*
15/0	*3.8-4.0*
16/0	*4.4*
18/0	*4.9*

- Evidence that large circle hooks reduces sea turtle bycatch
  - — The shielded point reduces both hooking and entanglement;
  - — A large hook deters bites & swallowing from smaller animals.

Sea turtle bycatch reduction in longline fisheries

Fish Bait

Circle Hooks

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Sea Turtle Bycatch Mitigation in U.S. Longline Fisheries

Yonat Swimmer[1], Alexis Gutierrez[2], Keith Bigelow[1], Caren Barceló[3], Barbara Schroeder[2], Kenneth Keene[4], Keith Shattenkirk[5] and Daniel G. Foster[6]*

[1] Pacific Islands Fisheries Science Center (NOAA Fisheries), Honolulu, HI, United States, [2] Office of Protected Resources (NOAA Fisheries), Silver Spring, MD, United States, [3] College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR, United States, [4] Southeast Fisheries Science Center (NOAA Fisheries), Miami, FL, United States, [5] Oceans Program, Leonardo DiCaprio Foundation, Los Angeles, CA, United States, [6] Southeast Fisheries Science Center (NOAA Fisheries), Pascagoula, MS, United States

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 leatherback turtle bycatch in the Atlantic and Pacific when circle hooks are used (vs. J hook). Use of fish bait (vs. squid) was also found to significantly reduce the capture probability of loggerheads in both ocean basins, and for leatherbacks in the Atlantic only. Capture probabilities are lowest when using a combination of circle hook and fish bait. Influences of light sticks, hook depth, geographic location, and sea surface temperature are discussed specific to species and regions. Results confirmed that in two U.S.-managed longline fisheries, rates of sea turtle bycatch significantly declined after the regulations. In the Atlantic (all regions), rates declined by 40 and 61% for leatherback and loggerhead turtles, respectively, after the regulations. Within the NED area alone, where additional restrictions include a large circle hook (18/0) and limited use of squid bait, rates declined by 64 and 55% for leatherback and loggerhead turtles, respectively. Gains were even more pronounced for the Pacific shallow set fishery, where mean bycatch rates declined by 84 and 95%, for leatherback and loggerhead turtles, respectively, for the post-regulation period. Similar management approaches could be used within regional fisheries management organizations to reduce capture of sea turtles and to promote sustainable fisheries on a global scale.

Keywords: sea turtles, longline fishing, observer data, statistical models, bycatch reduction

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Mariana M. P. B. Fuentes,
Florida State University, United States

Reviewed by:
Marc Girondot,
Université Paris-Sud, France
Brett W. Molony,
Department of Fisheries,
Western Australia, Australia

***Correspondence:**
Yonat Swimmer
yonat.swimmer@noaa.gov

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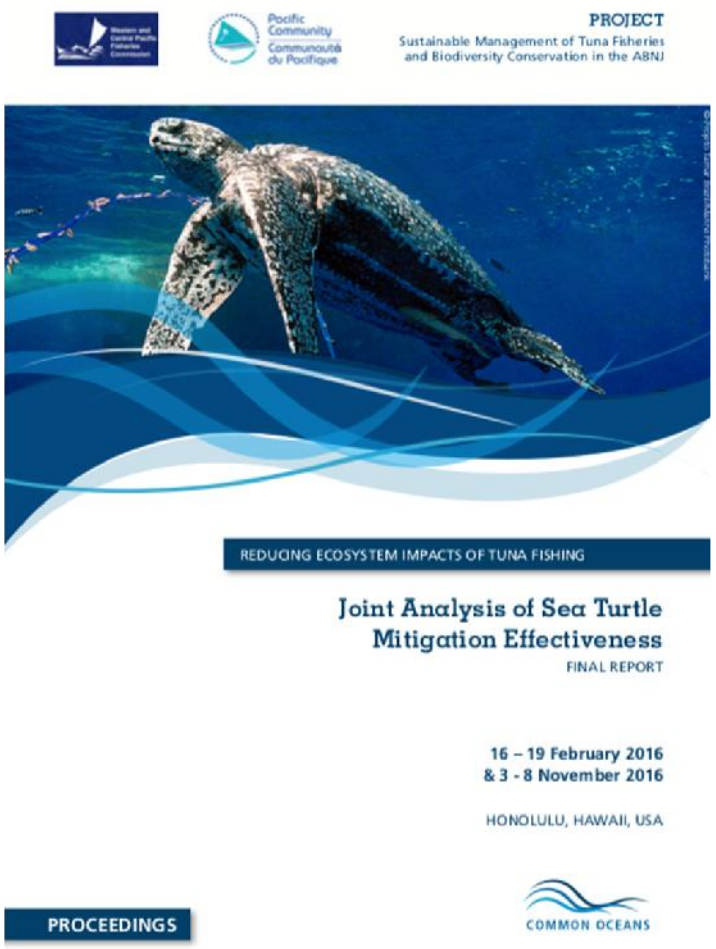
- Evaluated effects of regulatory measures to reduce sea turtle bycatch in U.S. shallow-set longline fisheries;
- Study compared catch rates before and after regulations (2004). Found significant reductions in loggerhead (95%) and leatherback (84%) sea turtles;
- GAMM models confirmed that circle hooks and fish bait were major factors associated with reduced sea turtle capture risk.

