

# Yellowfin tuna movements, behavior, and habitat utilization in the eastern Pacific Ocean

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**Inter-American Tropical Tuna Commission**



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# Outline

- INTRODUCTION: OVERVIEW OF EXISTING IATTC YFT TAG DATA
- CONVENTIONAL TAG DATA: LINEAR DISPLACEMENTS AND DISPERSION
- ARCHIVAL TAG DATA: HORIZONTAL MOVEMENTS AND DISPERSION
- ARCHIVAL TAG DATA: VERTICAL MOVEMENTS AND BEHAVIOR
- ARCHIVAL TAG DATA: HABITAT UTILIZATION

# Introduction

- Tropical tuna tagging experiments by IATTC in the eastern Pacific commenced in 1955, and through 1964 a total 59,547 yellowfin were tagged and released throughout the range of the fishery, from northern Mexico to northern Chile. There were 8,397 yellowfin (14.1%) tags returned from those releases.
- During 1964 to 1979 there were only a few tuna tagging cruises undertaken on opportunistic or chartered live-bait pole-and-line vessels.
- During 1969 through 1974 there were several tuna tagging cruises undertaken on purse-seine vessels through various types of charter arrangements principally targeting YFT. During those cruises 30,290 YFT were tagged and released, and 1,449 tags returned (4.8%). Tuna tagging cruises continued sporadically aboard purse-seine vessels until 1980.
- During 1979 through 1981 there were several tropical tuna tagging cruises undertaken on chartered live-bait pole-and-line vessels with tagging conducted from Mexico to Ecuador. During those cruises 12,256 YFT were tagged and released, and 1,594 tags returned (12.7%).

# Introduction

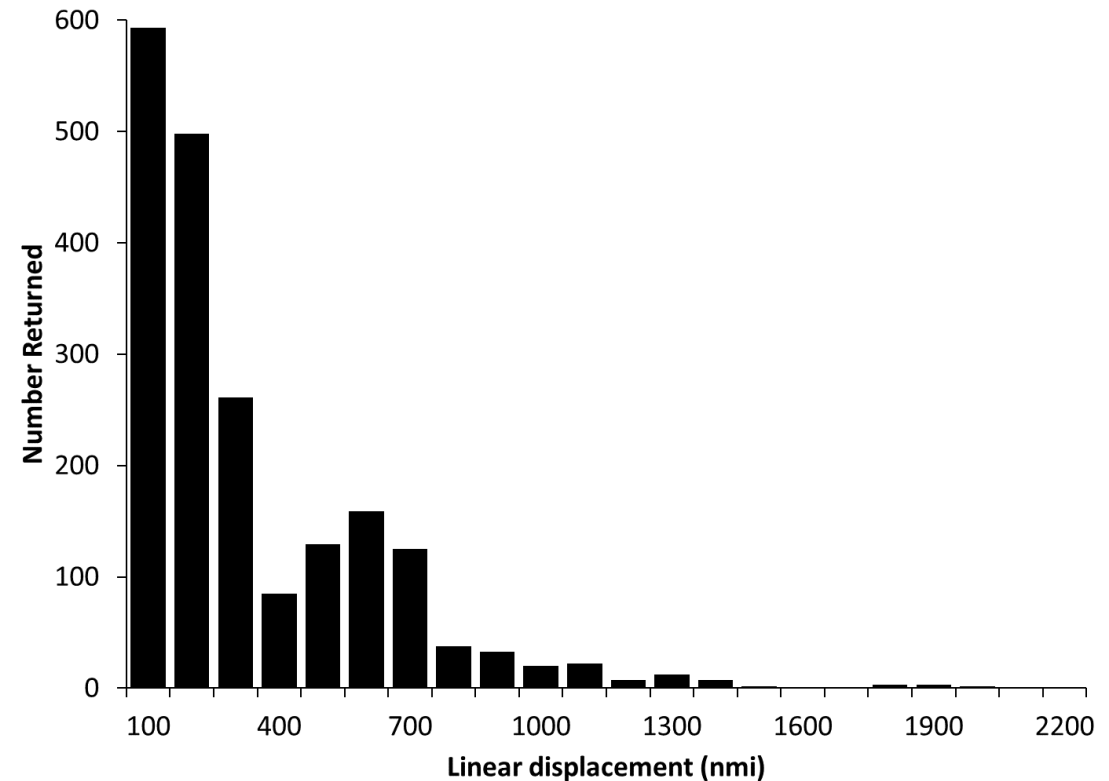
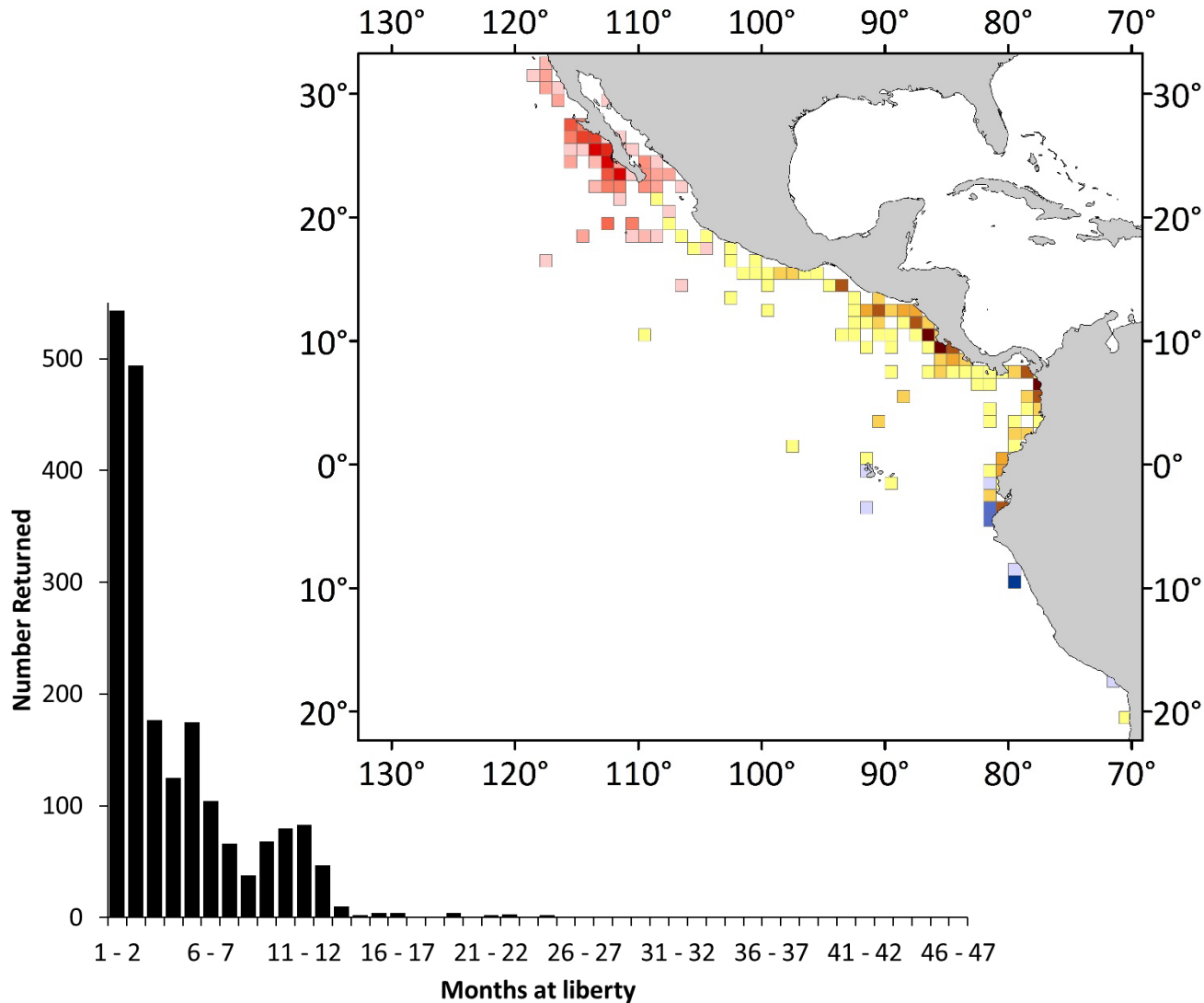
- During 2000 through 2006 there were six tuna tagging cruises undertaken on a chartered live-bait pole-and-line vessel to the equatorial EPO, principally targeting BET. During those cruises 2,234 YFT were tagged and released with conventional tags and 405 tags returned (18.1%), and 53 YFT were tagged and released with archival tags and 8 tags returned (15.1%).
- During 2002 through 2008 there were 10 YFT tagging cruises undertaken aboard the San Diego based long-range sportfishing vessels *FV Royal Star* and *FV Shogun* off Baja California, Mexico. During those cruises 500 YFT were tagged and released with archival tags and 260 tags returned (52.0 %).
- During 2006 through 2011 there were 11 tagging cruises undertaken aboard the San Diego based long-range sportfishing vessel *FV Royal Star* at the Revillagigedo Islands, Mexico. During those cruises 4,318 YFT were tagged and released with conventional tags and 836 tags returned (19.4%), and 335 YFT were tagged and released with archival tags and 99 tags returned (29.6%).
- During 2007 to 2009 there were 3 tagging events undertaken around the Frailes Islands offshore the IATTC Achotines laboratory on the Azuero Peninsula, Panama, utilizing pangas. During those events 110 YFT were tagged and released with archival tags and 23 tags returned (20.9%).

# Introduction

- During 2012 and 2013 there were 2 YFT tagging cruises undertaken aboard the San Diego based long-range sportfishing vessels *FV Royal Star* to Clipperton Island. During those cruises 147 YFT were tagged and released with archival tags and 36 tags returned (24.5%).
- During 2009 through 2015 there were 4 tagging cruises undertaken aboard the Hawaii based vessels *FV Double D*, *FV AoShibi Go* and *FV Gutsy Lady 4* to the equatorial Central Pacific, principally targeting BET. During those cruises 1,255 YFT were tagged and released with conventional tags and 128 tags returned (10.2%), and 186 YFT were tagged and released with archival tags and 10 tags returned (5.4%).

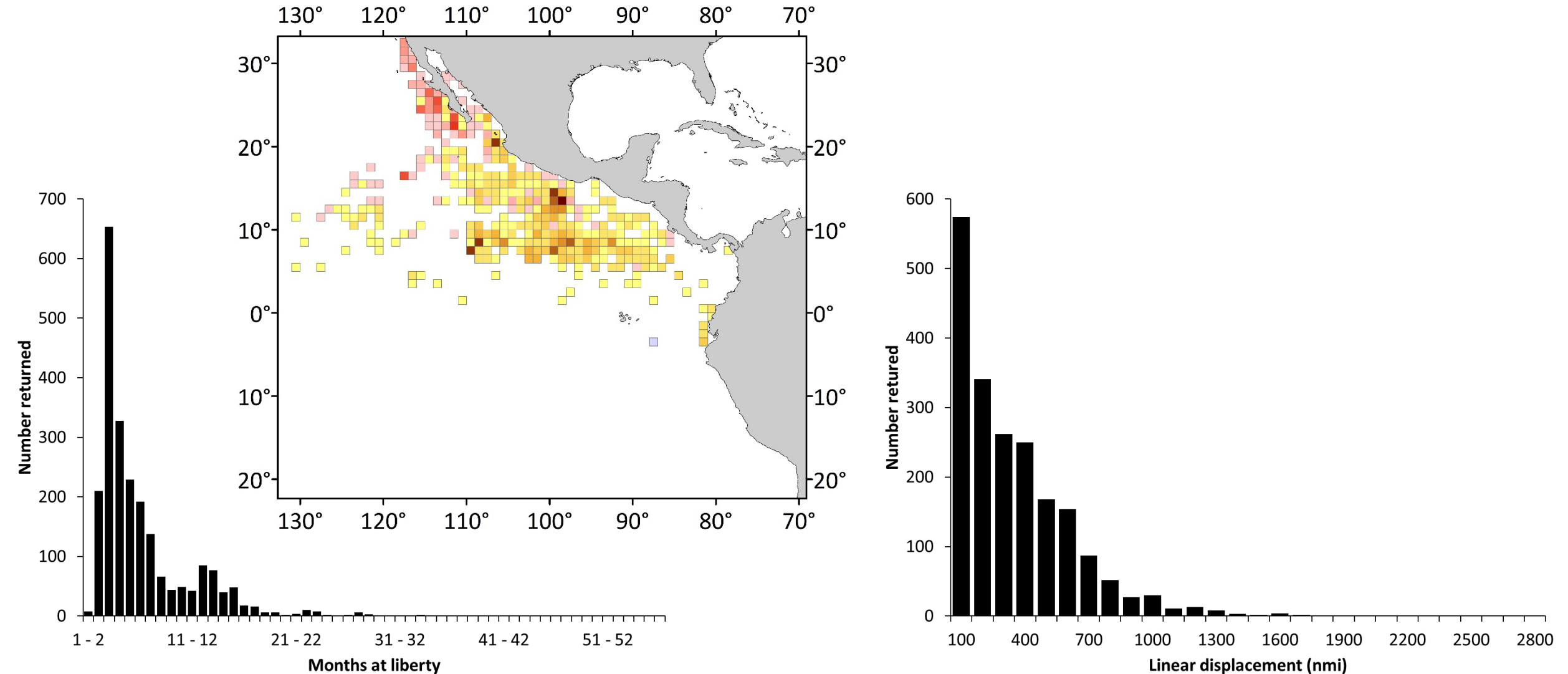
# Conventional tag data

Tag returns for fish released during 1957 - 1965 by 1-degree areas ( $n = 1993$ ), time at liberty, and linear displacement for fish at liberty for 30 d or longer. Releases North of  $15^{\circ}\text{N}$  (red),  $0^{\circ}$  to  $15^{\circ}\text{N}$  (yellow), south of  $0^{\circ}$  (blue).



