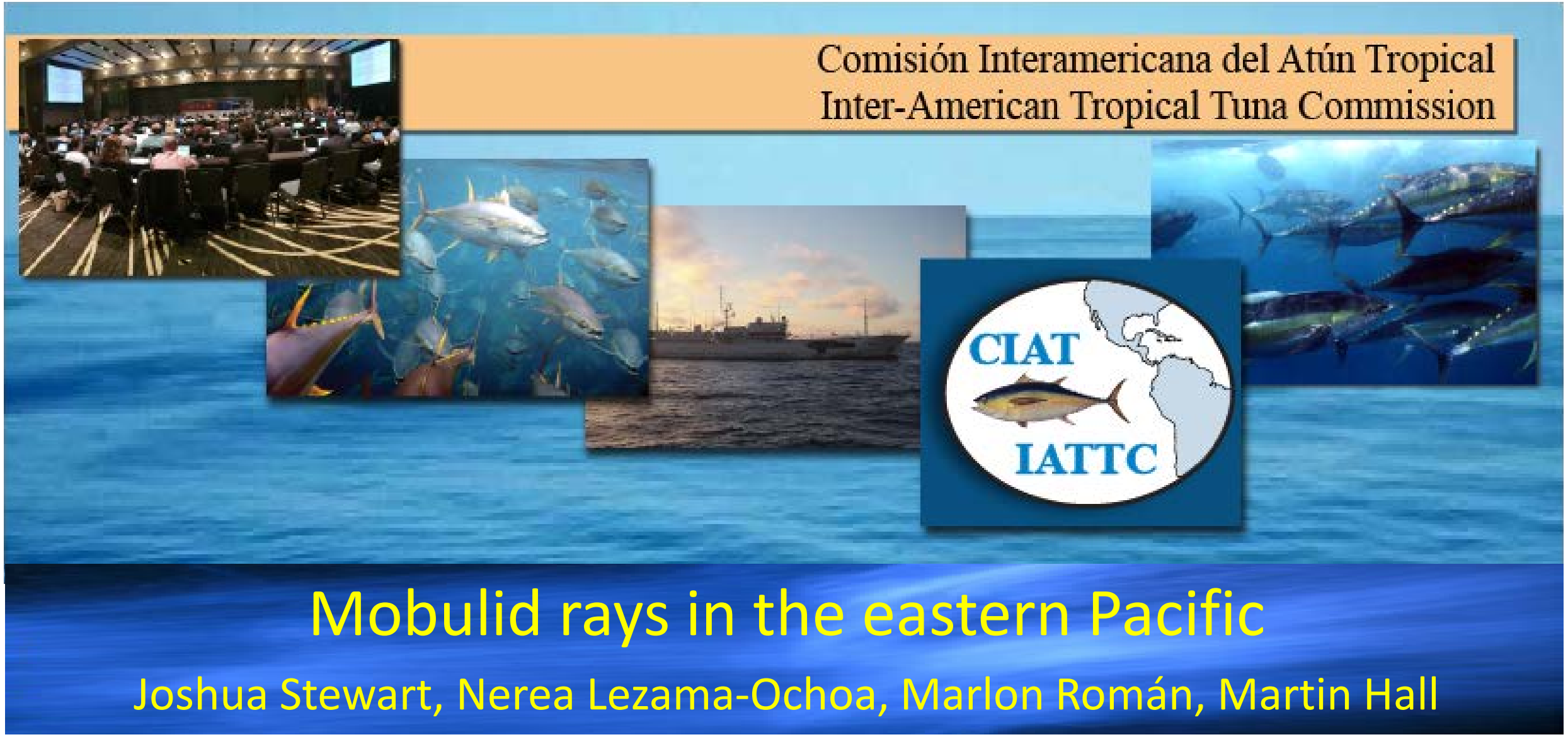


Mobulid rays in the eastern Pacific

Joshua Stewart, Nerea Lezama-Ochoa, Marlon Román, Martin Hall

8th Meeting of the Bycatch Working Group La Jolla, California USA, 10-11 May 2018

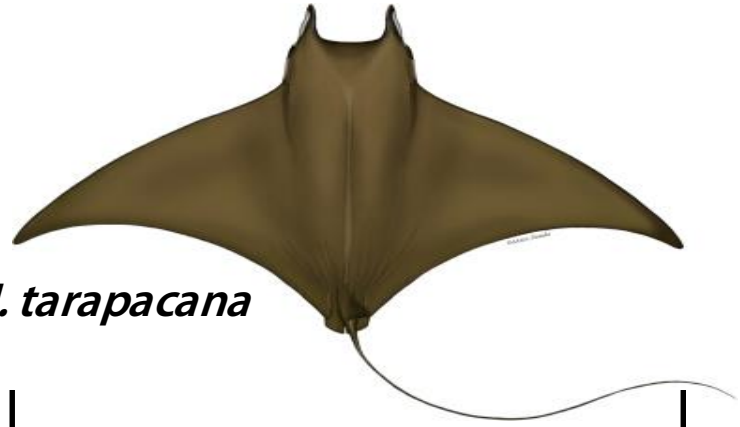
Outline

- Introduction to group: mobulid rays
- Data collection: uncertainties, new forms
- Bycatch estimates: assumptions, release methods
- Spatial distributions
- Knowledge gaps
  - Species Distribution Models
  - Survival estimates: pilot program
- Proposed program: partners

Mobulid rays: Ecology and life history

Mobulid rays: Ecology and life history

M. birostris



M. tarapacana

Disc width

M. munkiana

M. thurstoni

M. mobular

Mobulid rays: Ecology and life history

Old name	New name	Common name
Manta birostris	*Mobula birostris*	Giant manta now Giant devil ray
Mobula japanica	*Mobula mobular*	Spinetail devil ray
Mobula thurstoni		Smooth tail or Bentfin devil ray
Mobula tarapacana		Chilean devil ray
Mobula munkiana		Munk's devil ray