ABNJ/Common Oceans Workshops (2016)



- Analysis of longline observer data from Pacific Ocean regarding factors that influence sea turtle bycatch;
- For all four turtle species, large (16/0 or larger) circle hooks and fish bait were shown to reduce sea turtle captures, with greater effects achieved by use of large circle hooks.
- The degree of differences varies across species and across sectors (i.e. shallow versus deep-set fisheries)

Observer Data Analyzed:
Hawaii & American Samoa Deep-Set Fisheries

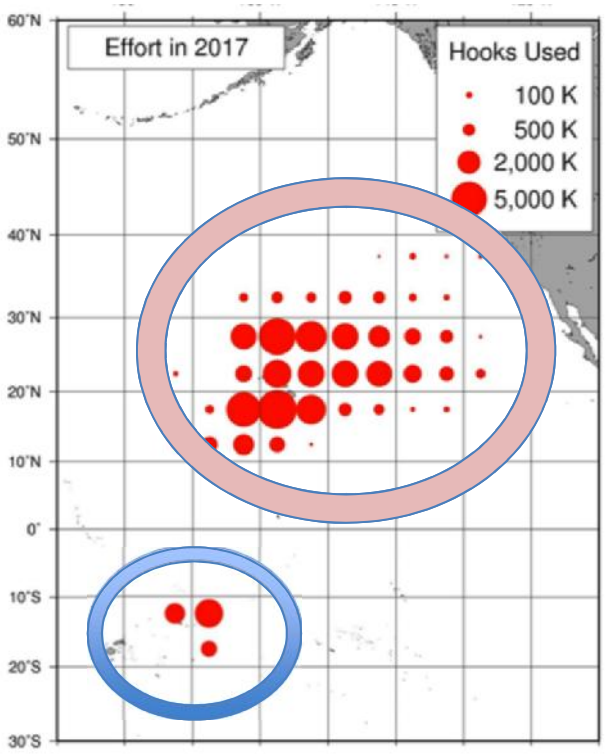
- Since January 2013, the NMFS Pacific Islands Regional Office observer program has recorded proportion of circle hook sizes on each set;
- Our analysis included sets that had 100% of the same hook size;
- Data: Jan 2013 to April 2018;
- Observer coverage represents ~ 20% of total annual effort in both fleets.

Hawaii Data

- Target: bigeye (*T. obesus*)
- 10,245 sets
- Hook sizes: 14/0, 15/0, 16/0
- 22 species
- 25,882,977 hooks

American Samoa Data

- Target: albacore (*T. alalunga*)
- 1,153 sets
- Hook sizes: 13/0, 14/0
- 16 species
- 3,302,562 hooks



Generalized Linear Model (GLM): Catchability related to hook size

GLMs, Catch data & Circle hook sizes:

