Spillover Effects of Environmental Regulation for Sea Turtle Protection in the Hawaii Longline Swordfish Fishery

NOAA FISHERIES

Pacific Islands Fisheries Science Center

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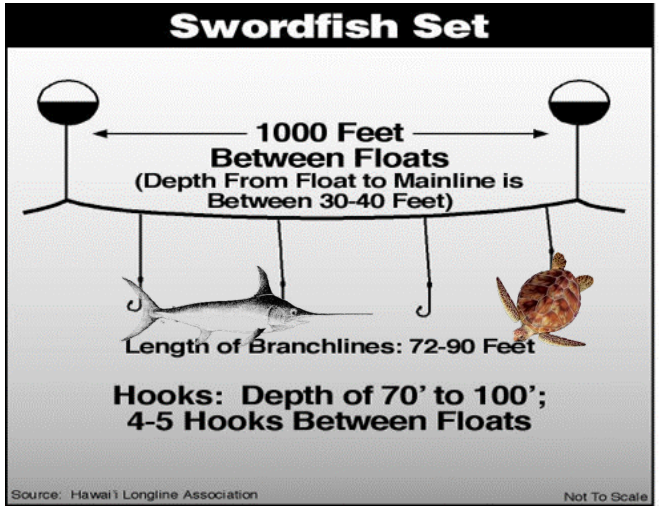
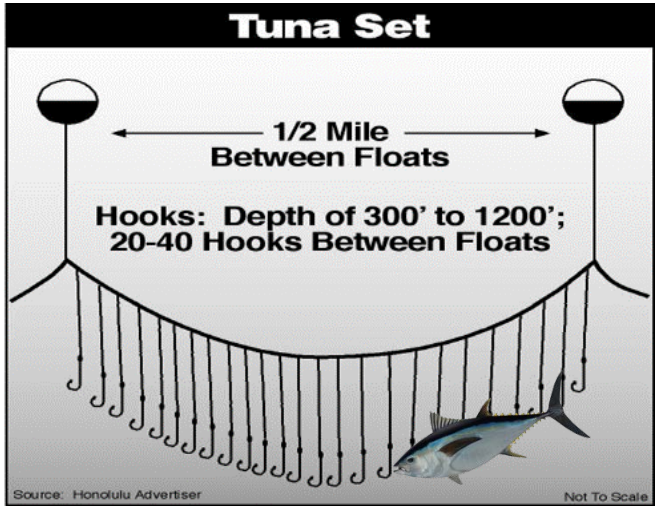
Study Motivation

Provide information for fishery management agency (PIRO) in support of ESA section 7 consultations on the effects of Hawaii-based longline fisheries on ESA-listed species and provided analytical support to the legal case between Turtle Island Restoration Network, *et al.* vs. NMFS

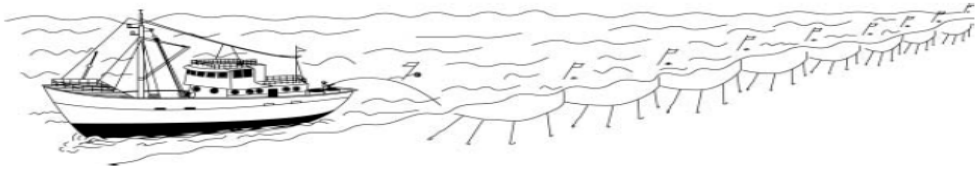
Study Background

- Hawaii longline fishery





- The shallow-set longline fishery incidentally catch endangered sea turtles – fish at water depths and sea surface temperatures that are favored by turtles



Study Background

- Hawaii longline fishery for swordfish was the major domestic producer for the U.S. swordfish market in the 1990s until it was restricted in 2001
- Hawaii shallow-set longline fishery for swordfish was closed between 2001 & 2004 by NMFS due to a lawsuit to reduce incidental sea turtle bycatch
- Fishery reopened in April 2004, with new regulations:
  - ✓ Circle hooks (instead of J hooks)
  - ✓ Fish as bait (instead of squid)
  - ✓ Annual fishing effort limit (2,120 sets, <50% historical level)
  - ✓ 100% observer coverage
  - ✓ Annual sea turtle caps (17 loggerhead & 16 leatherback turtles)

Study Background

- Impact from new regulations:

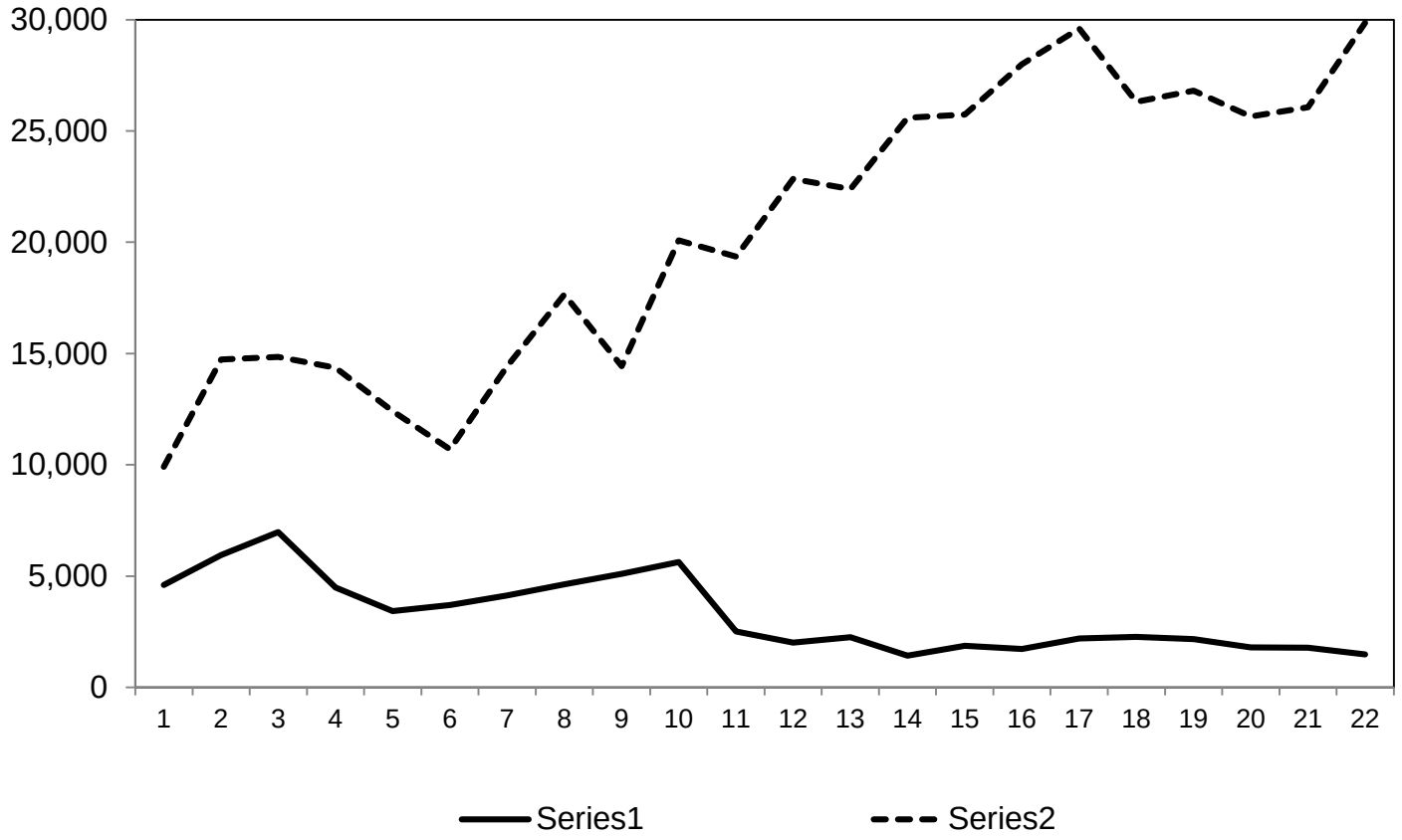
  ✓ Hawaii sea turtle bycatch rates declined by 90%