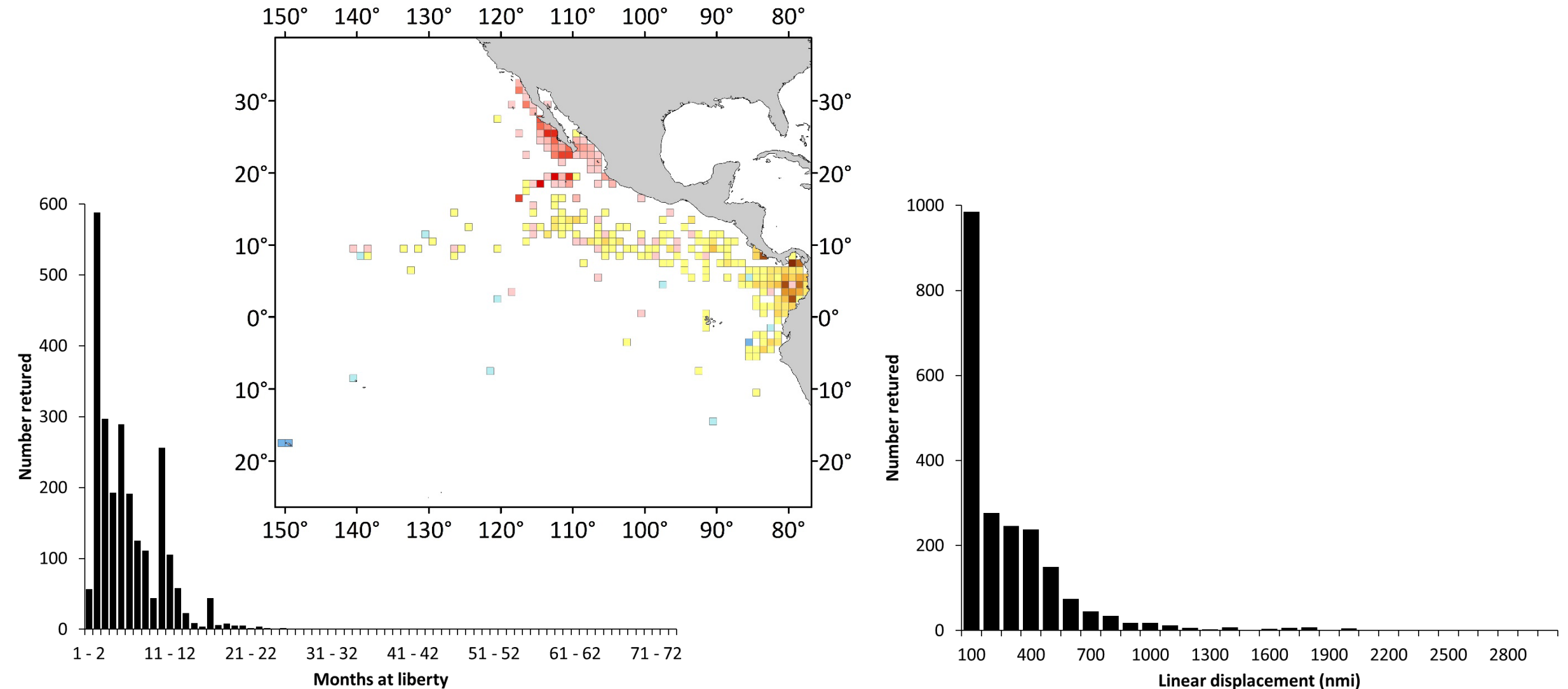
# Conventional tag data

Tag returns for fish released during 1967 - 1975 by 1-degree areas ( $n = 1991$ ), time at liberty, and linear displacement for fish at liberty for 30 d or longer. Releases North of  $15^{\circ}\text{N}$  (red),  $0^{\circ}$  to  $15^{\circ}\text{N}$  (yellow), south of  $0^{\circ}$  (blue).



# Conventional tag data

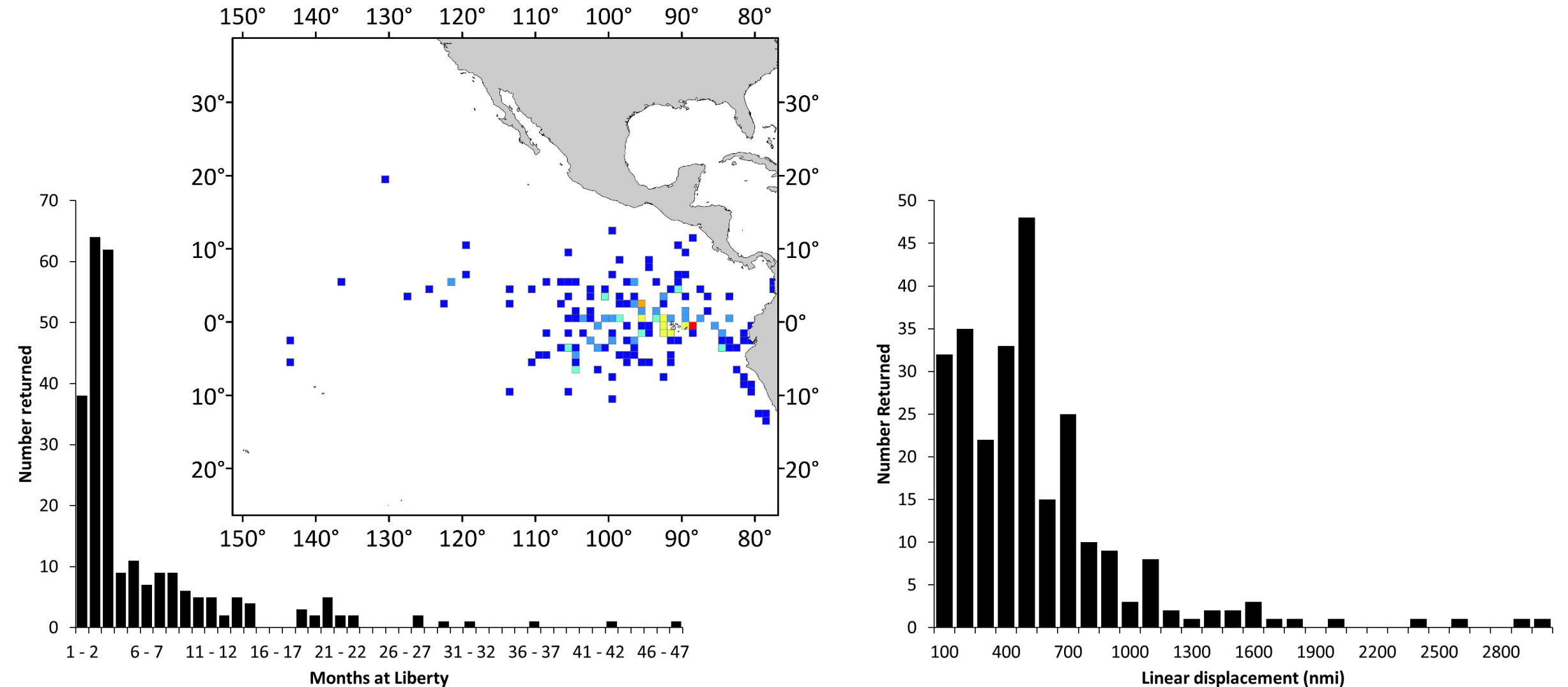
Tag returns for fish released during 1976 - 1988 by 1-degree areas ( $n = 2146$ ), time at liberty, and linear displacement for fish at liberty for 30 d or longer. Releases North of  $15^{\circ}\text{N}$  (red),  $0^{\circ}$  to  $15^{\circ}\text{N}$  (yellow), south of  $0^{\circ}$  (blue).





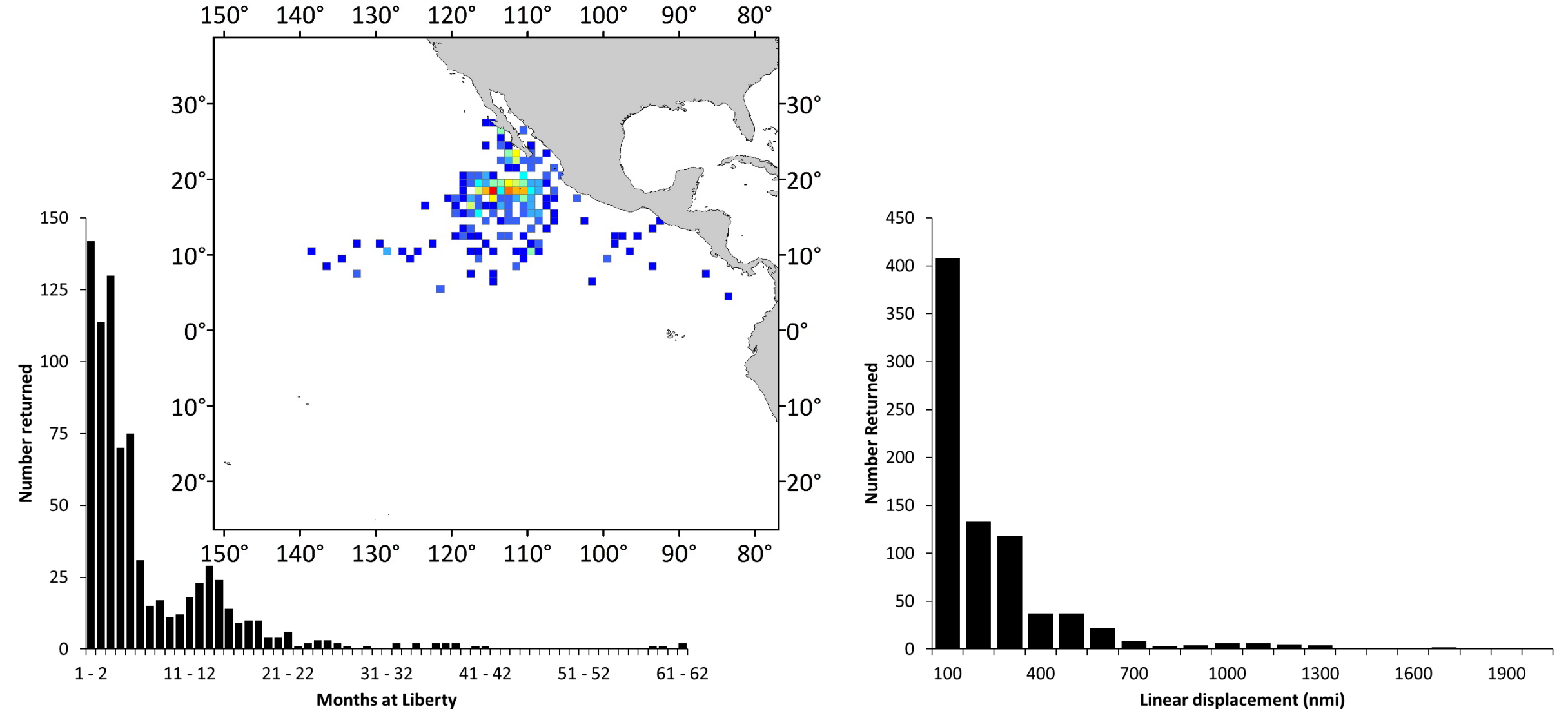
# Conventional tag data

Tag returns for fish released during 2000 - 2006 in the equatorial EPO by 1-degree areas, time at liberty, and linear displacement for fish at liberty for 30 d or longer ( $n = 257$ ).