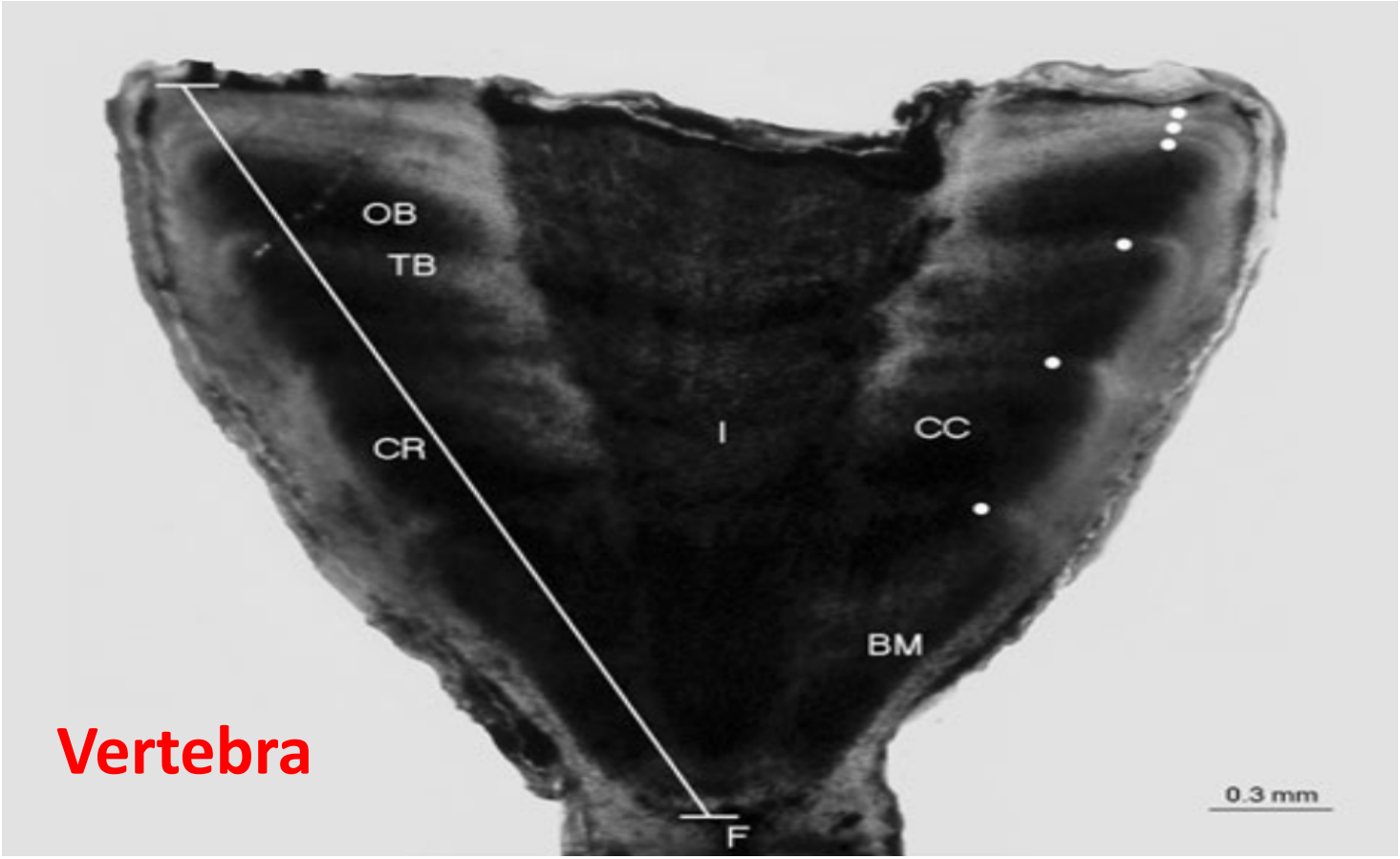
White et al. 2017

Mobulid life history

- Long lived
  - 40+ years for mantas
  - 15-20+ for mobulas

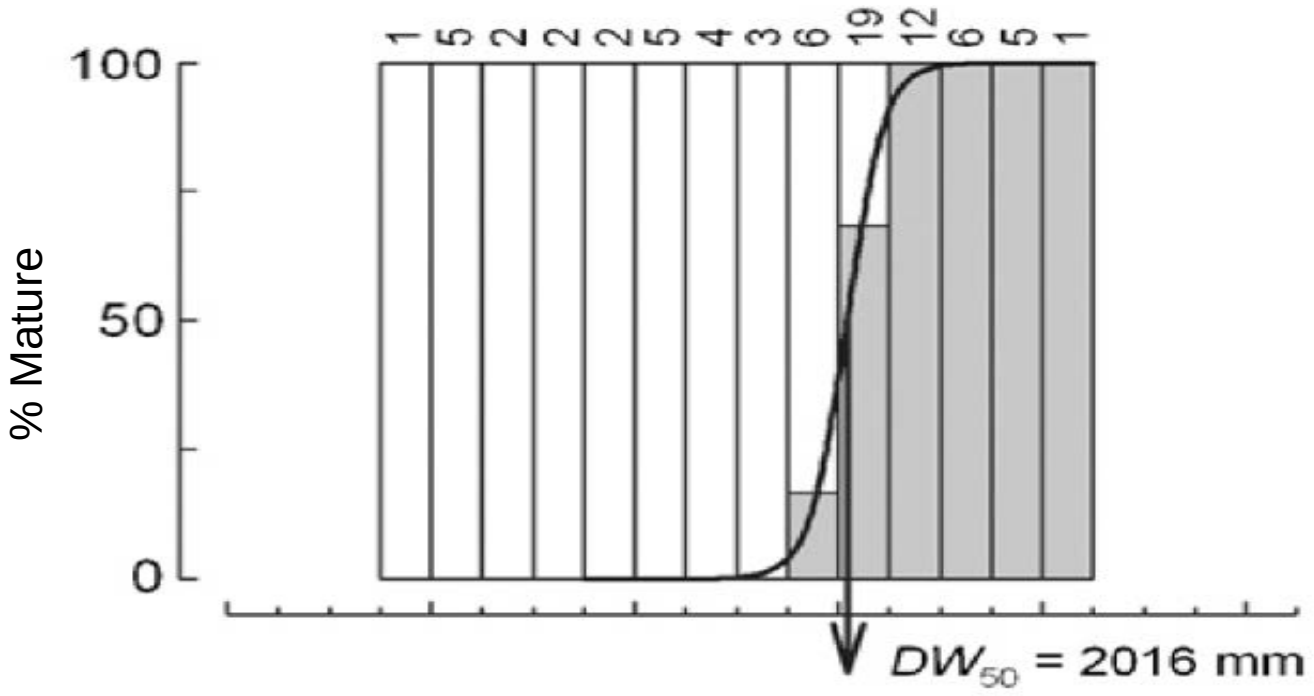
Mobulid life history

- Long lived
  - 40+ years for mantas
  - 15-20+ for mobulas



Mobulid life history

- Long lived
  - 40+ years for mantas
  - 15-20+ for mobulas
- Late maturity
- ~ 8 years for mantas
- ~ 6 years for mobulas

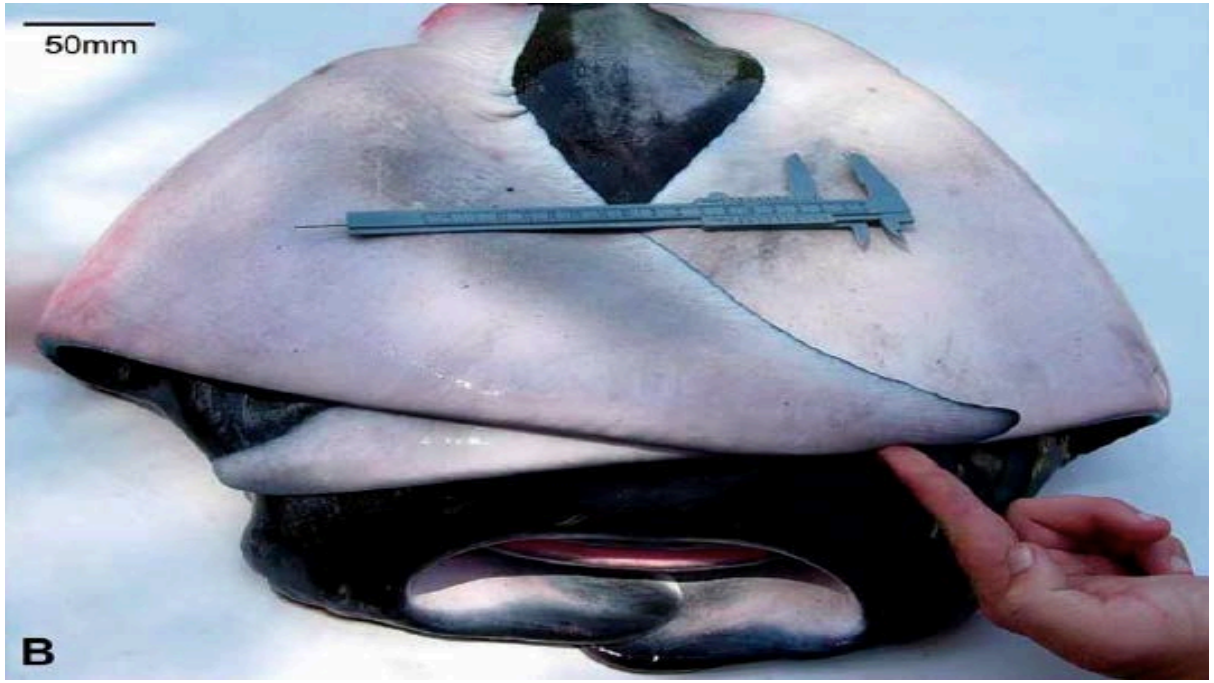


Disc width = 6 years

White et al., 2006

Mobulid life history

- Long lived
  - 40+ years for mantas
  - 15-20+ for mobulas
- Late maturity
  - ~ 8 years for mantas
  - ~ 6 years for mobulas