  ✗ Hawaii swordfish production reduced by 50% compared with pre-closure period

  ? Increased foreign swordfish production in North and Central (N&C) Pacific Ocean

U.S. vs. Foreign Swordfish Production in North & Central Pacific Ocean

U.S. production represented 25% of total swordfish in N&C Pacific during 1991-2000, 8% during 2001-2004, and 7% during 2005-2012



Study Objective

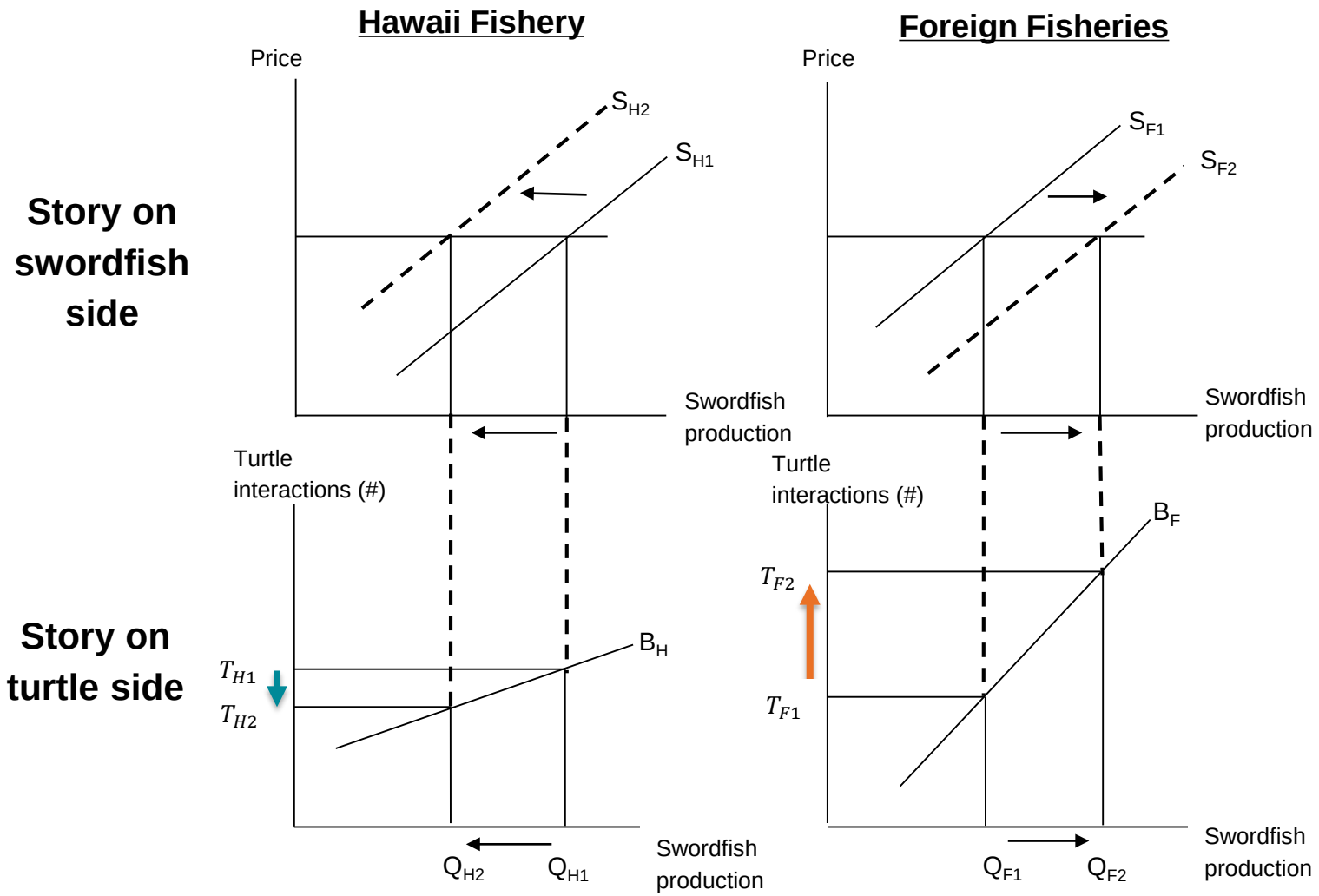
- While these regulations reduced sea turtle interactions and swordfish production by the Hawaii fleet, what happen to ocean-wide turtle stocks?

- This study examines whether, and to what extent, U.S. fishing regulations could cause a "**spillover effect**":

  - ? Foreign fleet activity change (production displacement)

  - ? Adverse effects on the very species intended for protection

Conceptual Model of Spillover Effects



Conditions for Spillover Effects

1) **Bycatch reduction policy is country specific**: foreign countries have little incentive to adopt costly bycatch reduction activities

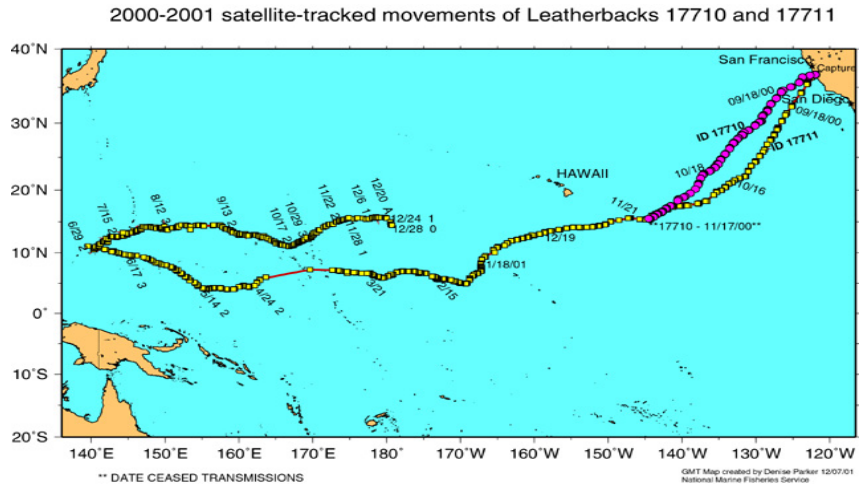
2) **Shared resources in high seas**: both turtles and swordfish are resources on the high seas and caught by Hawaii and foreign longline fisheries

3) **Production displacement**: fishing activities of foreign fleets respond to the changes of Hawaii swordfish production

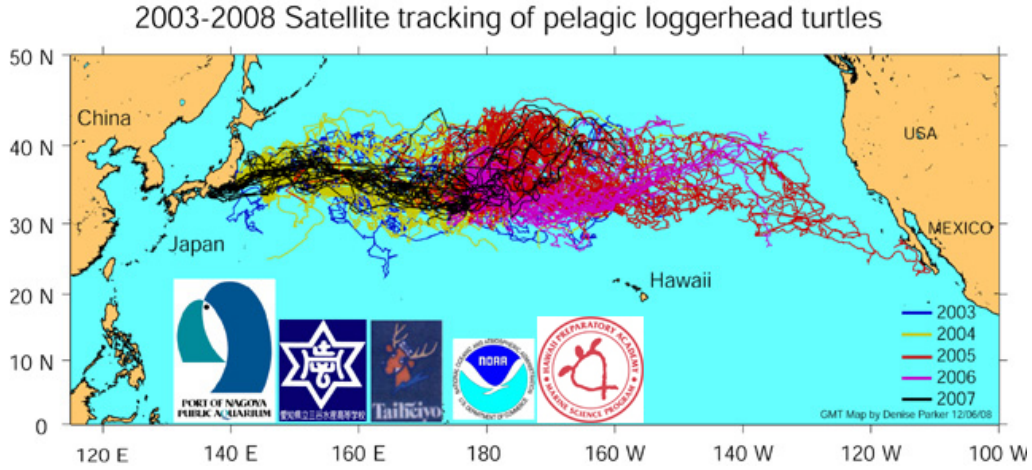
4) **The Hawaii and foreign fisheries have different sea turtle bycatch rates:** the turtle bycatch rate in Hawaii swordfish fishery is one of the lowest in the world