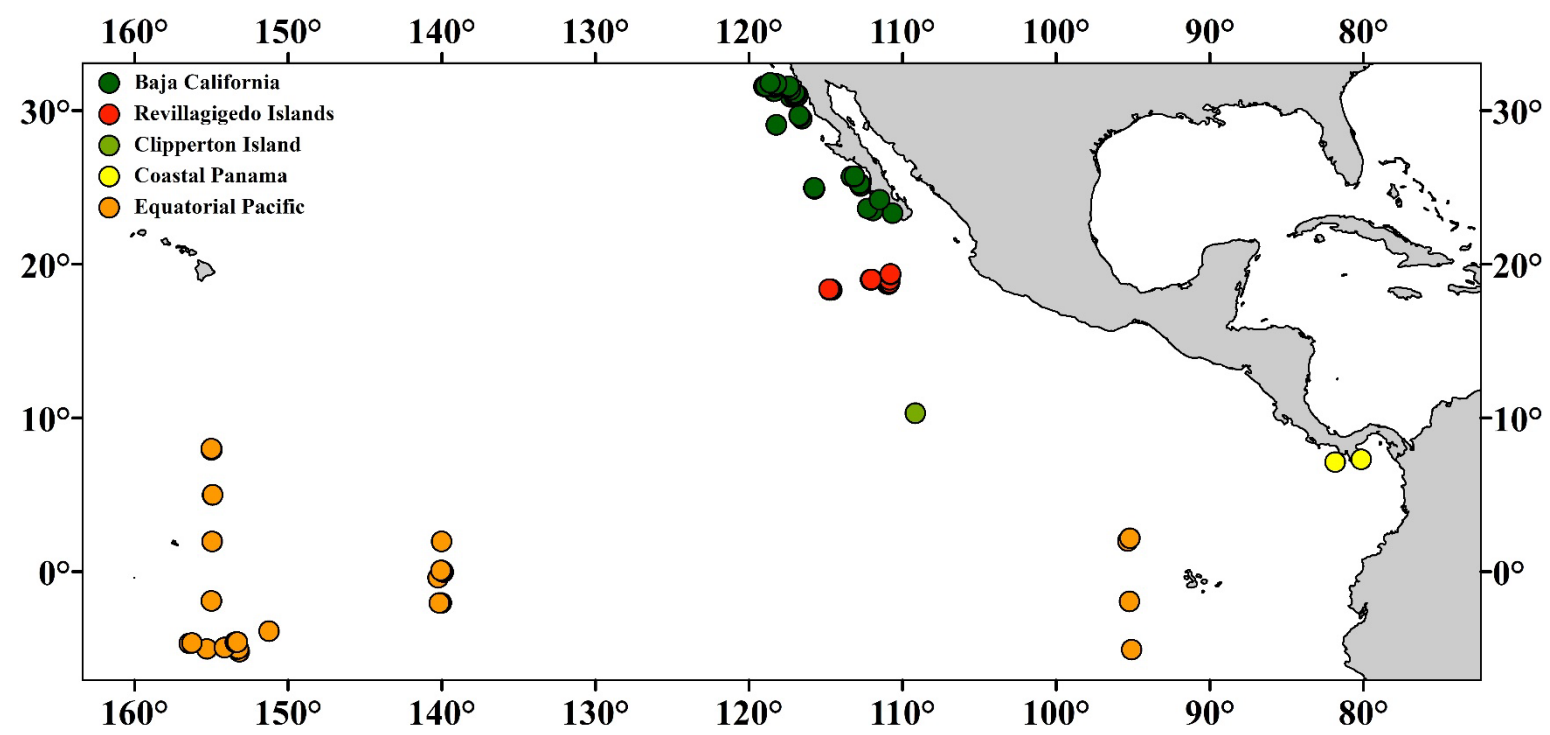
# Conventional tag data

Tag returns for fish released during 2006 - 2011 around the Revillagigedo Islands by 1-degree areas, time at liberty and linear displacement for fish at liberty for 30 d or longer ( $n = 797$ ).



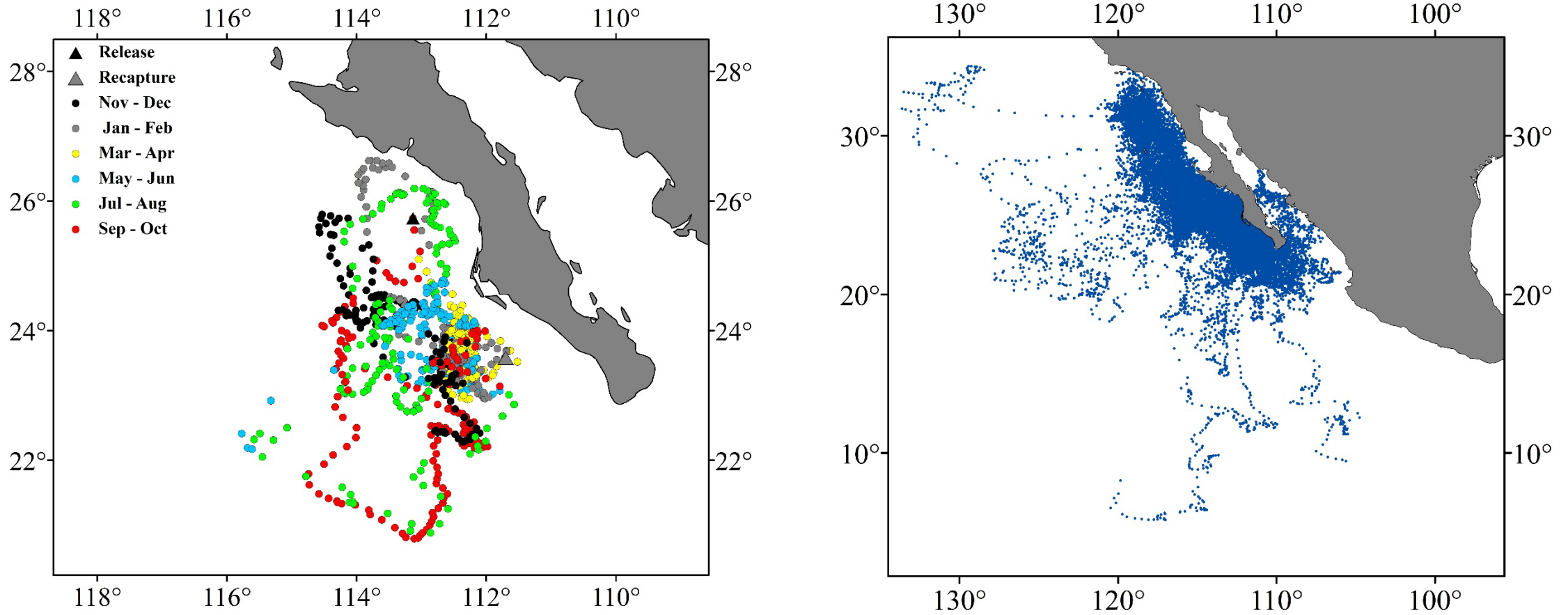
# Archival tag data

Area	Released	Returns	% Returned
<b>Baja California (TOPP)</b>	500	260	52.0
<b>Revillagigedo Islands</b>	335	99	29.6
<b>Clipperton Island</b>	147	36	24.5
<b>Coastal Panama</b>	110	23	20.9
<b>Equatorial Pacific Ocean</b>	234	21	9.0
<b>Total</b>	1326	439	33.1



# Archival tag data

Most probable track for a yellowfin released off southern Baja California, at liberty for 1160d, and 27,578 position estimates for 126 yellowfin at liberty for >90d, estimated from the uKFSST model

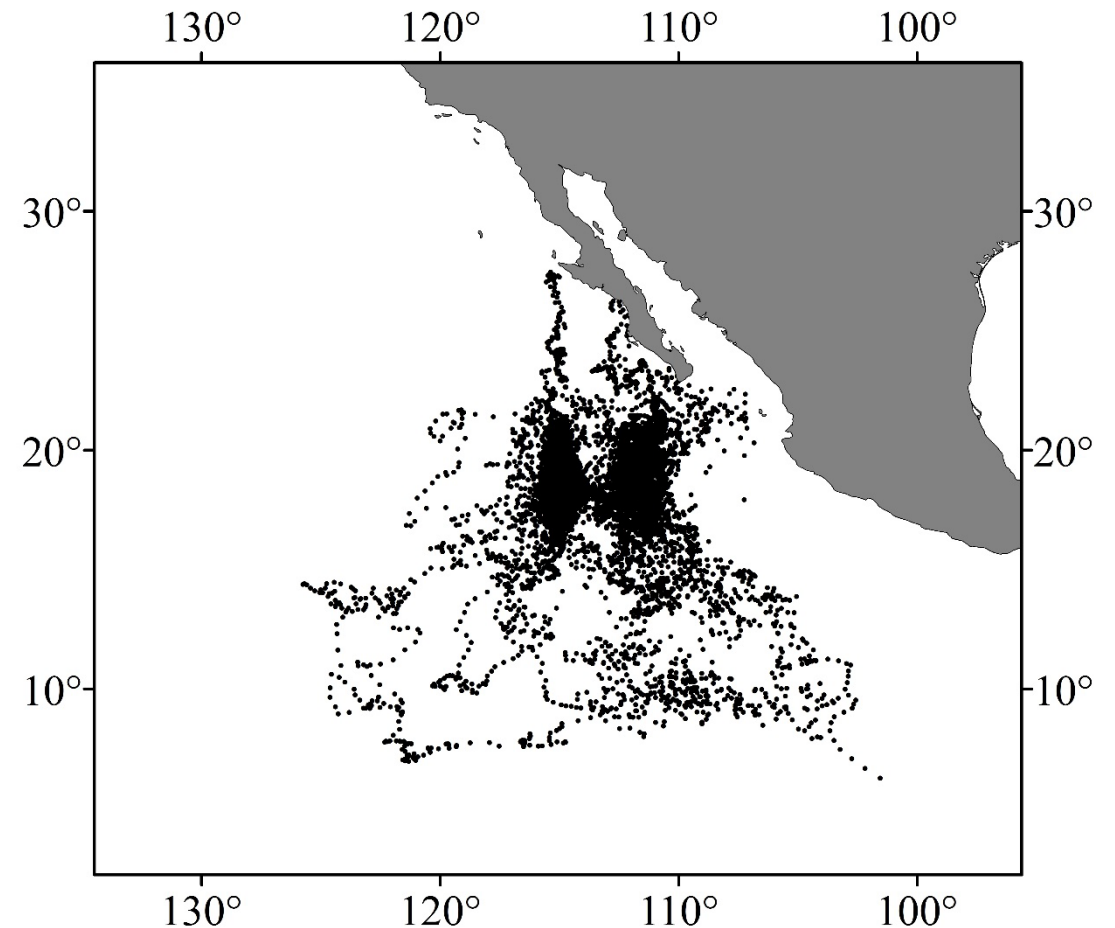
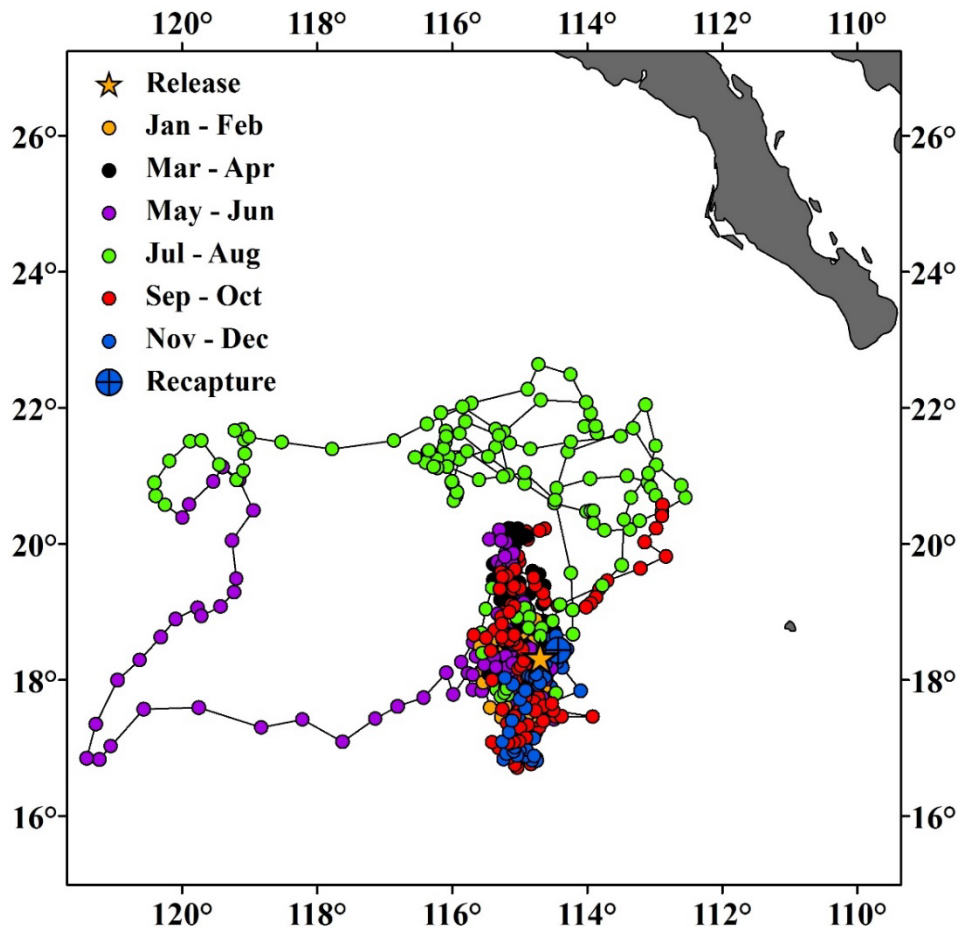


Schaefer, K.M., Fuller, D.W., and Block, B.A., 2011. Movements, behavior, and habitat utilization of yellowfin tuna (*Thunnus albacares*) in the Pacific Ocean off Baja California, Mexico, determined from archival tag data analyses, including unscented Kalman filtering. *Fish. Res.* 112:22-37.