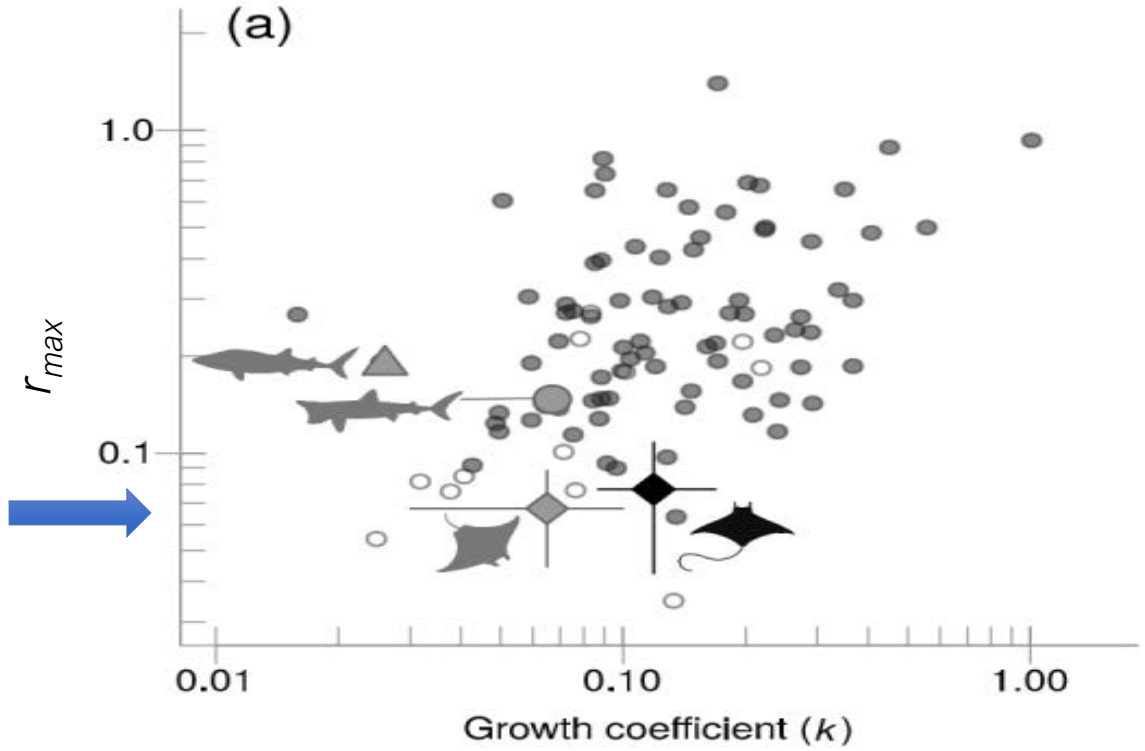


Mobula alfredi Fetus

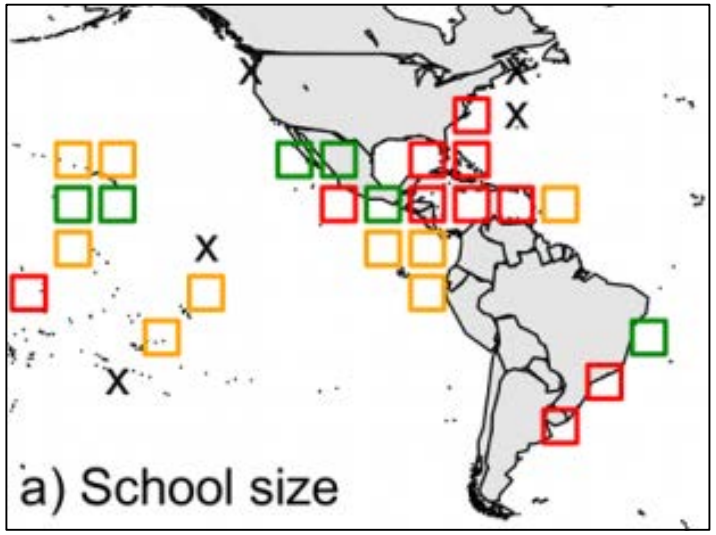
- Low fecundity
  - Single pup per pregnancy, gaps of 2-7 years between pregnancies

Mobulid life history

- Long lived
  - 40+ years for mantas
  - 15-20+ for mobulas
- Late maturity
  - ~ 8 years for mantas
  - ~ 6 years for mobulas
- Low fecundity
  - Single pup per pregnancy, gaps of 2-7 years between pregnancies
- One of the lowest population growth rates among elasmobranchs