Shared Resources in High Seas: Turtles

- Turtle's migration routes intersect swordfish fishing grounds on high seas



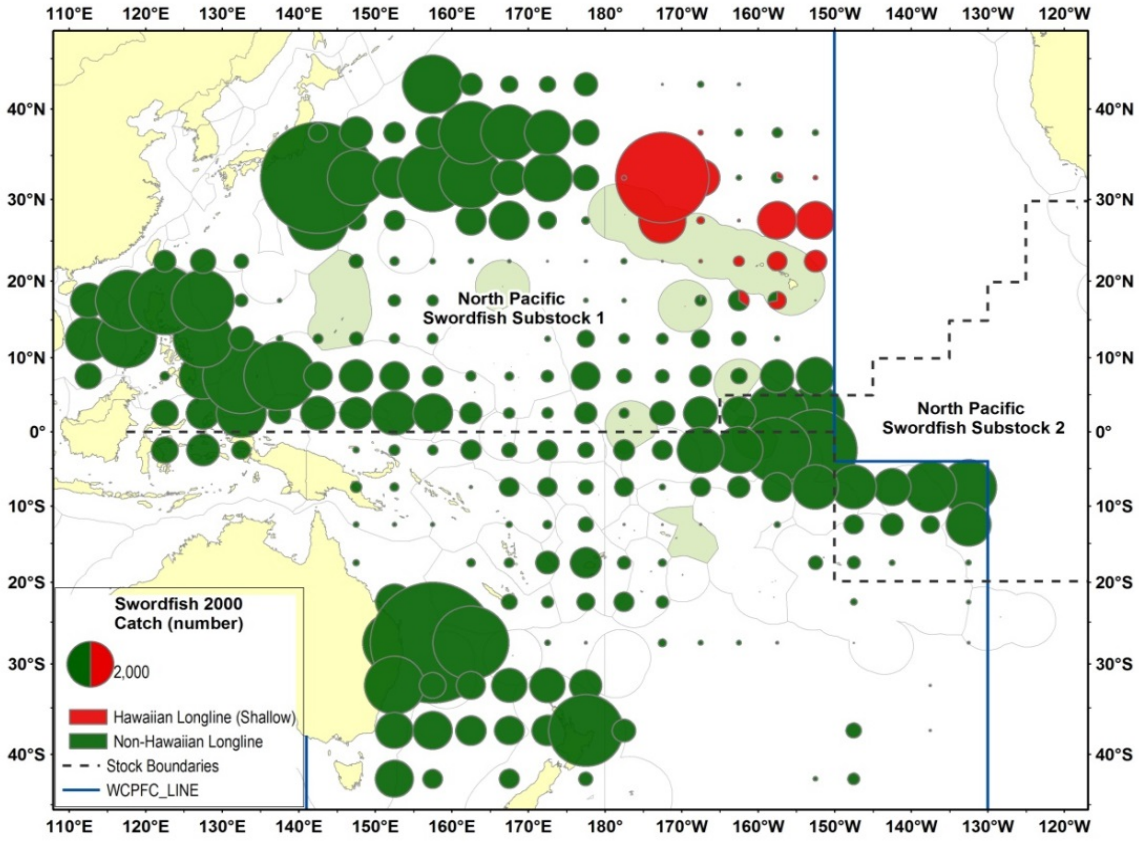
Leatherback turtle



Loggerhead turtle

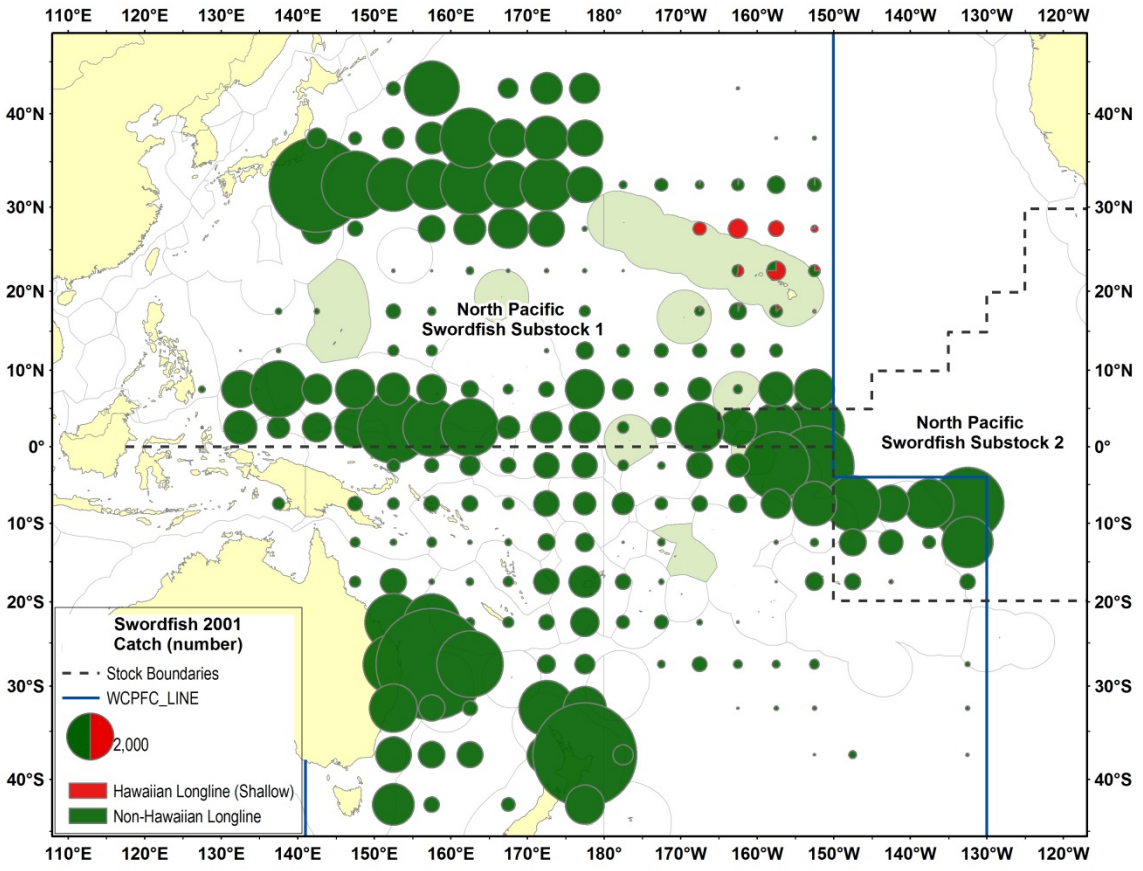
Shared Resources in High Seas: Swordfish

- Hawaii swordfish production represented 12% of total swordfish in North and Central (N&C) Pacific in 2000, ~3,100 mt in 1997-2000