# Archival tag data

Most probable track for a yellowfin released around the Revillagigedo Islands, Mexico, at liberty for 653d, and 16,250 position estimates for 52 yellowfin at liberty for >90d, estimated from the uKFSST model

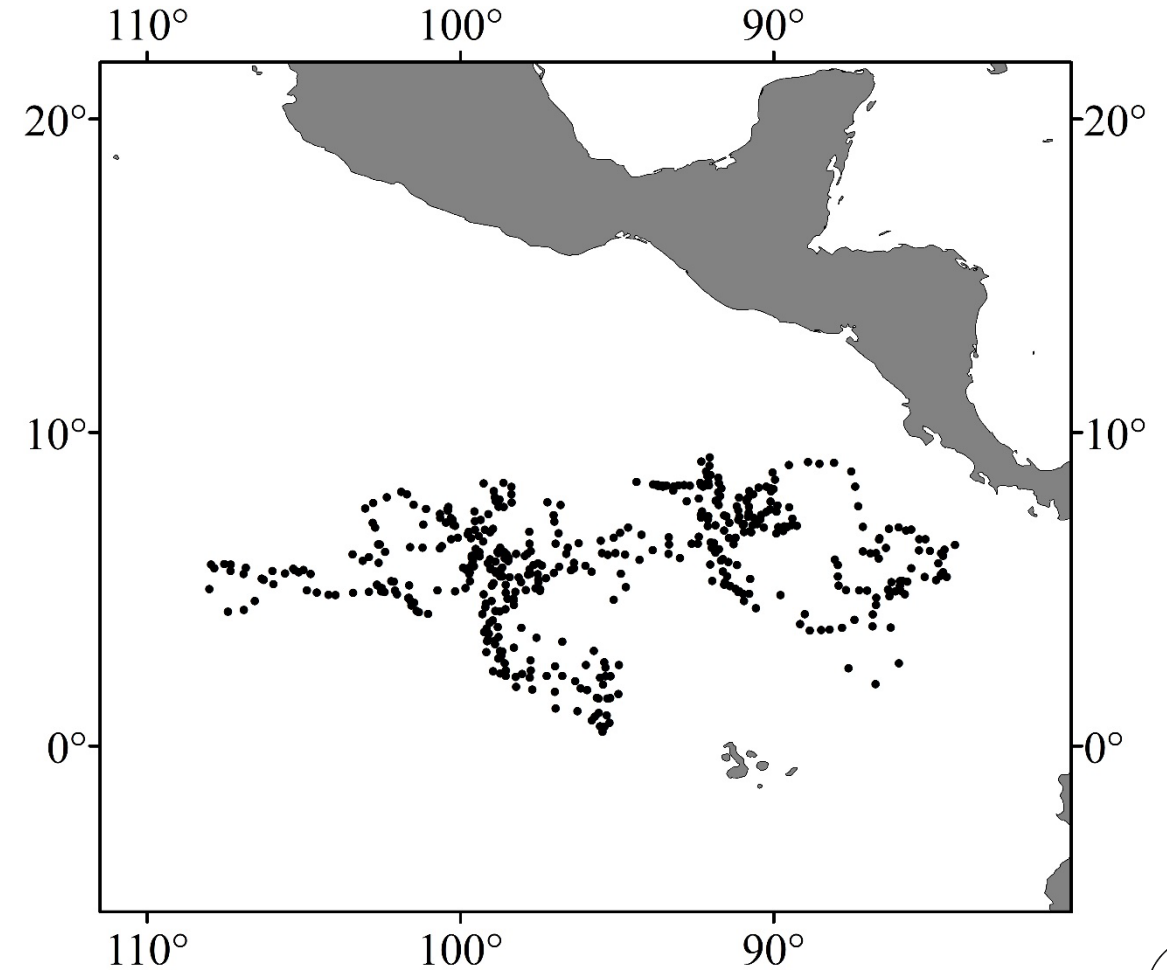
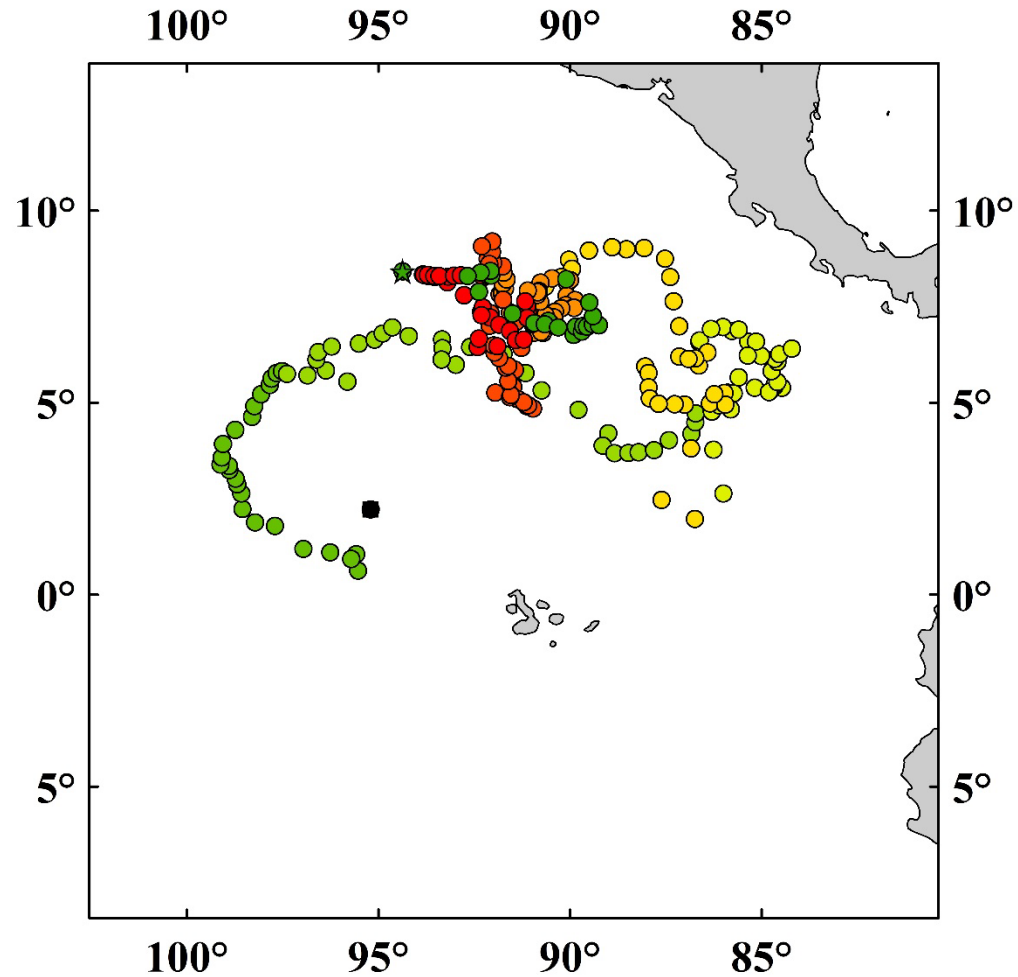


Schaefer, K.M., D.W. Fuller, and G. Aldana. 2014. Movements, behavior, and habitat utilization of yellowfin tuna (*Thunnus albacares*) in waters surrounding the Revillagigedo Islands Archipelago Biosphere Reserve, Mexico. *Fish. Ocean.* 23(1):65-82.



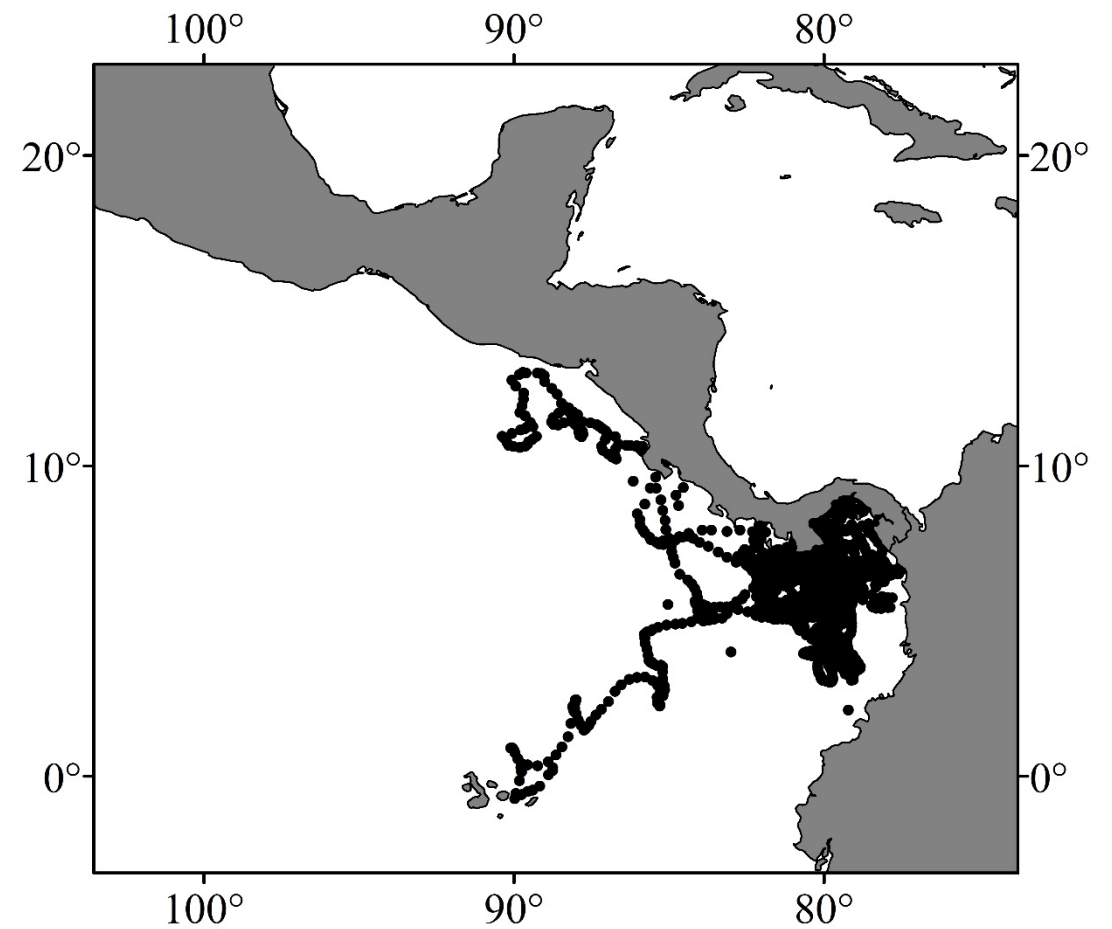
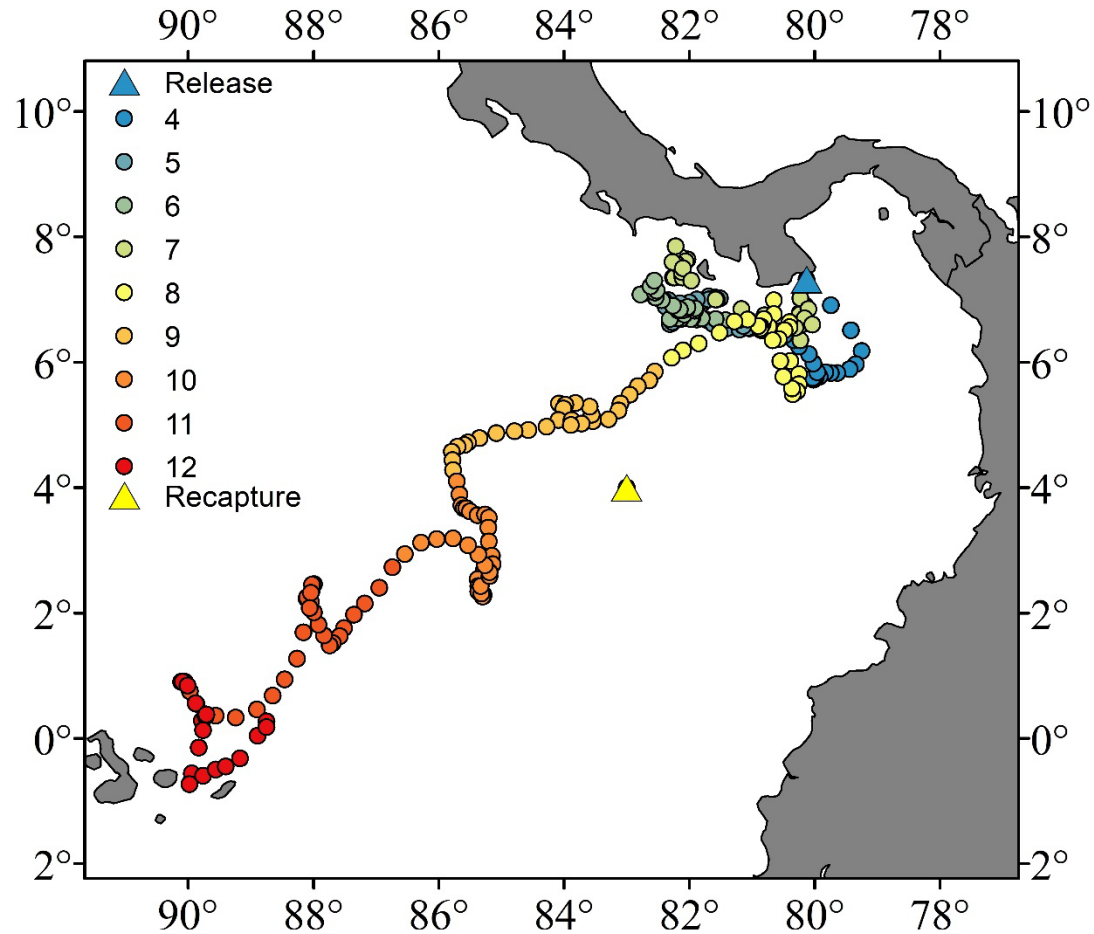
# Archival tag data