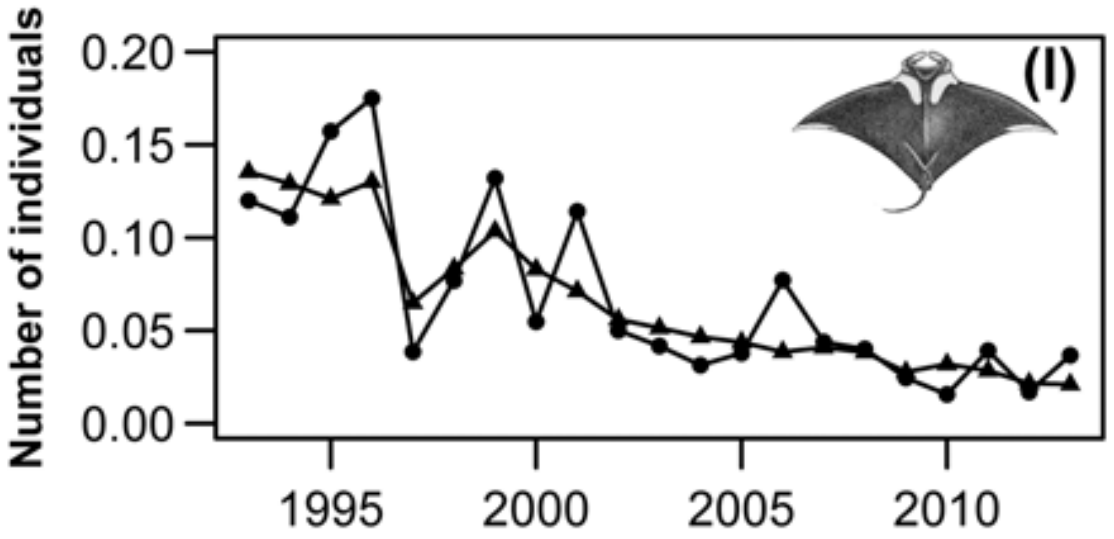


Population trends



- Global decline in school size and sighting frequency

Ward-Paige et al., 2013



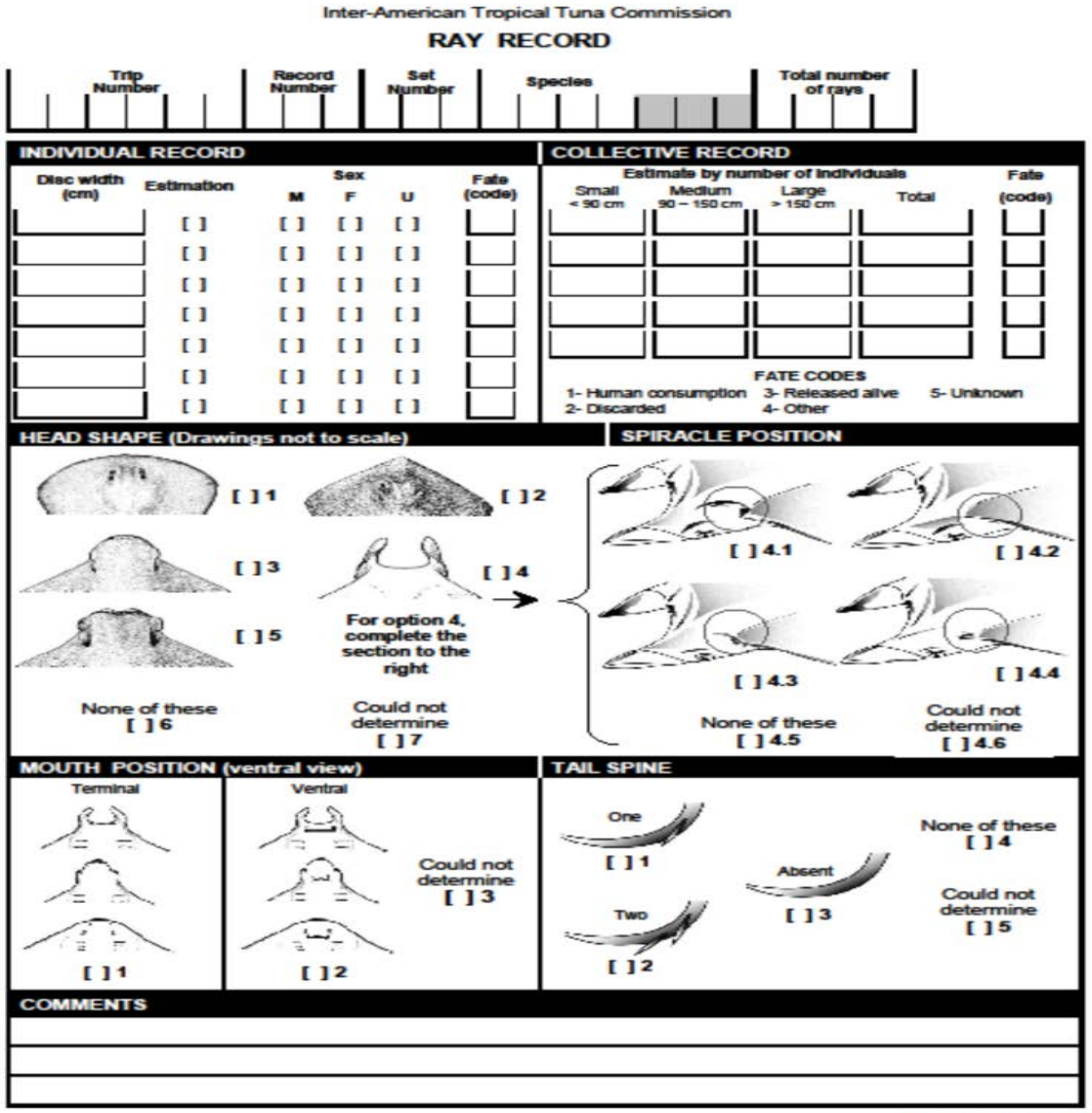
- Declines in manta and mobula sighting frequency (Cocos Is.)

White et al., 2015

Data collection issues

- Early years of the AIDCP program 1993 – 2000, most unidentified
- Observer training begins to improve in 2002 – 2005
- Taken in all types of sets; most in school and dolphin sets
- Still many unidentified because of inability to observe characteristics needed
- Not retained
- Release methods and vulnerability suggested assumption of 100% mortality

Data collection



Inter-American Tropical Tuna Commission

RAY RECORD

Trip Number | Record Number | Set Number | Species | Total number of rays

INDIVIDUAL RECORD

Disc width (cm)	Estimation	Sex M	Sex F	Sex U	Fate (code)
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	
	[ ]	[ ]	[ ]	[ ]	

COLLECTIVE RECORD

Estimate by number of individuals: Small < 90 cm	Medium 90 – 150 cm	Large > 150 cm	Total	Fate (code)

FATE CODES

1- Human consumption
2- Discarded
3- Released alive
4- Other
5- Unknown

HEAD SHAPE (Drawings not to scale)

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5

For option 4, complete the section to the right

None of these [ ] 6

Could not determine [ ] 7

SPIRACLE POSITION

[ ] 4.1 [ ] 4.2 [ ] 4.3 [ ] 4.4

None of these [ ] 4.5

Could not determine [ ] 4.6

MOUTH POSITION (ventral view)

Terminal [ ] 1

Ventral [ ] 2

Could not determine [ ] 3

TAIL SPINE

One [ ] 1

Two [ ] 2

Absent [ ] 3

None of these [ ] 4

Could not determine [ ] 5

COMMENTS

IATTC RR 05/2016

Created by M. Román

Data collection

Comisión Interamericana del Atún Tropical

REGISTRO DE LIBERACIÓN DE MEGAFAUNA

No. de Crucero

SECCIÓN DE LIBERACIÓN DE ESPECIES

No. de lance	Código		Formación bolsa	Inicio liberación	Cond. inicio liberación	Método(s) usado(s)				Fin liberación	Cond. fin liberación	¿Marcada?	Longitud	Sexo M	Sexo H	Sexo D

Códigos de métodos de liberación:

1. Manualmente
2. Salabardo
3. Camilla
4. Sarria
5. Parrilla
6. Hundimiento de corchos
7. Hoyo en la red
8. Soga, estrobo
9. Otro (describa)

Códigos de condición: **(Ver instrucciones)**

1. Excelente
2. Bueno
3. Correcto
4. Pobre
5. Inaceptable

COMENTARIOS

CIAT COPBC1-5 08/2017
Página __ de __

Created by M. Román

Bycatch estimates

Table 2 Distribution of species by years and set type

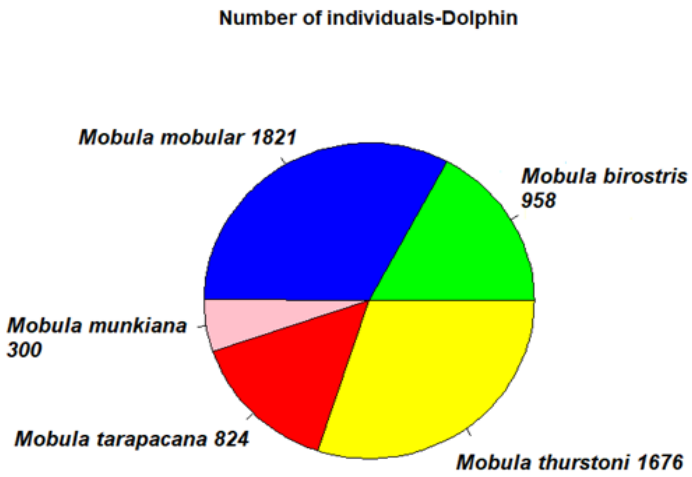
Dolphin sets	Avg all years	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Giant manta	17	0	0	0	0	0	1	1	2	6	5	1	15	36	219	8	18	6	4	1	13	21	0	38	8
Spinetail manta	85	0	0	0	0	0	0	0	0	16	96	11	57	126	187	148	87	243	303	152	34	62	57	338	117
Chilean devil ray	35	0	0	0	0	0	0	0	0	0	7	8	4	79	45	55	30	190	148	78	21	26	18	93	26
Smoothtail manta	66	0	0	0	0	0	0	1	102	98	72	141	86	205	43	105	50	93	132	27	67	40	75	101	150
Munk's devil ray	16	0	0	0	0	0	0	0	0	3	10	26	17	14	31	24	36	6	33	29	6	6	15	74	63
Unid Manta/devil rays	389	504	375	500	385	396	337	474	1"284	447	723	904	356	197	486	257	119	338	316	99	51	328	42	173	233
Total	**607**	**504**	**375**	**500**	**385**	**396**	**338**	**476**	**1"388**	**570**	**913**	**1"091**	**535**	**657**	**1"011**	**597**	**340**	**876**	**936**	**386**	**192**	**483**	**207**	**817**	**597**