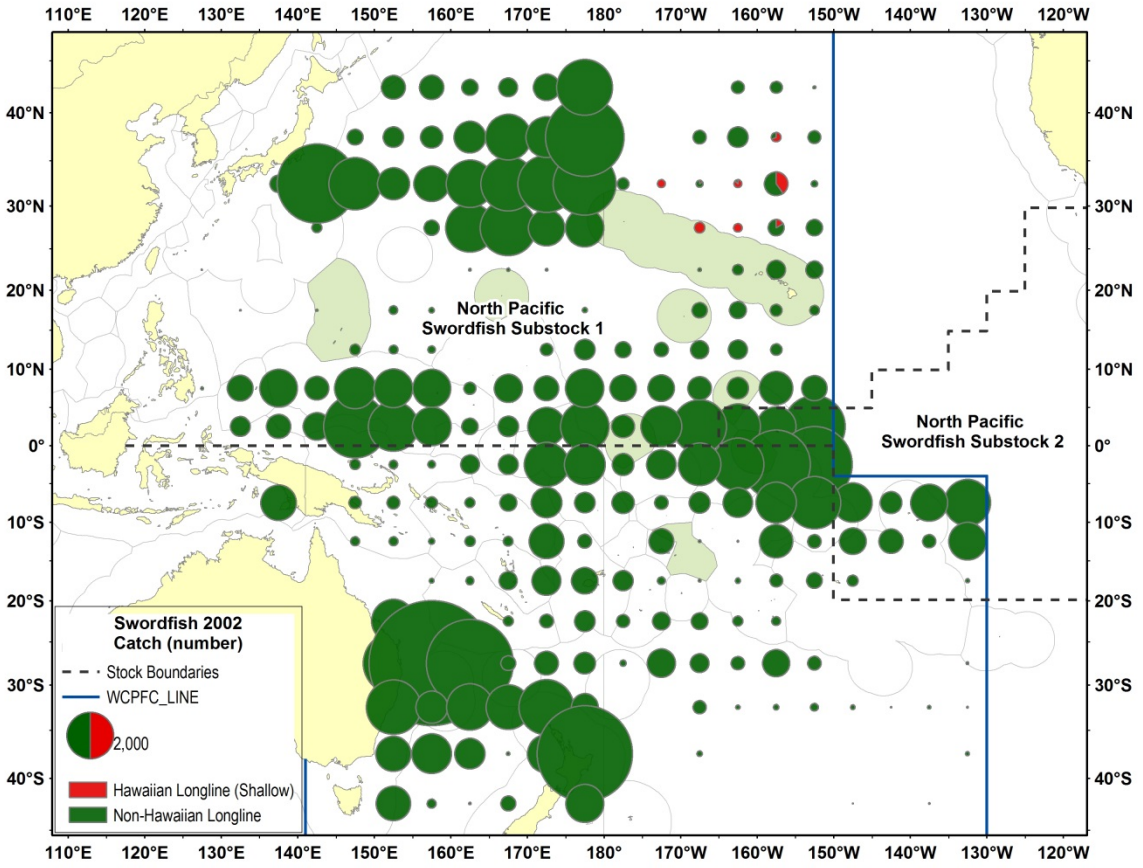
Swordfish Catch Distribution in WCPO, 2000 (before the closure)

Production Displacement



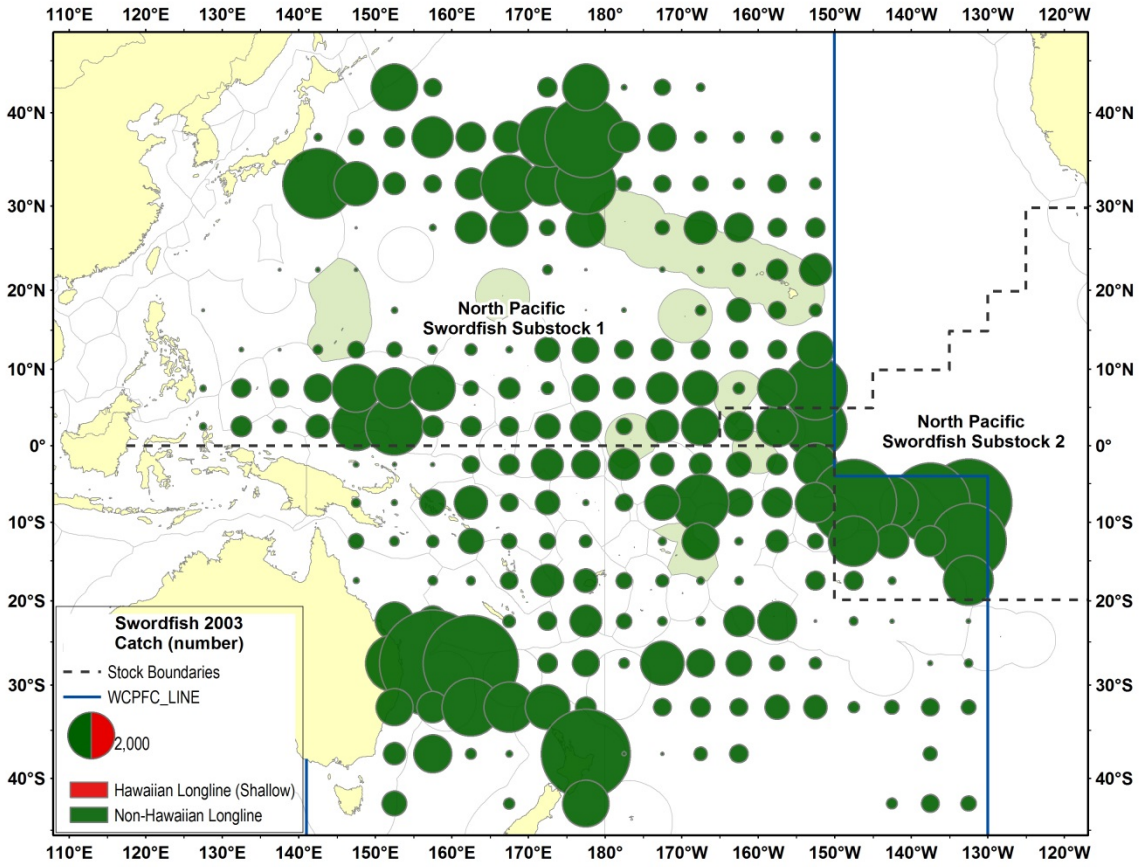
Swordfish Catch Distribution in WCPO, 2001 (closure started)

Production Displacement



Swordfish Catch Distribution in WCPO, 2002 (2nd year of closure)

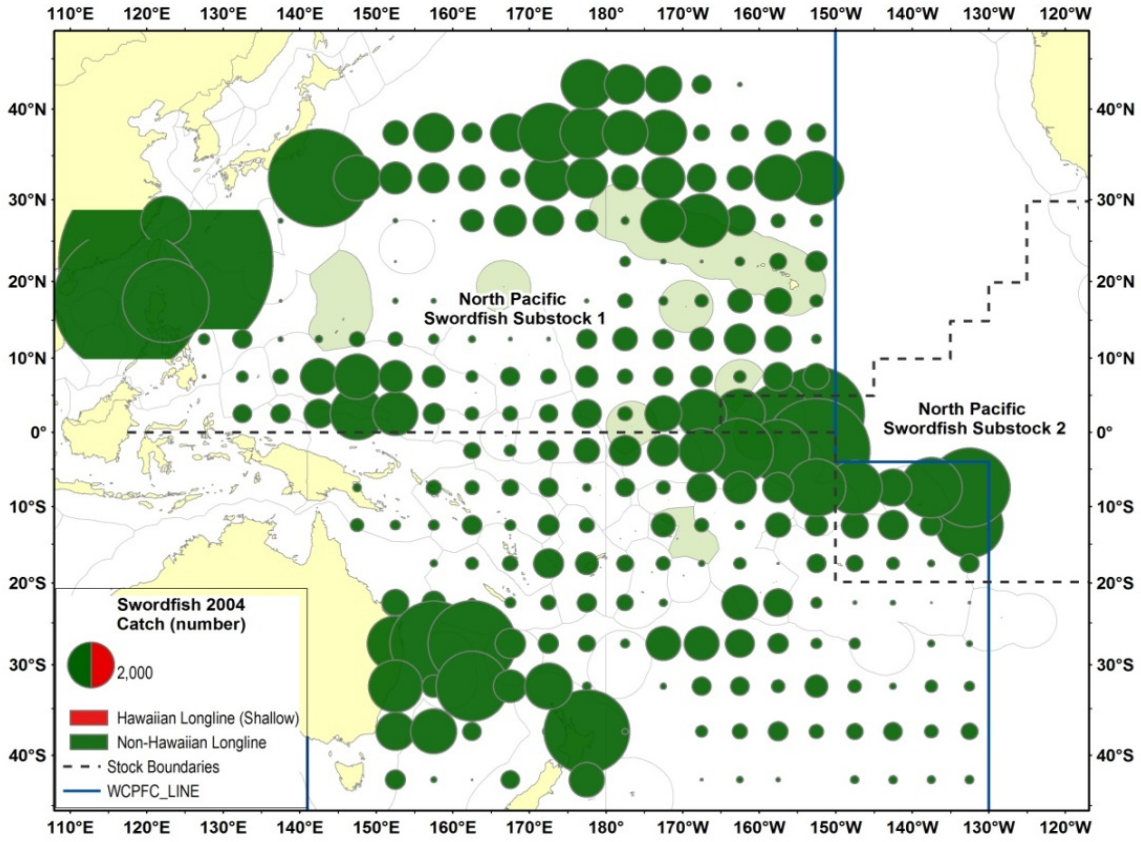
Production Displacement



Swordfish Catch Distribution in WCPO, 2003 (3rd year of closure)