Most probable track for a yellowfin released in the equatorial eastern Pacific, at liberty for 311 d, and 477 position estimates for 5 yellowfin at liberty for >30d, estimated from the uKFSST model



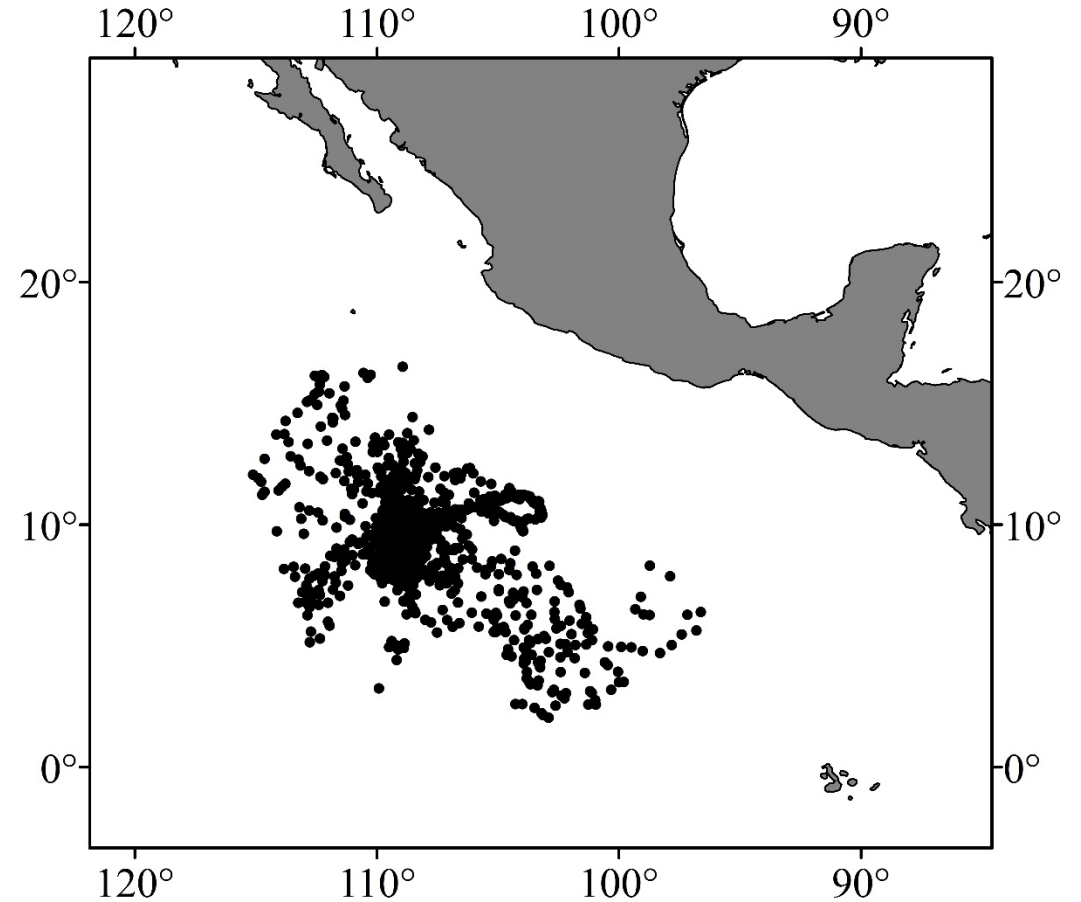
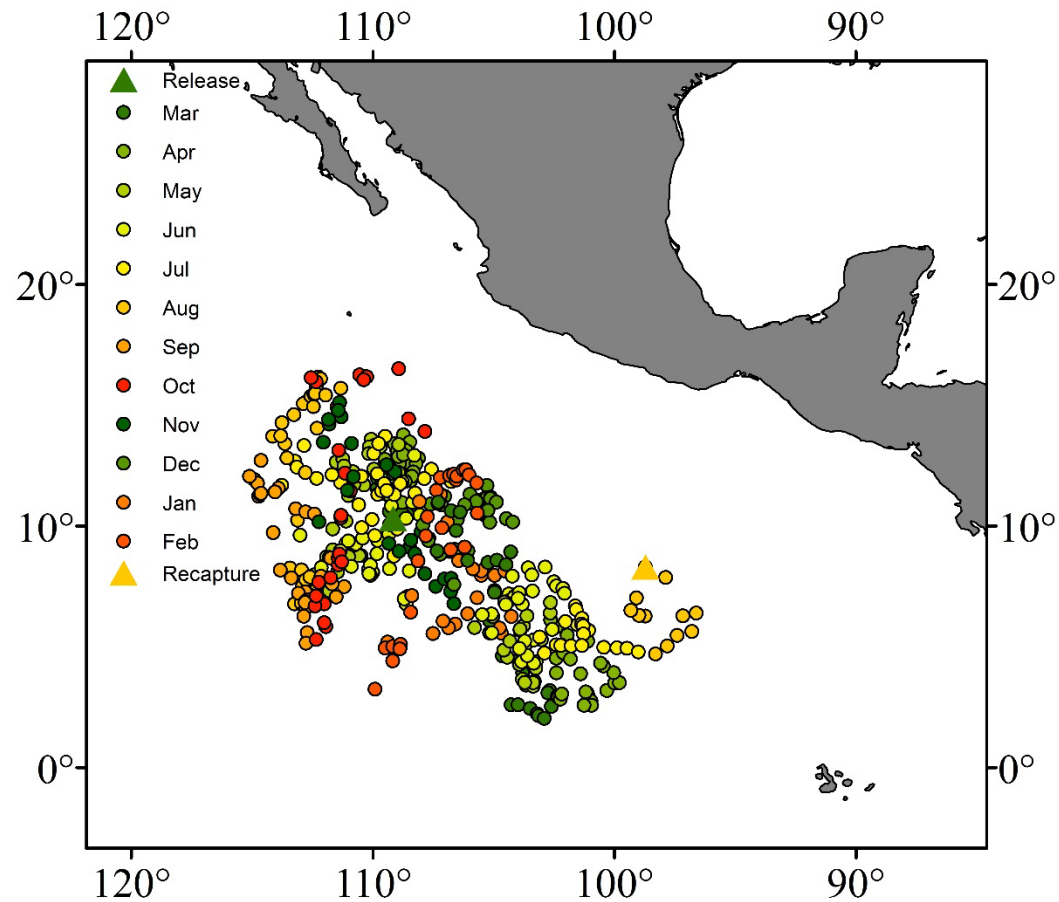
# Archival tag data

Most probable track for a yellowfin released along the coast of Panama, at liberty for 490 d, and 2388 position estimates for 15 yellowfin at liberty for >90d, estimated from the uKFSST model



# Archival tag data

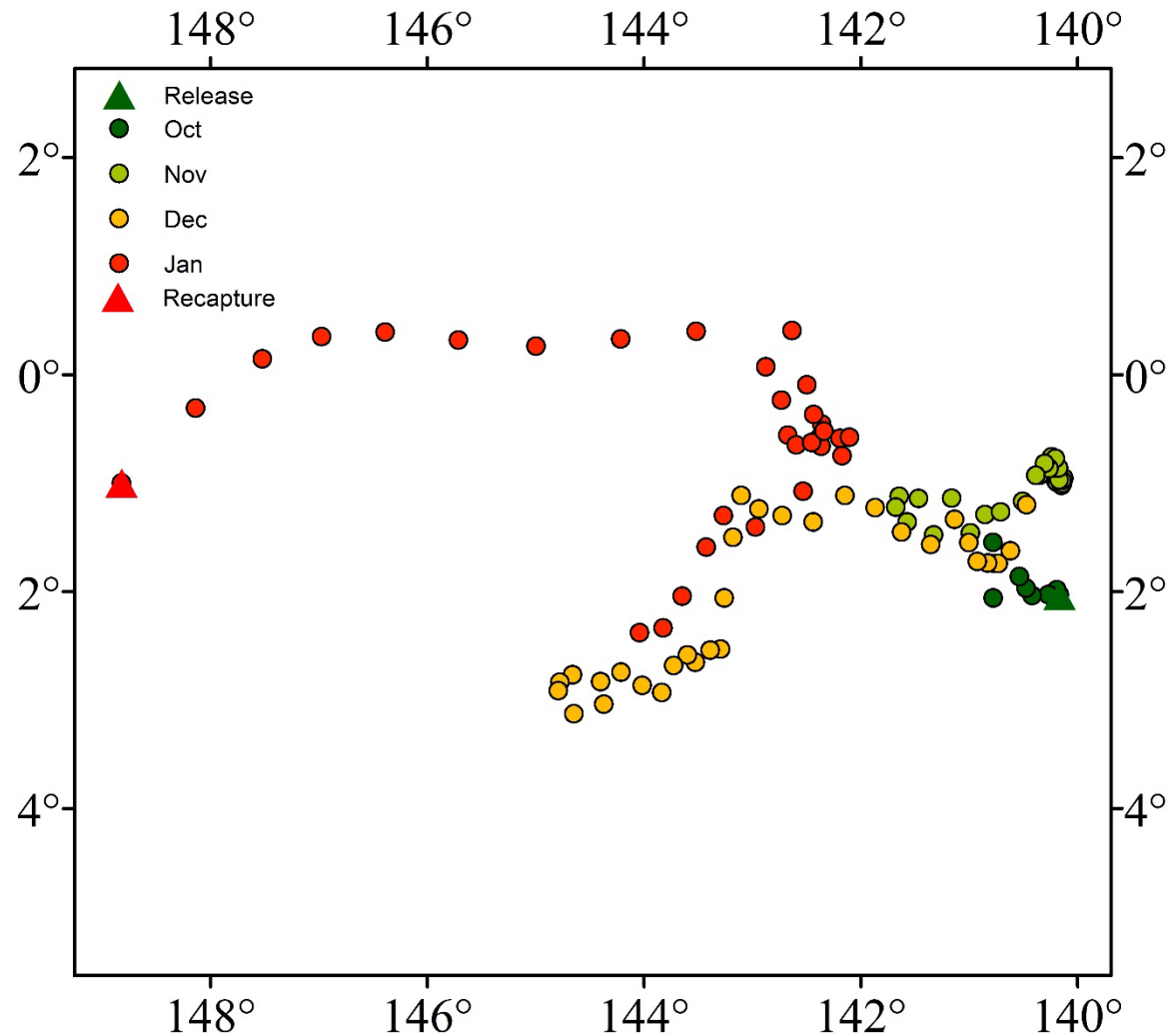
Most probable track for a yellowfin released at Clipperton Island, at liberty for 429 d, and 1789 position estimates for 8 yellowfin at liberty for >90d, estimated from the uKFSST model