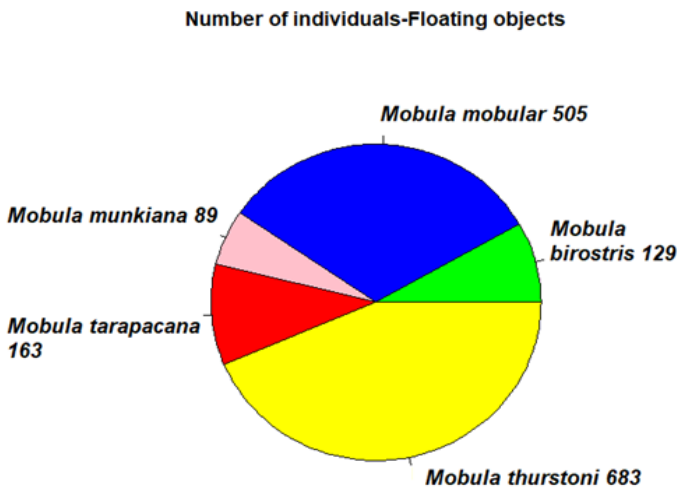
School sets	Avg all years	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Giant manta	112	0	0	1	0	2	94	63	12	6	6	10	47	23	37	17	61	11	1"163	9	949	24	9	67	66
Spinetail manta	89	0	0	0	0	0	0	0	0	8	8	79	30	111	473	202	247	56	334	104	243	112	87	21	19
Chilean devil ray	29	0	0	0	0	0	0	0	0	0	15	0	28	42	52	37	276	21	12	28	94	29	10	25	17
Smoothtail manta	275	0	3	0	0	0	8	2	121	185	2"052	707	429	72	572	64	126	31	123	397	1"435	180	29	41	31
Munk's devil ray	34	0	0	0	0	0	0	0	0	0	3	35	15	21	65	29	127	45	48	58	63	55	4	11	236
Unid Manta/devil rays	1"279	5"729	1"262	2"248	1"341	707	4"042	1"498	1"806	289	1"994	1"005	938	1"996	1"104	1"154	165	111	2"225	341	215	123	95	59	248
Total	**1"818**	**5"729**	**1"265**	**2"249**	**1"341**	**709**	**4"145**	**1"563**	**1"939**	**489**	**4"079**	**1"837**	**1"487**	**2"265**	**2"303**	**1"503**	**1"003**	**275**	**3"905**	**937**	**2"999**	**524**	**235**	**224**	**617**

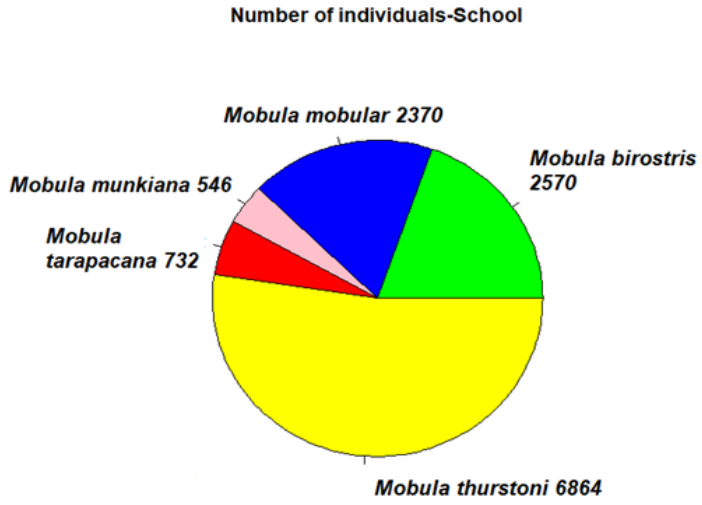
Bycatch estimates

All sets	Avg all years	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Giant manta	133	0	1	1	0	2	99	74	15	14	13	14	64	69	286	30	82	18	1"169	15	968	47	15	106	81
Spinetail manta	194	0	0	0	0	0	0	0	0	26	111	96	89	253	679	383	364	316	659	274	325	192	324	420	141
Chilean devil ray	68	0	0	0	0	0	0	0	0	4	29	8	33	124	102	116	316	213	167	115	122	62	33	130	56
Smoothtail manta	355	0	3	0	0	0	8	3	257	290	2"143	885	523	291	629	183	190	146	294	430	1"517	246	127	156	199
Munk's devil ray	53	0	0	0	0	0	0	0	0	3	14	68	32	35	96	55	171	60	82	98	72	67	25	91	301
Unid Manta/devil rays	1"743	6"531	1"689	2"817	1"850	1"229	4"453	2"112	3"126	787	2"760	2"040	1"361	2"237	1"662	1"460	339	491	2"643	480	293	492	180	263	532
Total	**2"545**	**6"531**	**1"693**	**2"818**	**1"850**	**1"231**	**4"560**	**2"189**	**3"398**	**1"123**	**5"069**	**3"111**	**2"102**	**3"010**	**3"454**	**2"227**	**1"463**	**1"244**	**5"014**	**1"412**	**3"297**	**1"106**	**705**	**1"166**	**1"311**