Hawaii

Hooks compared:
14/0 vs 15/0, 14/0 vs 16/0, 15/0 vs 16/0

American Samoa

Hooks compared:
13/0 vs 14/0

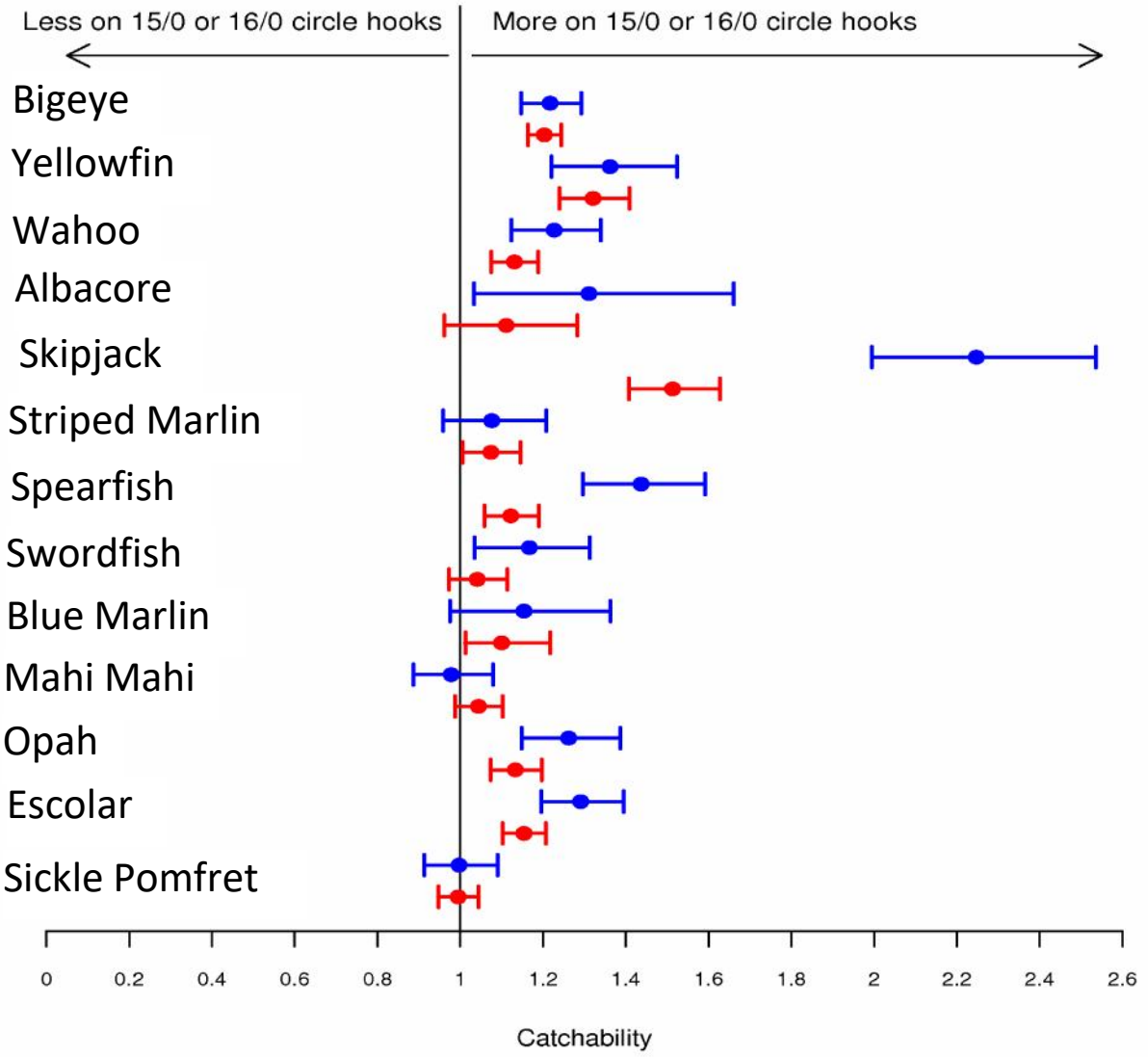
For each species, GLMs predicts mean catch (μ_i) as # of individuals using categorical & continuous variables with a log link :

$$\log(\mu_i)=N_i+H_i+T_i+B_1Lat_i+B_2Lat_i^2+B_3Lat_i^3+B_4Lon_i+B_5Lon_i^2+B_6Lon_i^3+log(E_i)$$