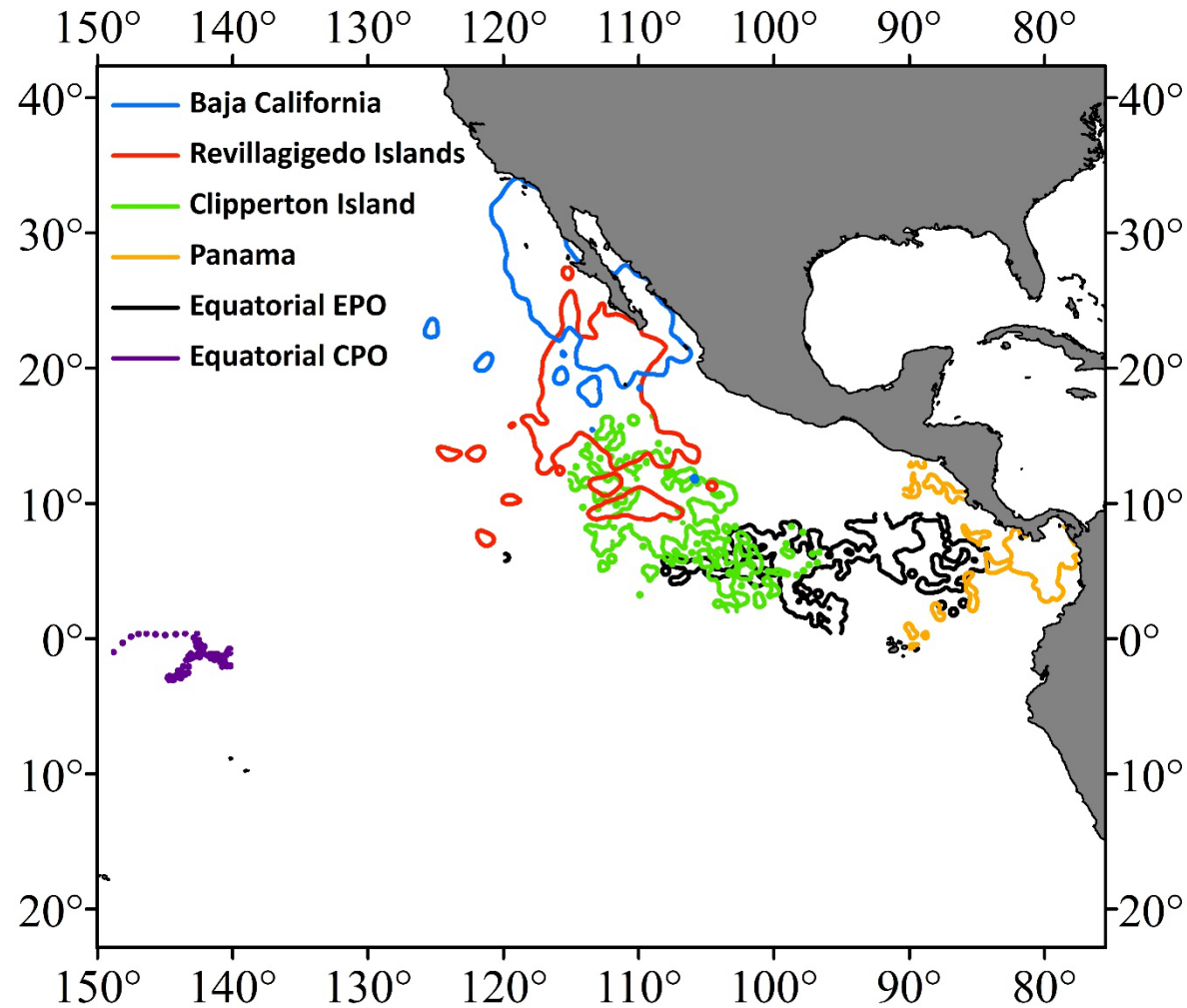
# Archival tag data

Most probable track for a yellowfin released in the equatorial central Pacific, at liberty for 99 d, estimated from the uKFSST model



# Archival tag data

95% volume contours calculated from a kernel density function for all archival tag position estimates for 6 release areas

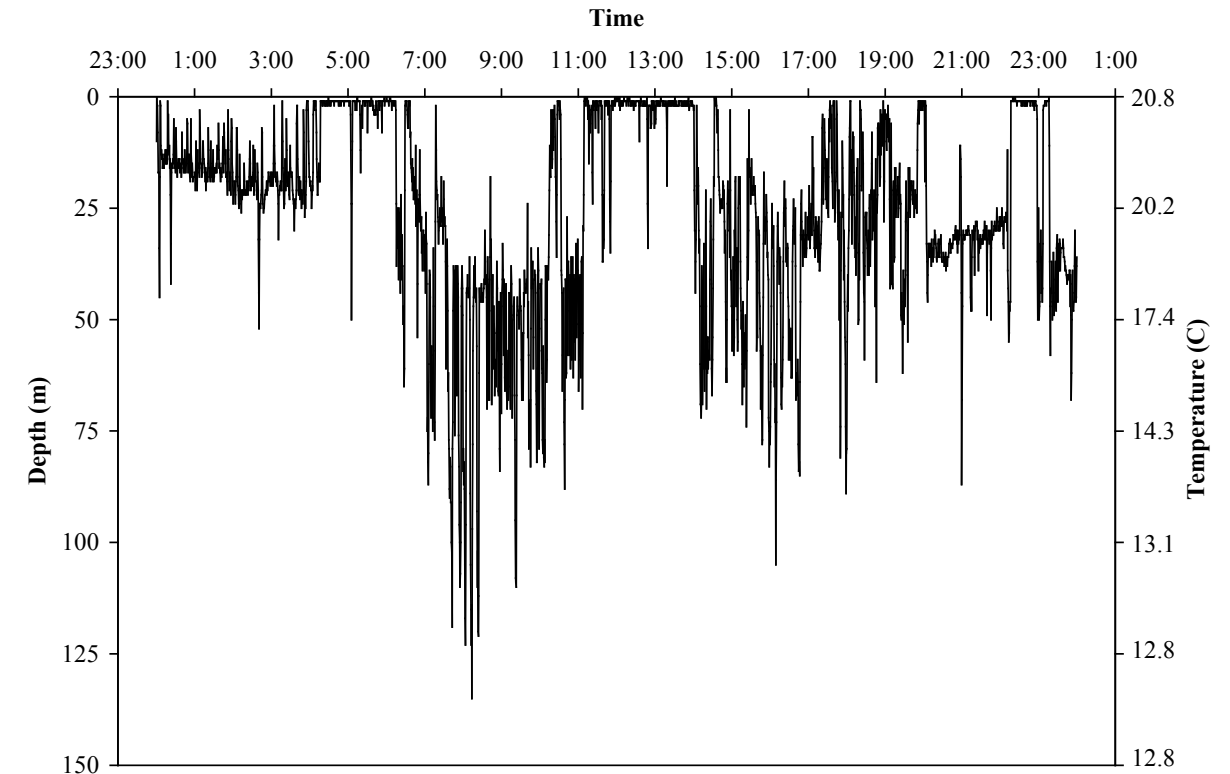
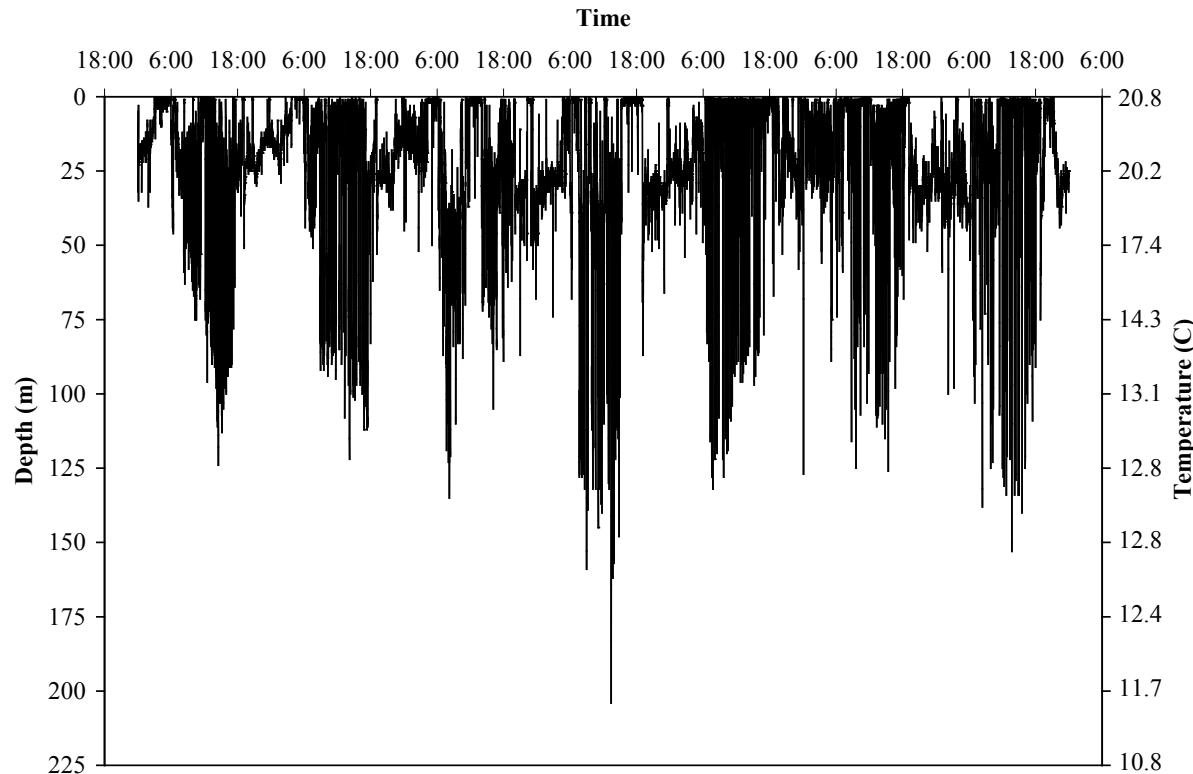


# Archival tag data - Behavior

- Evaluate 2 distinct daily behavior types, Type-1 and Type-2 (repetitive bounce diving), by size and age class
- Type-1 diving behavior was defined as fish remaining predominantly in depths  $< 100$  m, within a 24 h period.
- Type-2 diving behavior was defined as the behavior of fish that made 10 or more dives to depths greater than 150 m during the daytime, within a 24 h period.

# Archival tag data - Behavior

Type-1 diving behavior for seven days, March 6 - 12, 2009 and 1-day, March 8, 2009 for an estimated 81 cm yellowfin tuna at an estimated location is 24.5°N 113.3°W.

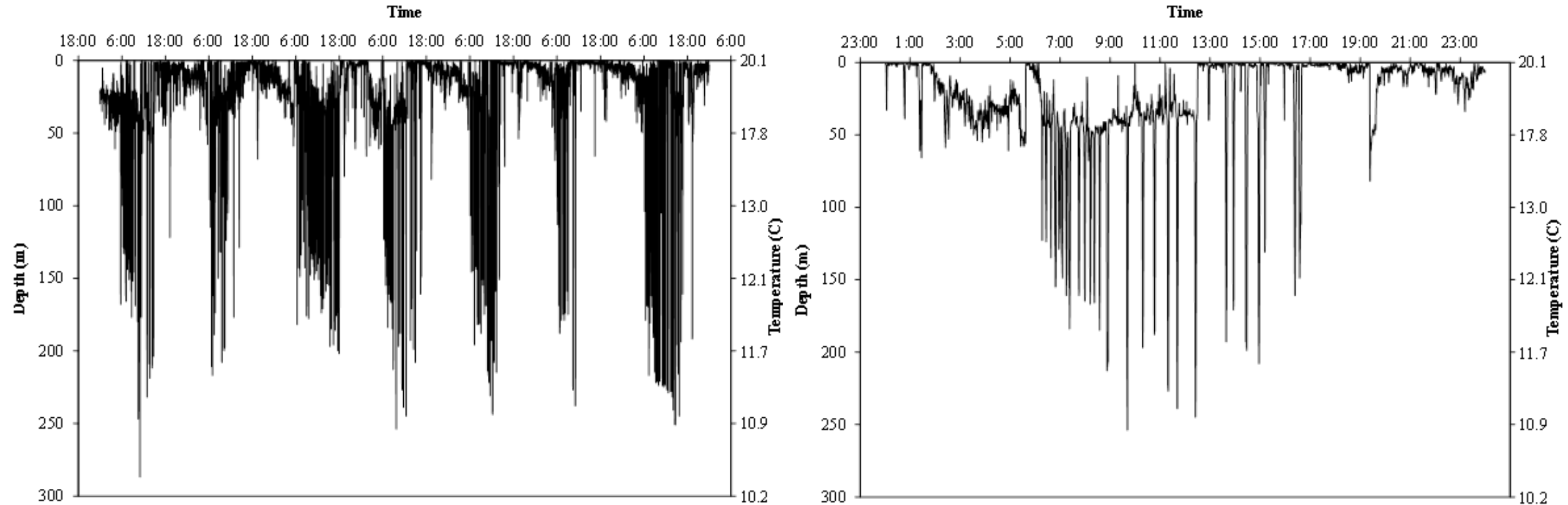


Schaefer, K.M., Fuller, D.W., and Block, B.A., 2011. Movements, behavior, and habitat utilization of yellowfin tuna (*Thunnus albacares*) in the Pacific Ocean off Baja California, Mexico, determined from archival tag data analyses, including unscented Kalman filtering. *Fish. Res.* 112:22-37.



# Archival tag data - Behavior

Repetitive bounce diving behavior. (A) Seven days, April 15 - 21, 2009. (B) One day, April 17, 2009. Estimated location is 23.5°N 112.0°W. Estimated length is 85 cm



Schaefer, K.M., Fuller, D.W., and Block, B.A., 2011. Movements, behavior, and habitat utilization of yellowfin tuna (*Thunnus albacares*) in the Pacific Ocean off Baja California, Mexico, determined from archival tag data analyses, including unscented Kalman filtering. *Fish. Res.* 112:22-37.