Bycatch estimates



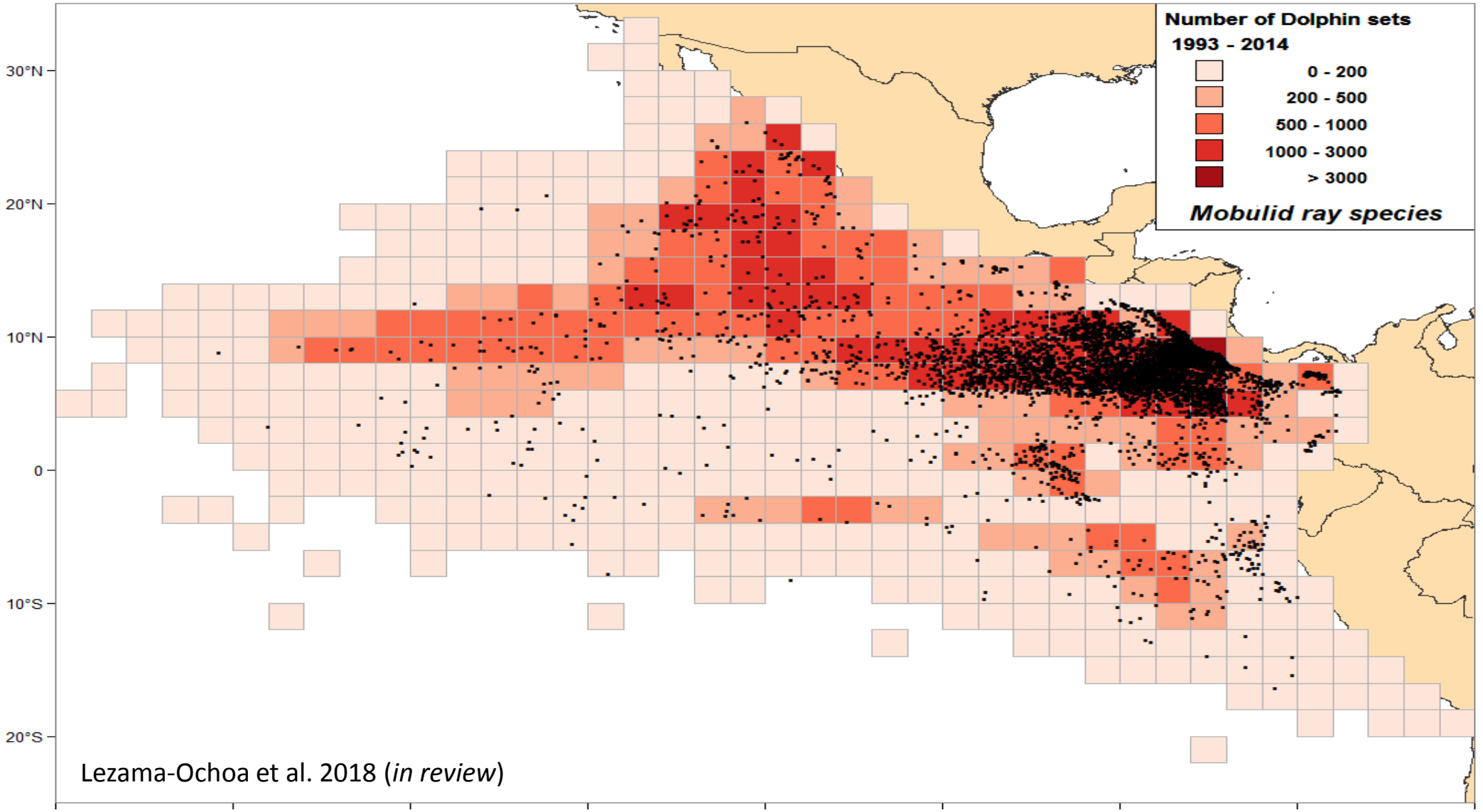




IATTC bycatch database (2005-2015)

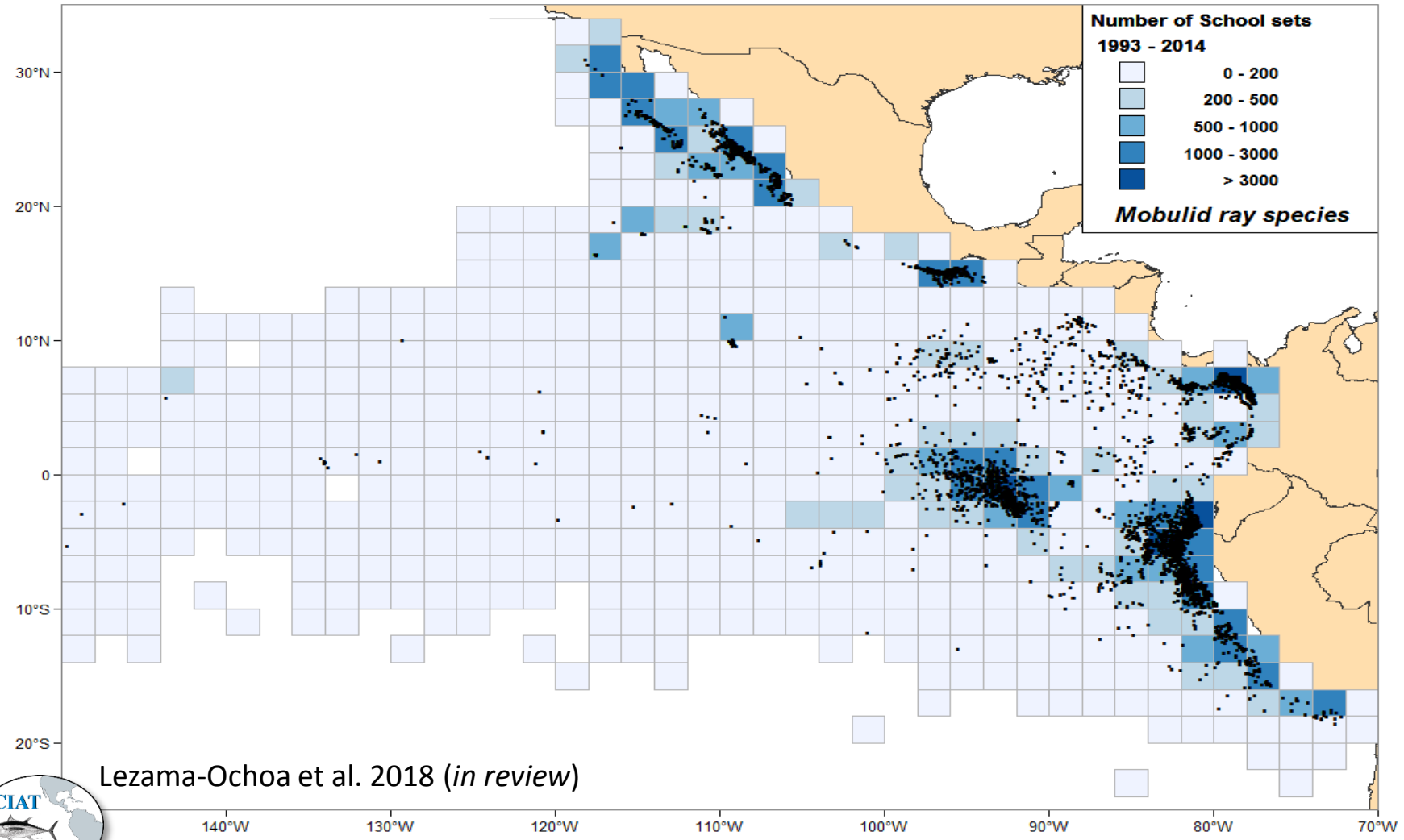
Lezama-Ochoa et al. 2018 (*in review*)

Bycatch estimates

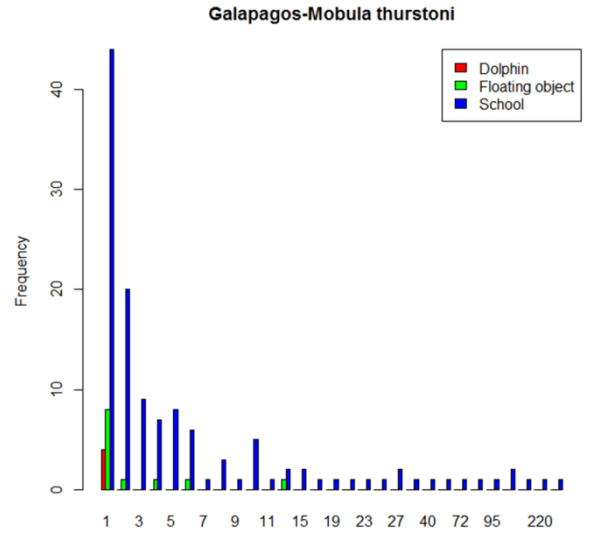


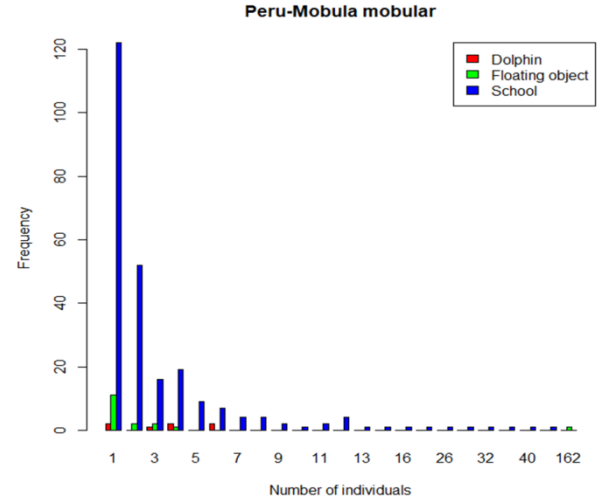
Lezama-Ochoa et al. 2018 (*in review*)