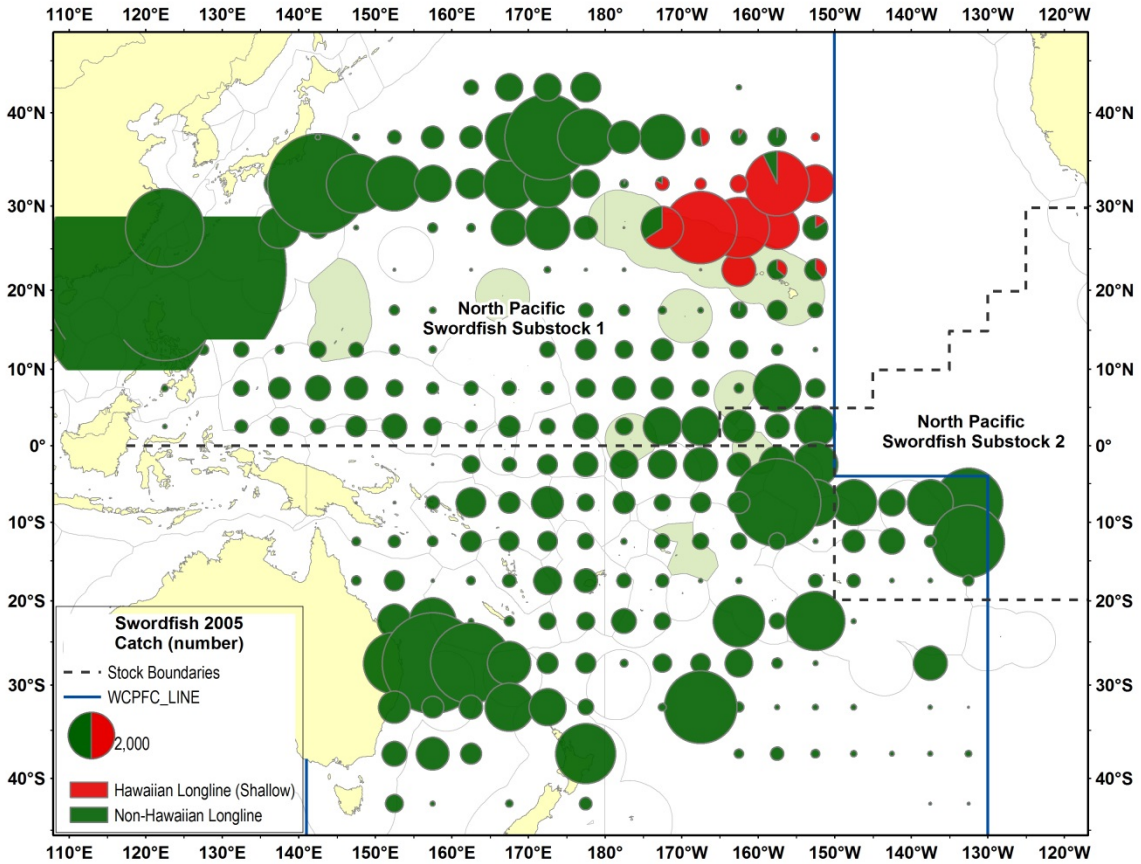
Production Displacement

- Higher foreign production in N&C Pacific: increased by 5,500 mt (annual average during 2001-2004 vs. 1997-2000)



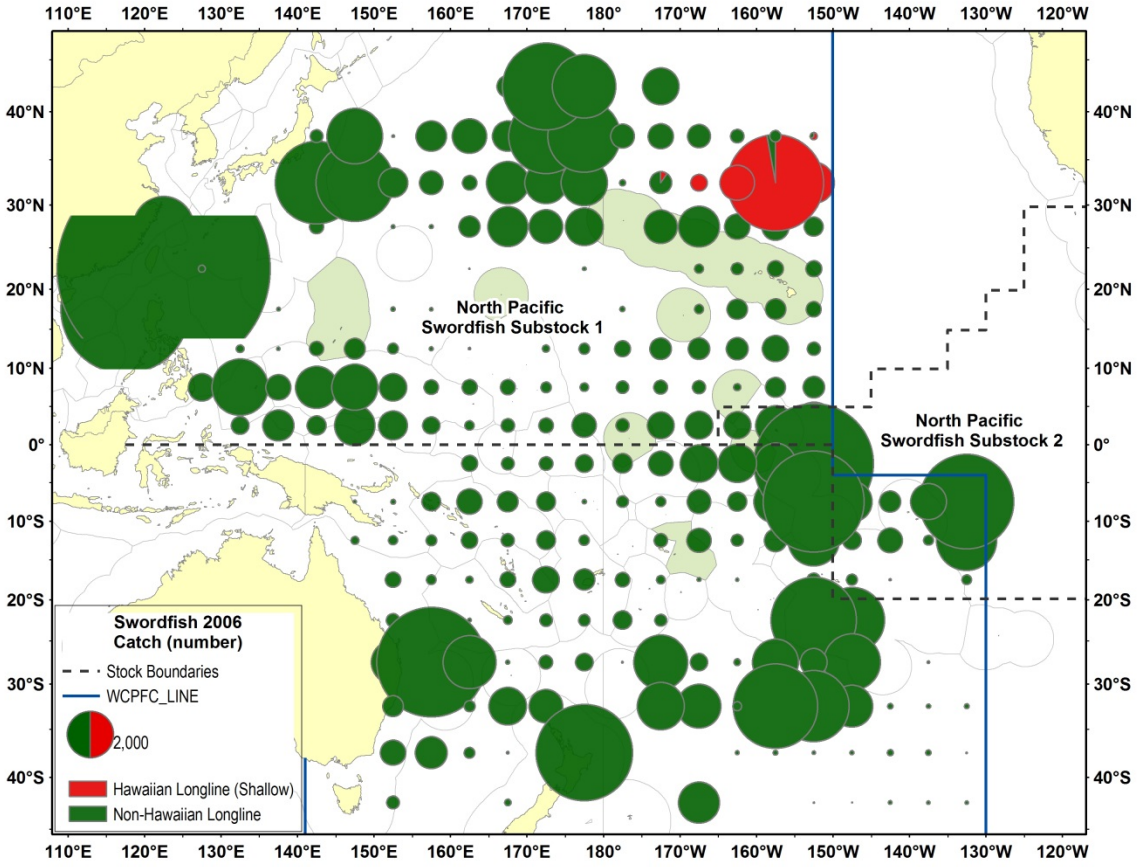
Swordfish Catch Distribution in WCPO, 2004 (4th year of closure)