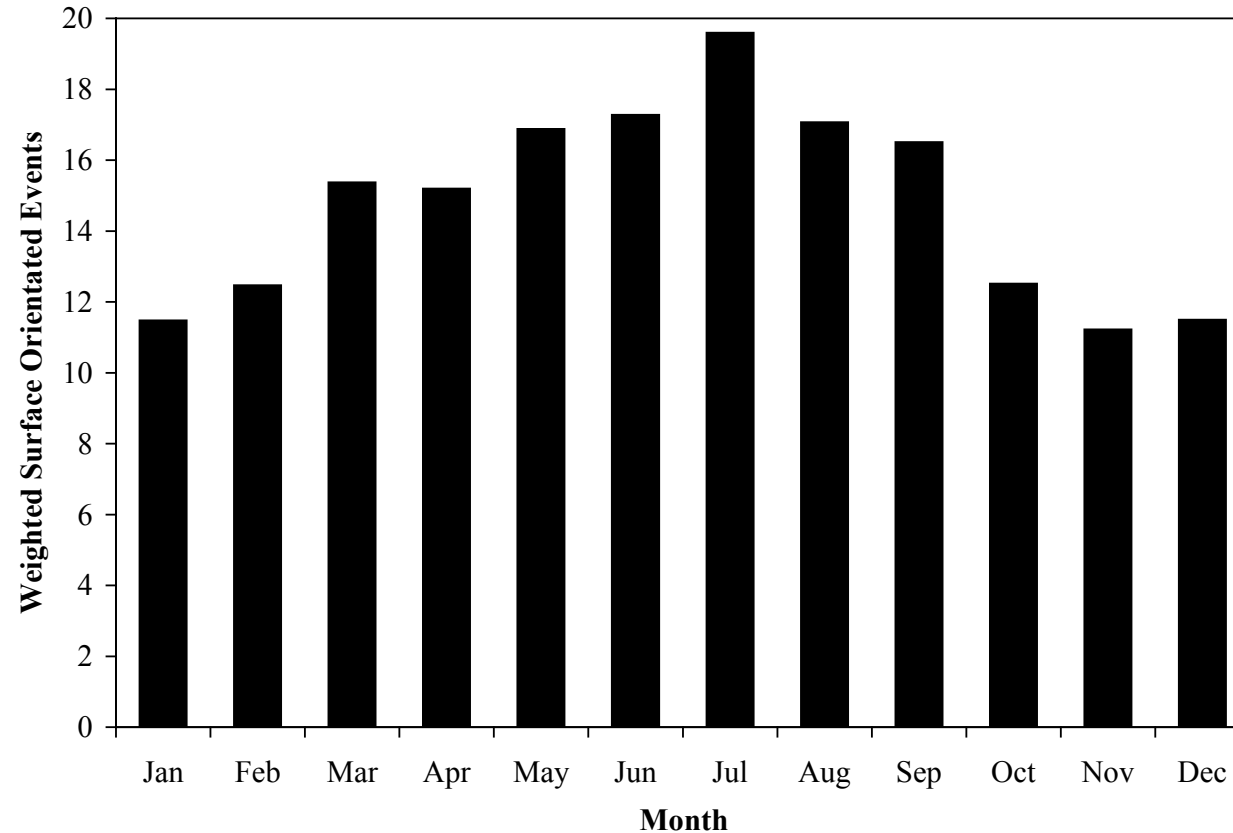


# Archival tag data - Behavior

- Define 2 distinct behavior types, Type-1 and Type-2 (repetitive bounce diving), by size and age class
- Describe surface-orientated events, where fish were within 10m of the surface for more than 10 minutes to evaluate potential detection and ultimately vulnerability to purse-seine fishing

# Archival tag data - Behavior

Summary of 413,173 surface-oriented events per day by month, weighted by the number of days per month for which events occurred



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- Evaluate ontogenetic changes in behavior and vertical habitat utilization



# Archival tag data - Behavior

## Daily classification of behavior types for 126 yellowfin tuna, by age groups

Age	Type-1 diving			Type-2 diving			Surface oriented		
	% days	events	$\bar{x}$ duration	% days	events	$\bar{x}$ duration	events	$\bar{x}$ events/day	$\bar{x}$ duration
1.25	89.8	23	8.8	10.2	20	1.6	199	6.5	23.5
1.50	79.7	304	6.4	20.3	297	1.9	12,924	5.0	22.5
1.75	81.5	633	7.2	18.5	614	1.9	55,110	6.9	23.0
2.00	86.0	815	10.1	14.0	788	1.8	106,856	8.3	24.6
2.25	87.8	263	12.3	12.2	237	1.6	100,159	7.7	23.9
2.50	82.3	250	13.2	17.7	227	2.5	57,722	8.1	24.2
2.75	87.7	119	13.7	12.3	109	1.9	32,525	9.9	25.4
3.00	81.6	64	8.6	18.4	59	1.7	18,929	8.5	25.4
3.25	86.8	22	15.4	13.2	20	2.0	6,580	6.1	25.1
3.50	61.3	28	8.6	38.7	27	4.7	5,721	7.1	27.7
3.75	67.9	24	3.7	32.1	25	2.9	3,270	6.5	23.4
4.00	53.9	28	4.7	46.1	27	3.0	2,566	4.6	24.8
4.25	38.6	24	2.8	61.4	24	4.8	2,330	5.3	25.2
4.50	56.0	27	3.9	44.0	28	2.9	3,283	9.3	31.6
4.75	68.7	38	2.8	31.3	37	1.4	2,580	6.4	29.1
5.00	39.1	16	5.2	60.9	16	6.4	2,482	5.3	21.6
Pooled	82.9	2555	9.3	17.1	2678	2.0	151,110	7.6	24.2

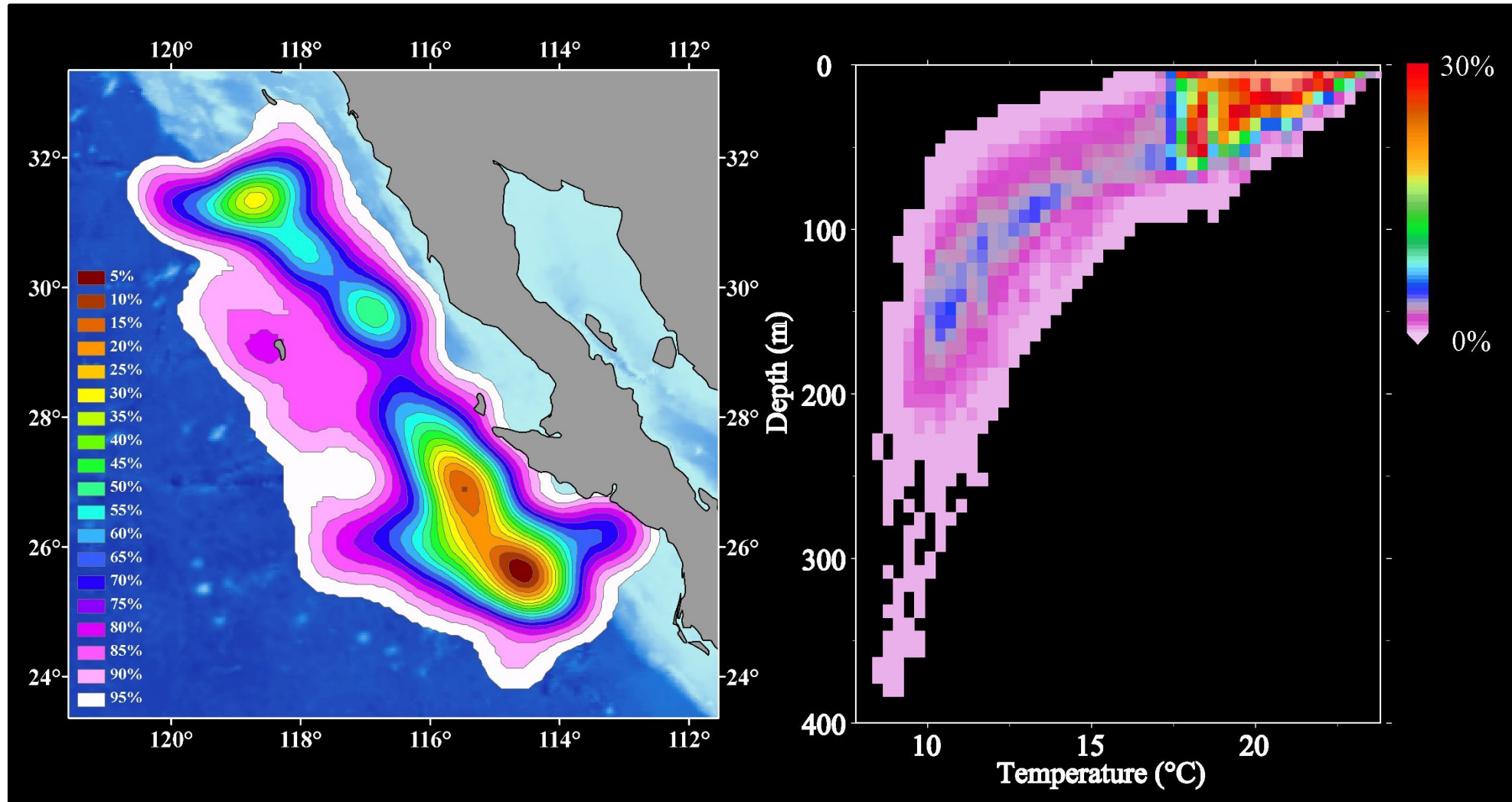
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# Archival tag data - Habitat utilization