Bycatch estimates

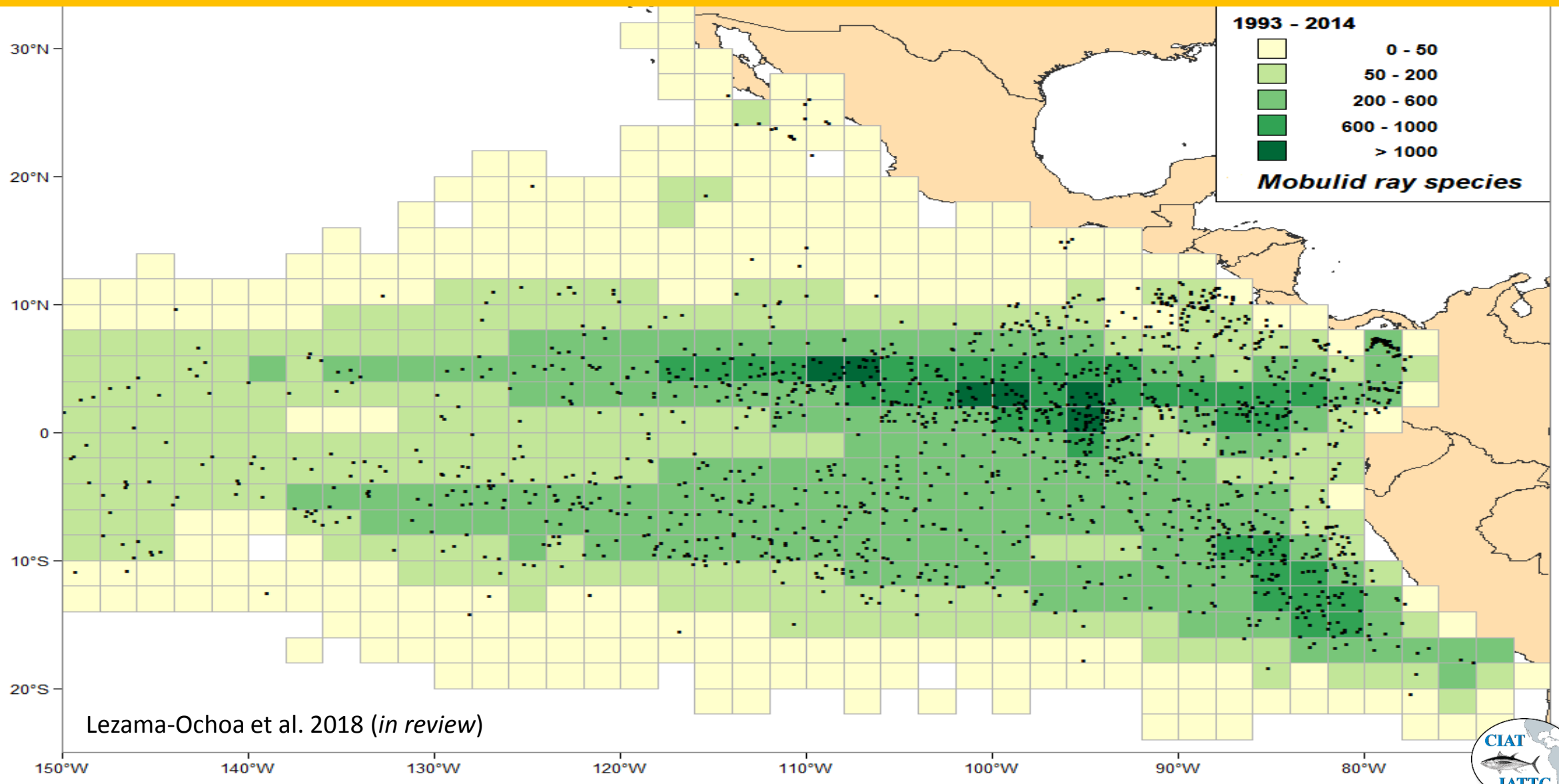


Lezama-Ochoa et al. 2018 (*in review*)





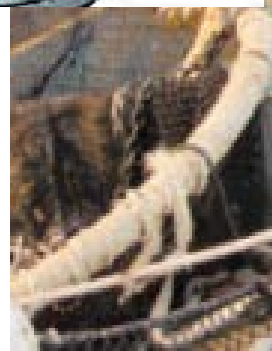
Bycatch estimates



Lezama-Ochoa et al. 2018 (*in review*)