Production Displacement



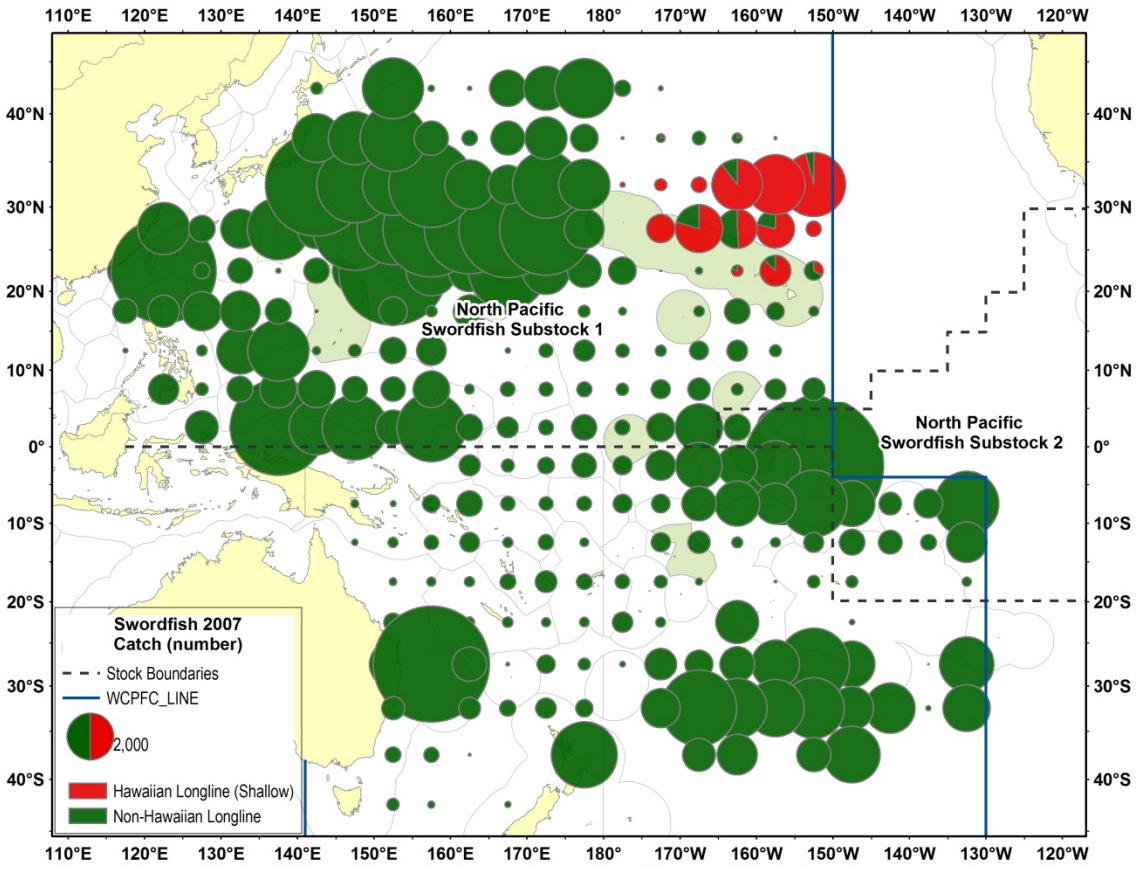
Swordfish Catch Distribution in WCPO, 2005 (1 year after fishery reopened)

Production Displacement



Swordfish Catch Distribution in WCPO, 2006 (2 years after fishery reopened, but closed on March 20 – loggerhead interactions reached 17)

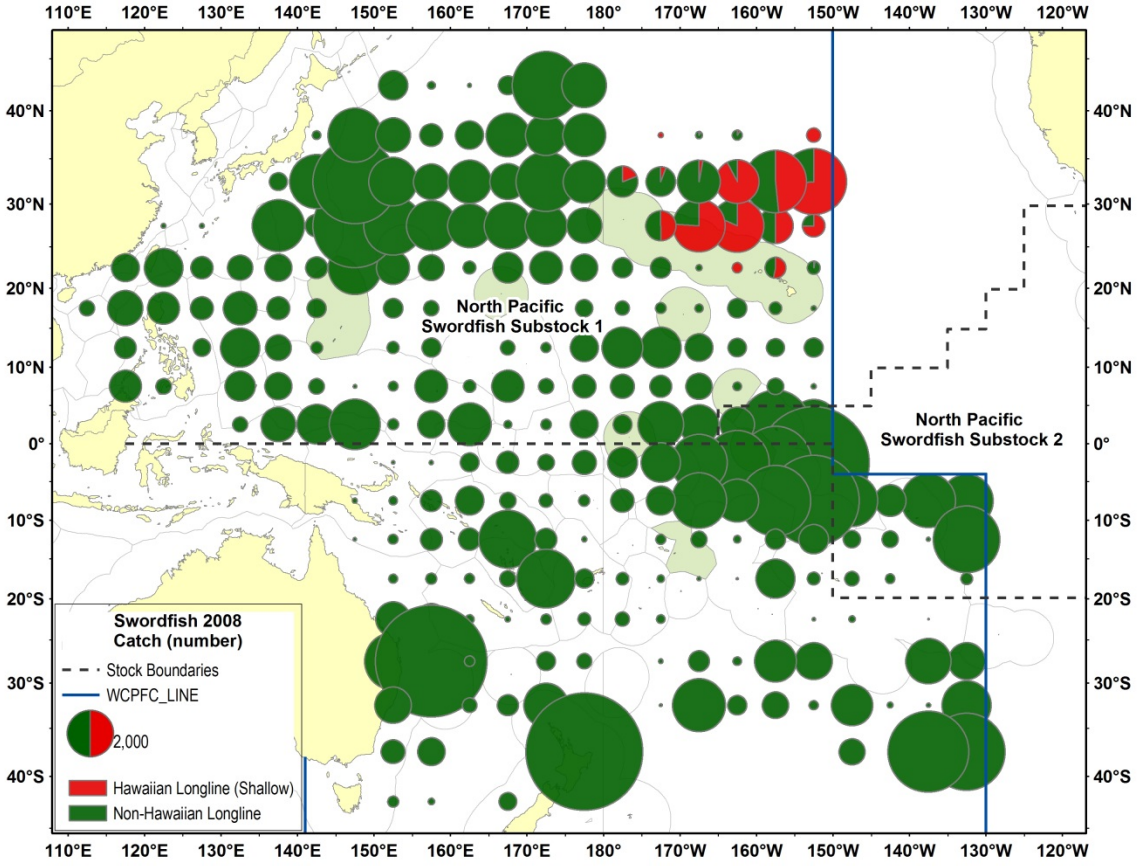
Production Displacement



Swordfish Catch Distribution in WCPO, 2007 (3 years after fishery reopened)

Production Displacement

- Hawaii production after fishery reopened: half of pre-closure (1,500 mt)
- Foreign production continued to increased by 5,000 mt (2005-2008)



Swordfish Catch Distribution in WCPO, 2008 (4 years after fishery reopened)

Sea Turtle Bycatch Rate Across Countries

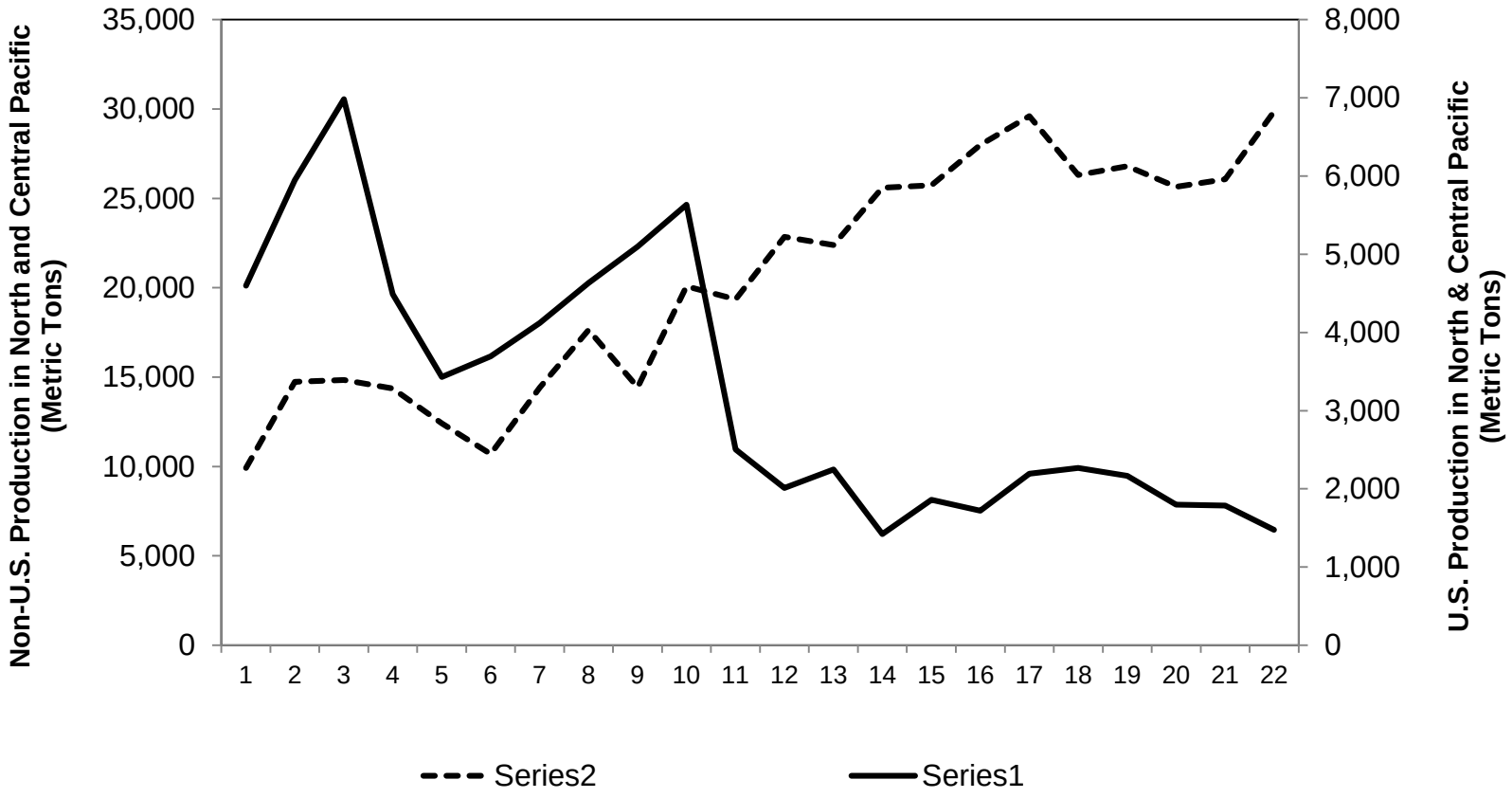
In 2012, U.S. swordfish landings comprised 4% of total swordfish landings in N&C Pacific, yet turtle interactions were just 0.8% of total (19 of 2,270 interactions)