- Evaluate geographic variation in horizontal and vertical habitat utilization

# Northern Baja California

## Horizontal and Vertical Habitat Utilizations



**95% = 452,288**

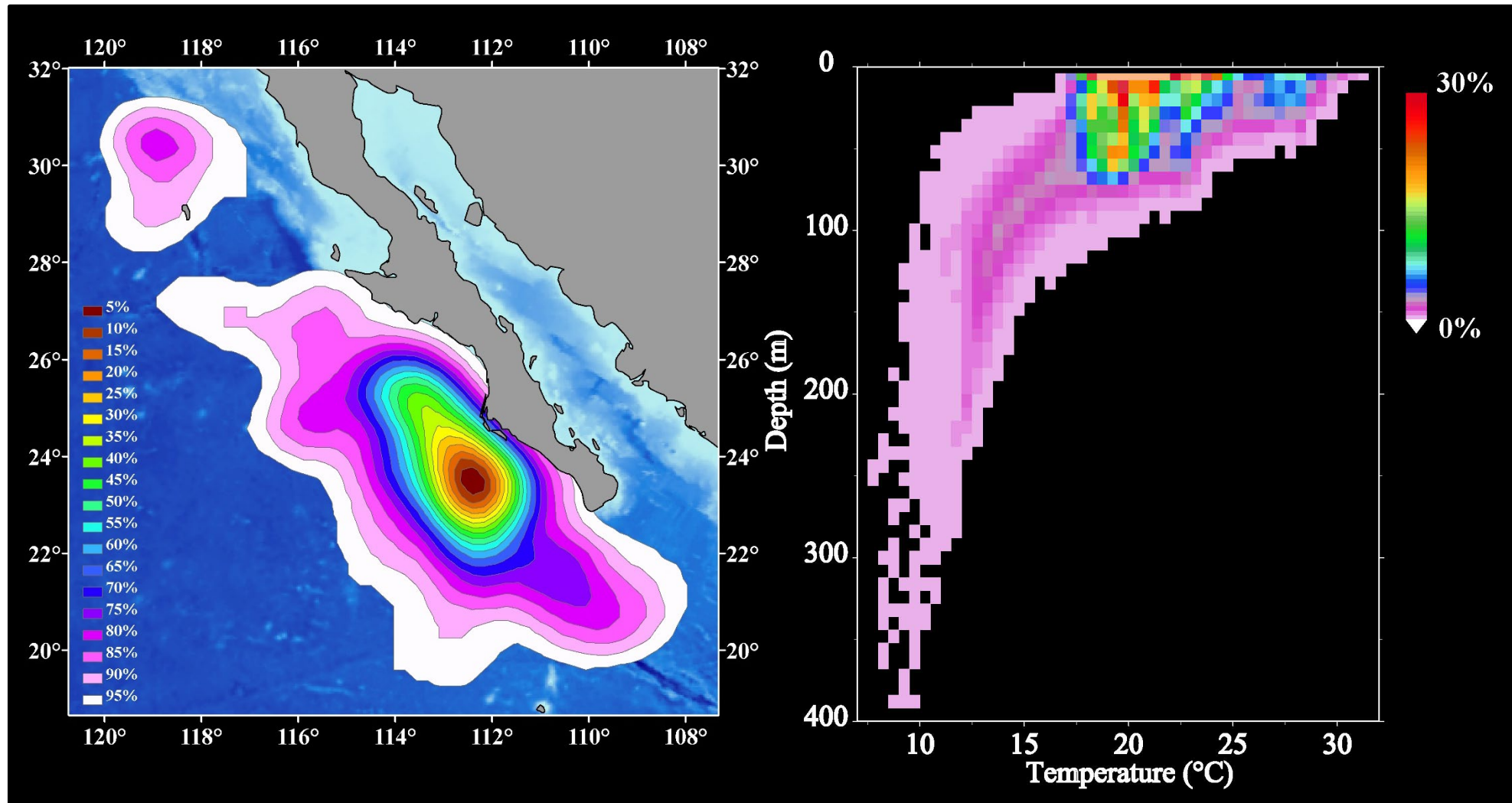
**50% = 67,888**

**34.5% Below MLD**

**n = 7.6 Million**

# Southern Baja California

## Horizontal and Vertical Habitat Utilizations



**95% = 709,487**

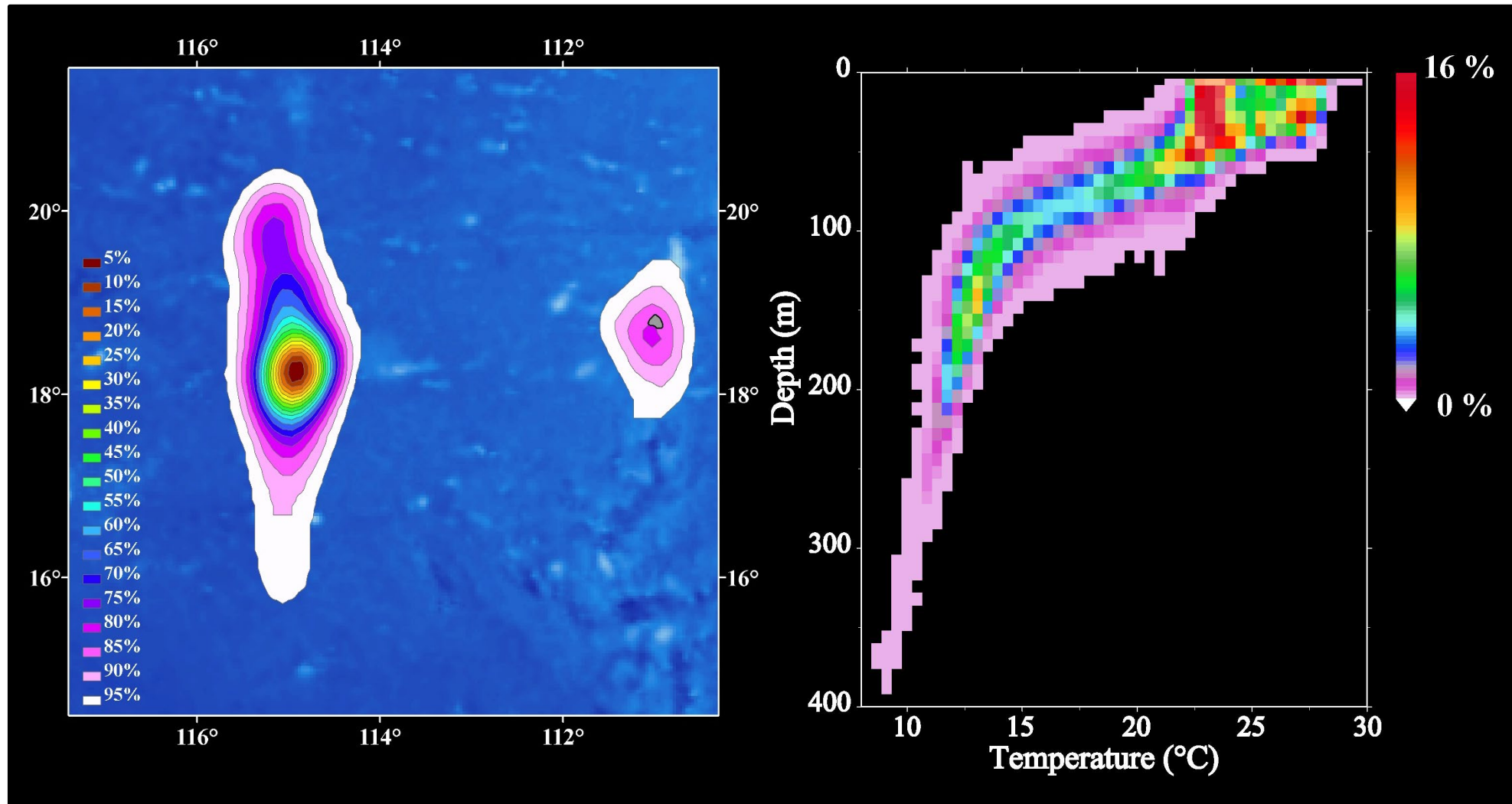
**50% = 74,610**

**47.5% Below MLD**

**$n = 2.5$  Million**

# Revillagigedo Islands

## Horizontal and Vertical Habitat Utilizations



95% = 77,275

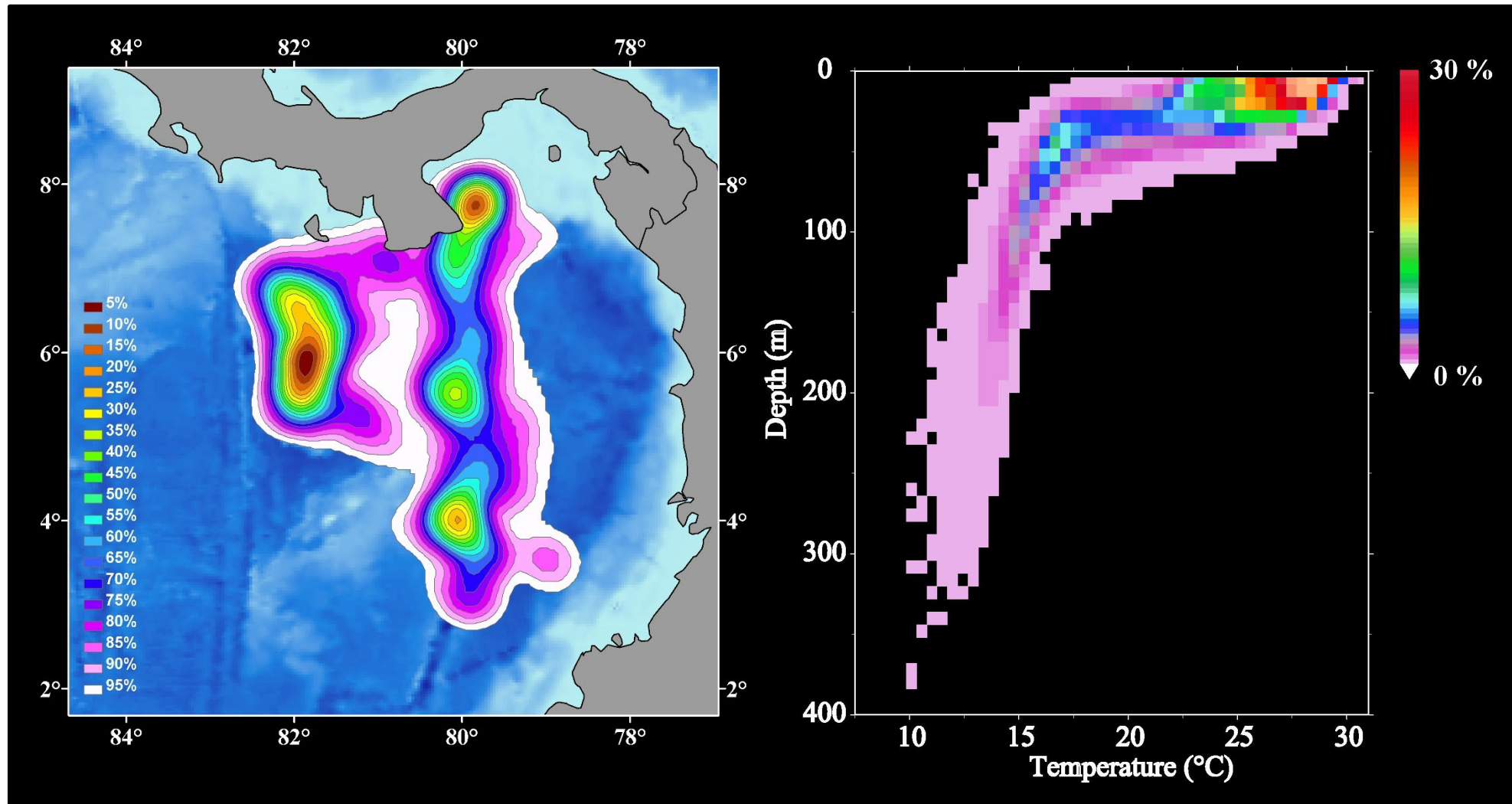
50% = 6,887

67.1% Below MLD

$n = 2.2$  Million

# Coastal Panama

## Horizontal and Vertical Habitat Utilizations



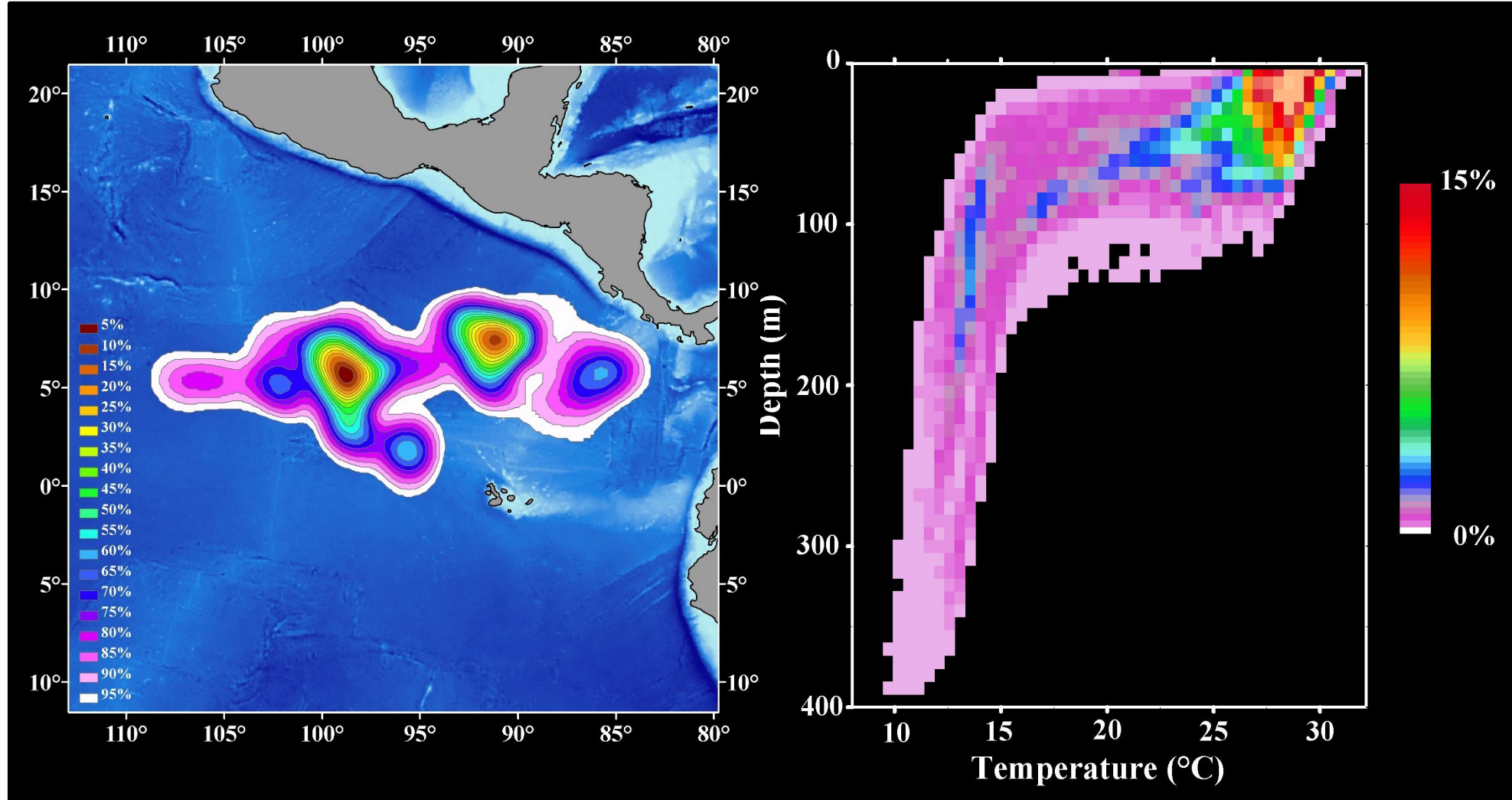
**95% = 164,437**

**50% = 25,595**

**44.4% Below MLD**

**n = 1.3 Million**

# Equatorial Eastern Pacific Ocean Horizontal and Vertical Habitat Utilizations



**95% = 1,817,997    50% = 225,613**

**57.7% Below MLD  
 $n = 0.6$  Million**

# Conclusions

- YFT tagging experiments throughout the EPO, utilizing PDTs and ATs, indicate movements of fish at liberty for more than 30 days tend to be restricted to less than 1,000 miles of release positions.
- These studies indicate regional fidelity of yellowfin to areas of release, with little exchange of fish between the northern and southern regions of the EPO.
- Higher proportions of repetitive bounce diving behavior was exhibited for larger fish and those away from the coast or islands.
- Surface oriented behavior, during the day, appears to be a reasonable approximation for the potential detection and vulnerability to capture by purse-seine vessels.
- There are spatial, temporal, and ontogenetic differences in YFT behavior and thus unequal vulnerability to capture by purse-seine and longline vessels throughout the EPO.



# Acknowledgements

- Fisheries agency of Japan
- Tagging of Pacific Pelagics, Census of Marine Life
- Pacific Tuna Tagging Program
- *F/V Royal Star* and participating fishers
- Oceanic Fisheries Program, SPC
- Wildlife computers and LOTEK Wireless
- IATTC staff and especially field office personnel



# Questions