Where:
N= mean local abundance
H= hook size effect;
T= time (year:quarter) effect;
Lat and *Lon* are third order (cubic) effects of latitude and longitude;
$log(E_i)$=number of hooks deployed during longline operation

Hook Catchability: **Hawaii** Retained Species

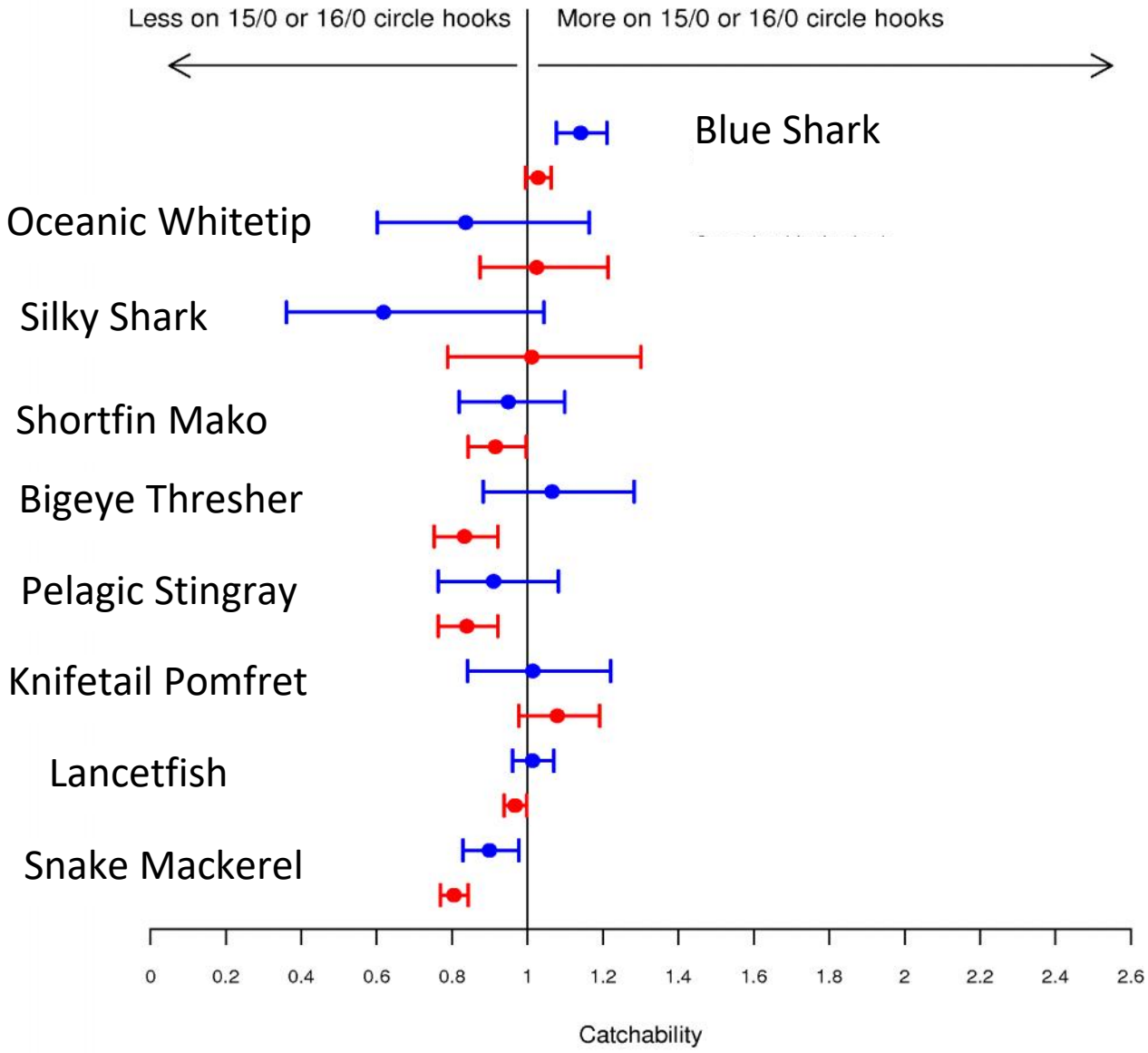
Circle Hook Size 14/0 (1) vs. 15/0 (Red) vs. 16/0 (Blue)



Mean catchability (circles) is exponent of GLM-estimated parameters by hook size. Horizontal lines are 95% confidence intervals around estimate.