Top Swordfish Producers in North and Central Pacific	Production Weight in North and Central Pacific 2012	Turtle Bycatch per Unit of Effort (turtle bycatch/mt)	Annual Turtle Bycatch
Hawaii/U.S.	4%	0.013	19
Taiwan	24%	0.073	550
Japan	18%	0.025	140
Indonesia	16%	0.100	500
Philippines	14%	0.100	440
China	8%	0.100	270
Republic of Korea	4%	0.100	130
Australia	3%	0.006	6
Mexico	1%	0.174	80
Others	6%		135
Total	100%		2,270

Spillover Estimation – Production Displacement

Step 1

Examine relationship between U.S. and non-U.S. production in N&C Pacific



Spillover Estimation – Production Displacement

Step 1

Examine the relationship in two ways:

1. Test correlation between non-U.S. and U.S. production

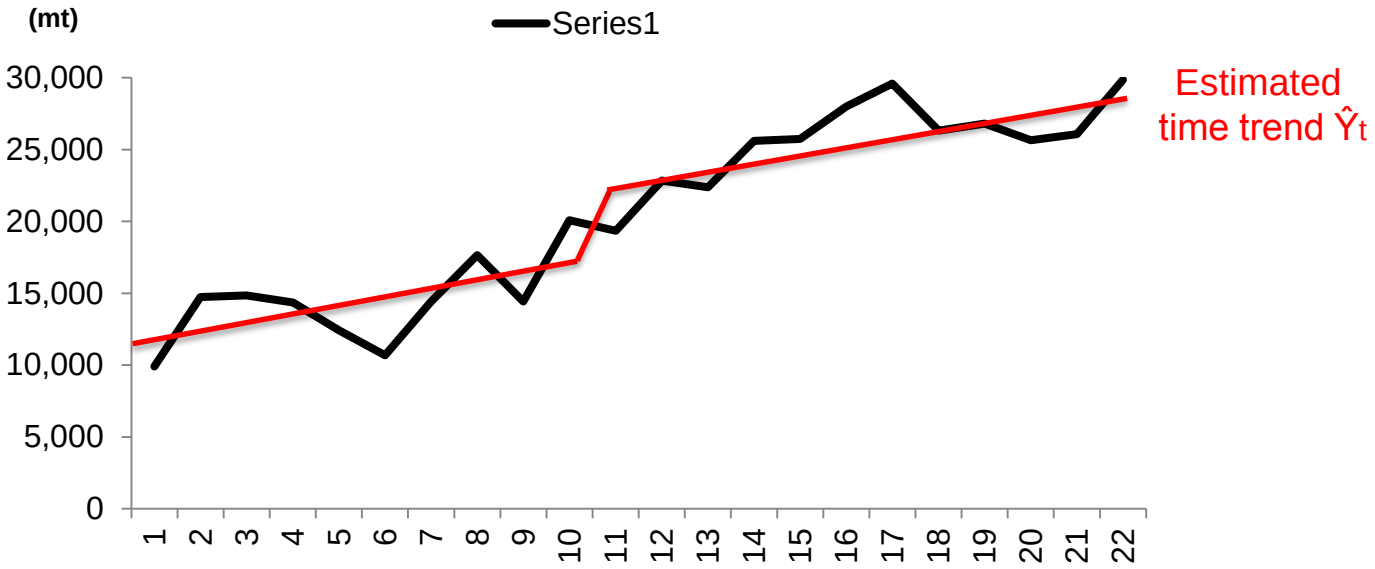
Pearson Correlation (r)		Non-U.S. Production (Y_t)
U.S. Production (X_t)	Before Policy (1991-2000)	0.455
	After Policy (2001-2012)	-0.527*

*significant at the 10% level.

Spillover Estimation – Production Displacement

2. Structural break was found in 2001 for non-U.S. production between 1991 to 2012

$$Y_t = a + b\,t + \mu D_L + \varepsilon_t \qquad \text{Dummy } D_L = 1 \text{ if t >= 2001}$$



- Non-U.S. production is trend-stationary with one time structural change in 2001 and no serial correlation in residuals

Spillover Estimation – Production Displacement

Step 2

Statistically test non-U.S. production in N&C Pacific attributable to Hawaii closure

- Intuition: if nothing changes except the Hawaii closure, foreign fleets harvesting swordfish in N&C Pacific would be catching more swordfish with the closure than without it
- Hawaii closure as a policy treatment: compare observed foreign production with counterfactual
- Counterfactual: normal trend without policy treatment
  - ➡ Estimate non-U.S. production time trend using the time period before the closure (1991-2000)
- Differences between non-U.S. production and counterfactual
  - ➡ Non-U.S. production attributable to closure