Hook Catchability: **Hawaii** Bycatch Species

Circle Hook Size 14/0 (1) vs. 15/0 (Red) vs. 16/0 (Blue)

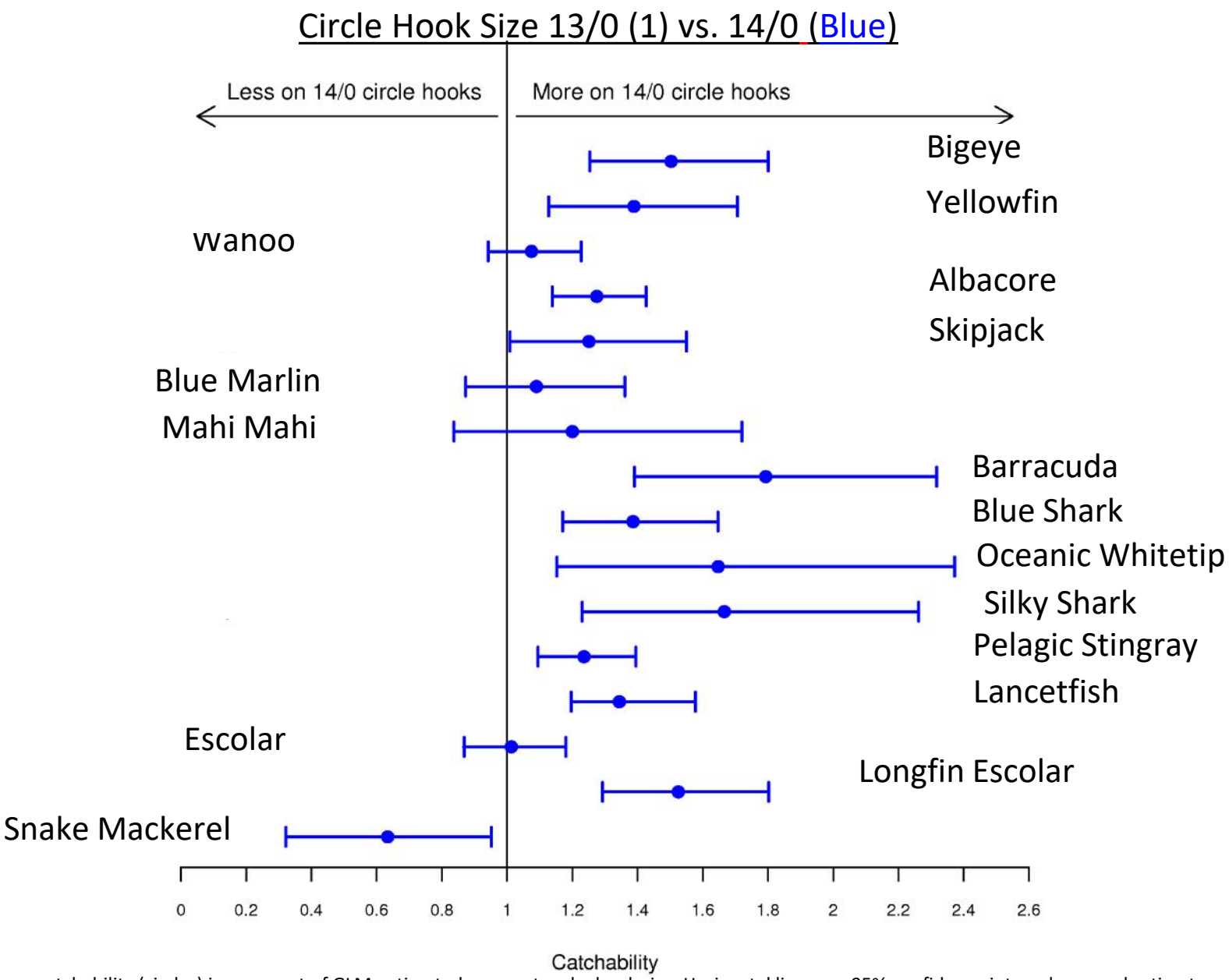


Mean catchability (circles) is exponent of GLM-estimated parameters by hook size. Horizontal lines are 95% confidence intervals around estimate.