Spillover Estimation – Production Displacement

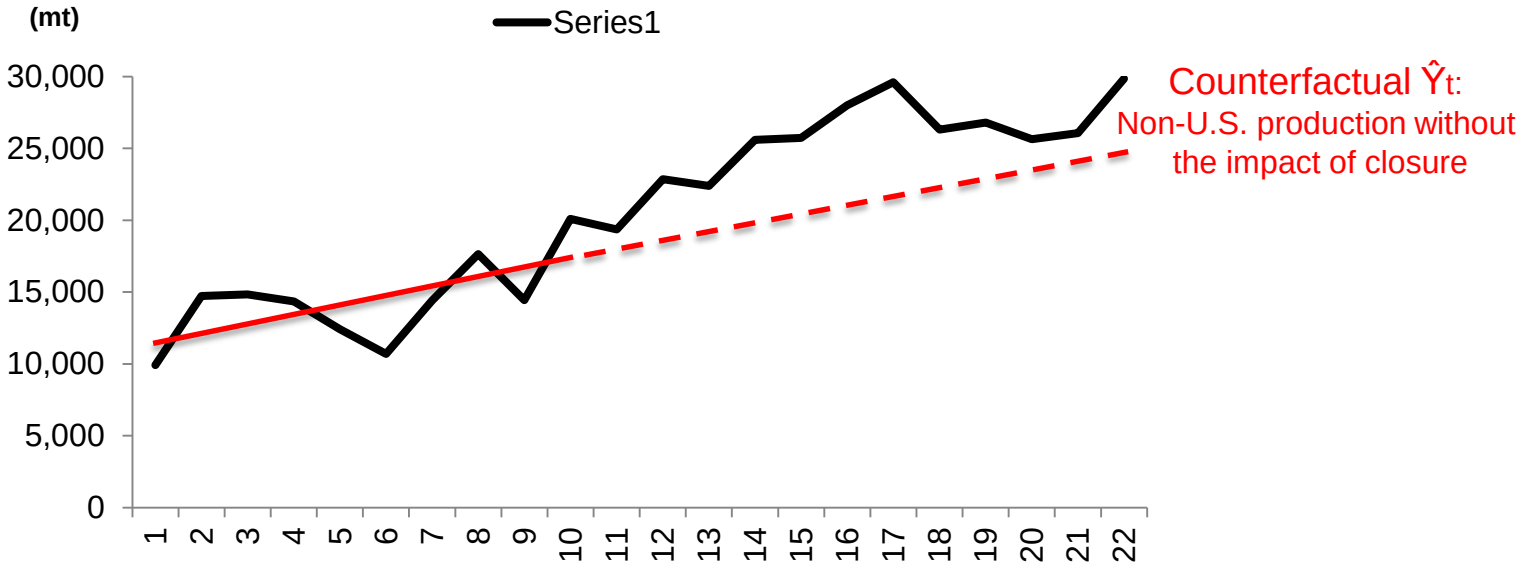
Step 2

Estimate the "normal" trend for non-U.S. production without policy treatment (1991-2000, before policy)

$$Y_t = a + b\,t + \varepsilon_t \quad \Rightarrow \quad \varepsilon_t = Y_t - \hat{Y}_t$$

(t = 1991-2000) (t = 1991-2012)

Non-U.S. production attributable to closure



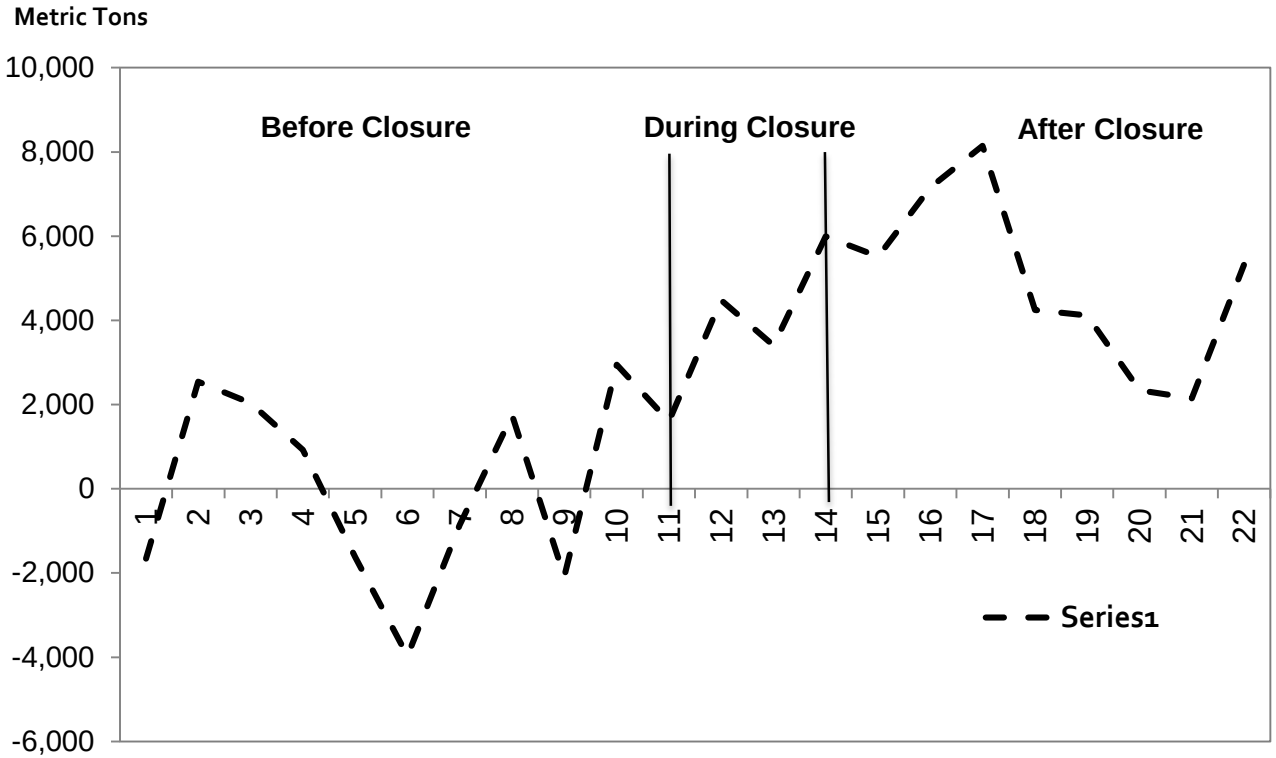
Spillover Estimation – Production Displacement

Step 2

Differences between non-U.S. production and counterfactual

$$\varepsilon_t = Y_t - \hat{Y}_t$$

Non-U.S. production attributable to closure



Spillover Estimation – Production Displacement

Step 3

Estimate how non-U.S. swordfish production attributable to closure ($Y_t - \hat{Y}_t$) respond to the changes in U.S. production (X_t) from 2001 to 2012

$$Y_t - \hat{Y}_t = c + d X_t + u_t$$

	Coefficient	t-value
c	5,770.09***	4.42
d	-1.01***	(-2.82)
R^2	0.28	

***significant at the 1% level

Results

- The coefficient d = -1.01 is significant at the 99% level and no heteroscedasticity
- This suggests that, a decrease of one unit of U.S. production is associated with an increase of 1.01 units of non-U.S. production, and vice versa
- Production displacement exists between U.S. and non-U.S. swordfish production
- Next step: apply the displacement estimation to different swordfish production scenarios

How Production Displacement Related to Sea Turtle Interactions?

	Hawaii Swordfish Production (mt)	Total Swordfish Production in N&C Pacific (mt)	# Total Turtle Bycatch	# Reduction in Turtle Bycatch	% Reduction in turtle Bycatch
Status quo (2012)	1,080	31,330	2,270	-	-

How Production Displacement Related to Sea Turtle Interactions?

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Status quo (2012)	1,080	31,330	2,270	-	-
Scenario 1: Hawaii produces at historical peak (5500 sets)	4,985	31,330	2,010	260	11%

How Production Displacement Related to Sea Turtle Interactions?

	Hawaii Swordfish Production (mt)	Total Swordfish Production in N&C Pacific (mt)	# Total Turtle Bycatch	# Reduction in Turtle Bycatch	% Reduction in Turtle Bycatch
Status quo (2012)	1,080	31,330	2,270	-	-
Scenario 2: Everyone fishes like Hawaii	1,080	31,330	392	1,878	83%

Conclusions

- Strong spillover effects exist on sea turtle bycatch from regulations of Hawaii shallow-set longline fishery due to production displacement
- Production displacement was nearly one-for-one between U.S. and foreign longline fisheries in the N&C Pacific
- Reduced swordfish production by Hawaii longline fishery through regulatory changes did not contribute overall conservation of sea turtles in N&C Pacific
- Conservation acts for marine resources cannot be isolated at the local level

Outcomes

Used as supporting document for the legal case between Turtle Island Restoration Network, *et. al.* vs. NMFS and helped NMFS to successfully defend the increase in sea turtle interaction caps in 2012 (from 16 to 26 for leatherback turtles and 17 to 34 for loggerhead turtles)

With the team effort, we received a General Team Award under NOAA General Counsel Award in 2013

Future Applications

Examine the effects on individual species of sea turtles if more detailed bycatch rates by species become available. Use bootstrap simulation to estimate upper and lower limits of turtle interaction rates

Use counterfactual approach and apply to future policy evaluations, e.g. economic impacts of Papahānaumokuākea Marine National Monument Expansion

Mahalo!