Hawaii Retained and Bycatch Species' Catchability

- Significant increase in catchability with larger hook size for 11 of 13 retained species, including bigeye tuna.
- Numerous species were not affected by hook sizes, including two bycatch shark species, oceanic whitetip and silky shark.
- Of the eight bycatch species, catchability was higher on larger hooks only for blue sharks.
- A significant decrease in catchability observed between 14/0 and larger hooks for five bycatch species, including shortfin mako, bigeye thresher, and pelagic stingray.
- Overall, larger hooks are economically viable and provide conservation benefits in Hawaii's deep set fisheries, with the exception for blue sharks.

Hook Catchability: **American Samoa**



Mean catchability (circles) is exponent of GLM-estimated parameters by hook size. Horizontal lines are 95% confidence intervals around estimate.

American Samoa Retained and Bycatch Species' Catchability

- Significant increase in catchability for many retained species, including albacore, between hook sizes 13/0 and 14/0;

- Bycatch species: Larger (14/0) hooks were associated with higher catchability of pelagic stingray, blue shark, oceanic whitetip, silky shark;

- American Samoa data considered preliminary given wide confidence intervals. (Also, analyzed data was ~ 8 x greater in Hawaii as compared to A. Samoa).

Conclusions

- Analysis of robust Hawaii data confirm that catchability of target and non target species is affected by hook size;

- Use of a larger (15/0, 16/0) hook increases catchability of retained species and can serve as a conservation tool in subtropical longline fisheries;

- Depending on a perceived risk to a population, there is an opportunity to regulate hook size specific to resource concerns.

- It is important to consider cross-taxa (fish, turtles, marine mammals, sharks) implications and trade-offs in future management decisions, which will be region-specific.

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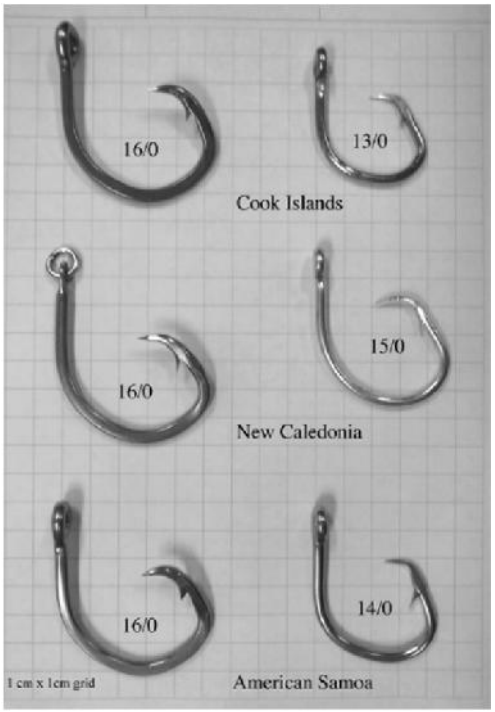
Yonat Swimmer: yonat.swimmer@noaa.gov
Keith Bigelow: keith.bigelow@noaa.gov

"Effects of 16/0 Circle Hooks on Pelagic Fish Catches in Three South Pacific Albacore Fisheries"



Cook Islands — No significant difference in catch by hook type for two main target species, but there was an increase in catchability for swordfish;

New Caledonia — No significant difference in catch by hook size for any species;

American Samoa — No significant difference in with albacore tuna, but 16/0 hooks significantly reduced catch of skipjack tuna, dolphinfish, and wahoo.

*For all locations, catch rates on 16/0 circle hooks were nominally lower, but not always significant for smaller pelagic species.

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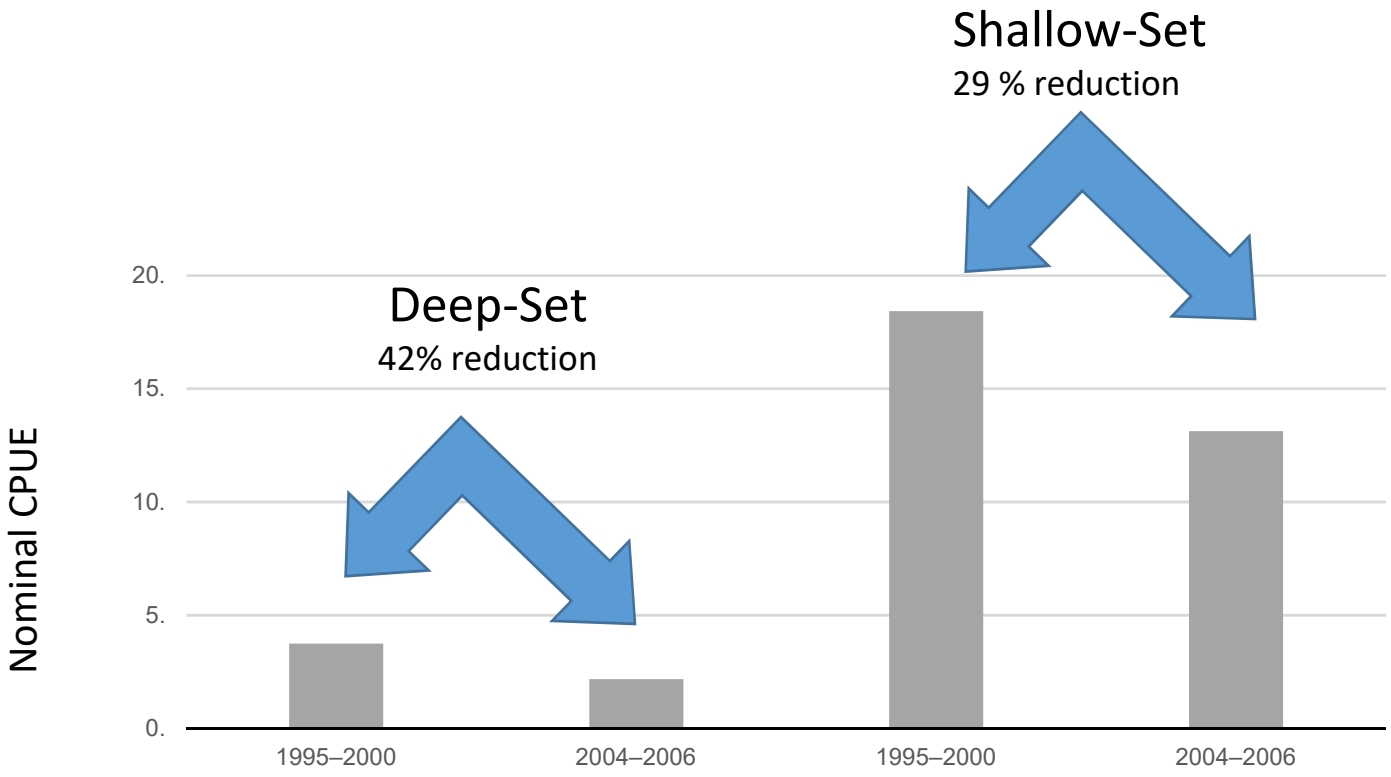
Curran and Beverly 2012, BULLETIN OF MARINE SCIENCE. 88(3):485–497.

Impacts of gear changes to Blue Shark (CPUE) when Hawaii switched to circle hooks and fish bait after sea turtle regulations in shallow set fishery (2004)



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.

Advantages of large circle hooks that may offset potential higher capture rates

- Larger hooks found to increase blue shark at vessel survival: survival 79% on larger Circle hooks (16/0) vs 67 % (Curran and Beverly 2011)

- Circle hooks resulted in lower at-vessel mortality
  - At the vessel:
    - 35% lower at vessel mortality with circle hooks (Godin et al 2012, blue sharks).
    - Afonso et al. (2011), Curran & Bigelow (2011), Epperly et al. (2012), Huang et al. (2016), NMFS (2011), Pacheco et al. (2011), Yokota et al. (2006)
  - Post-release mortality: (Compana et al., 2009)
    - 0 healthy sharks died
    - ~33% of injured sharks died.
    - J hooks cause more injury

Circle hooks capture mortality:

Advantages associated with circle hooks.