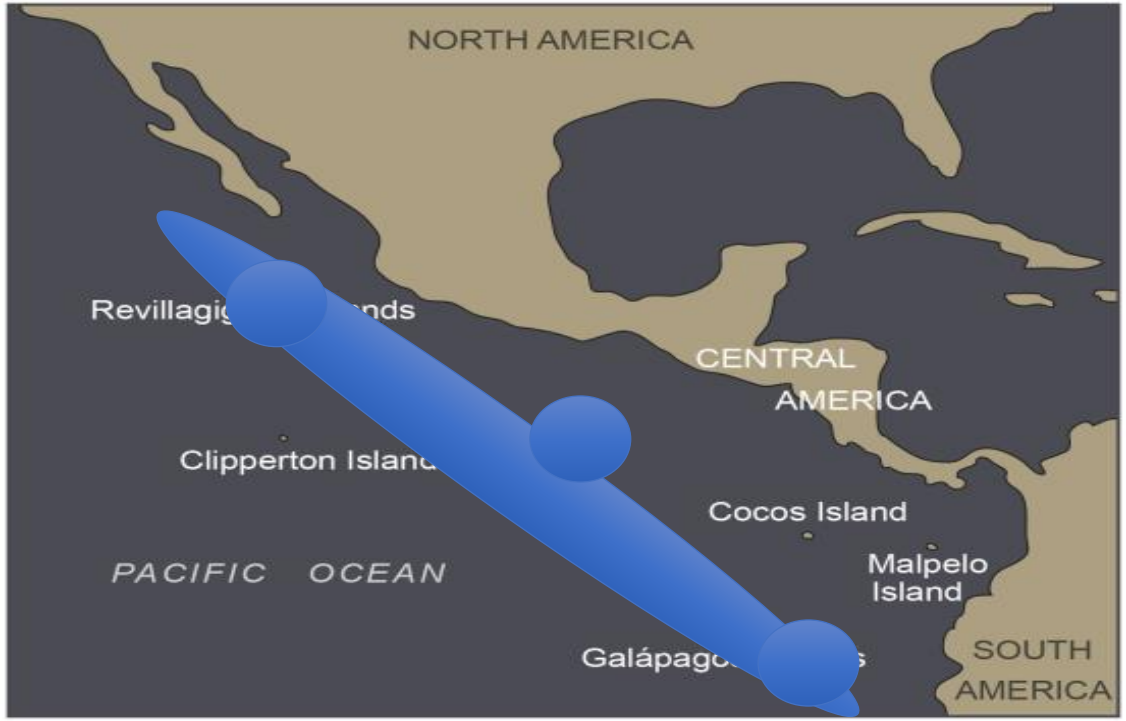
Bycatch estimates: release methods

Skipper's workshops
ISSF – IATTC in the EPO



Knowledge gaps

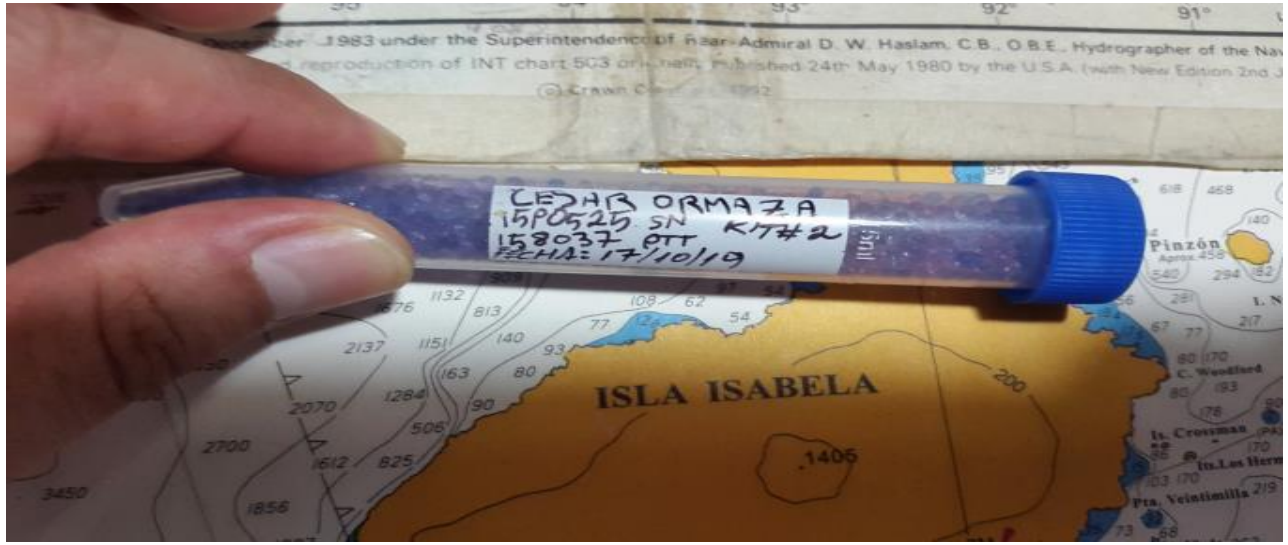
- Population structure
  - Panmictic?
  - Independent stocks?



Knowledge gaps

- Population structure
  - Panmictic?
  - Independent stocks?
  - Genetic analyses of tail samples

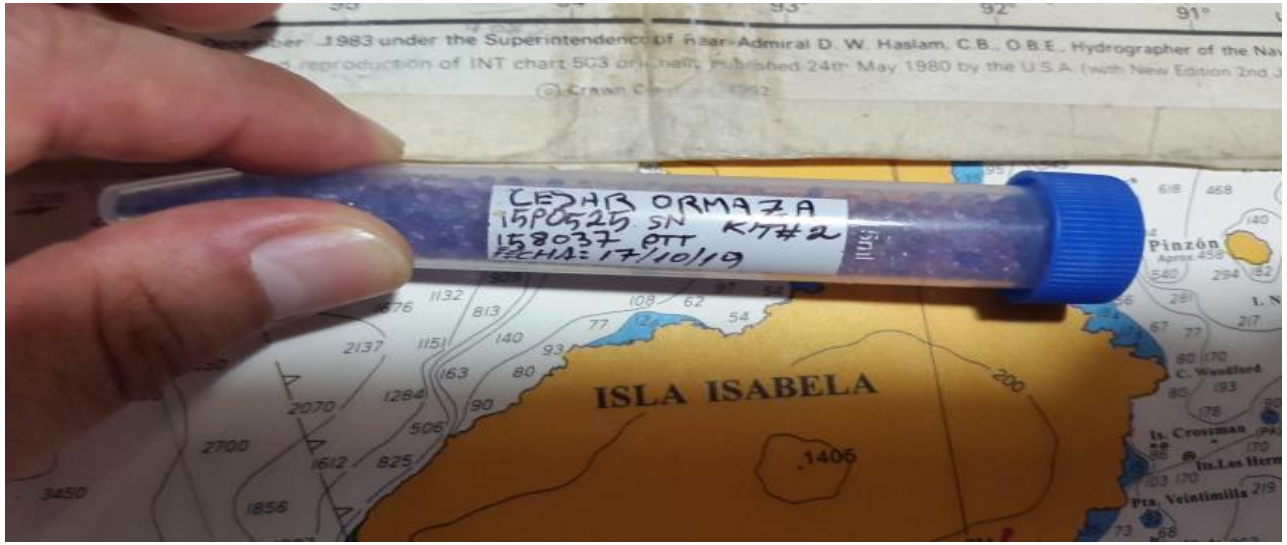
    UC Santa Cruz



Knowledge gaps

- Population structure
  - Panmictic?
  - Independent stocks?
  - Genetic analyses of tail samples

    UC Santa Cruz

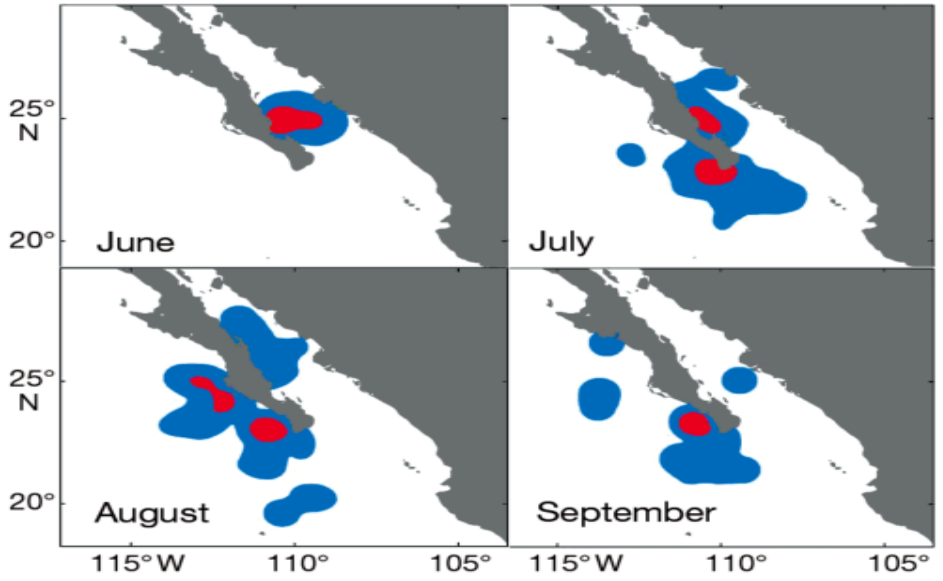


- Abundance & trends
  - Virtually no data for mobulas
  - Close-kin mark recapture
  - Effective population size
  - Determine impacts of fisheries (still largely unknown)

Knowledge gaps

- Population structure
  - Panmictic?
  - Independent stocks?
  - Genetic analyses of tail samples

    UC Santa Cruz
- Abundance & trends
  - Virtually no data for mobulas
  - Close-kin mark recapture
  - Effective population size
  - Determine impacts of fisheries (still largely unknown)
- Movements & diving behavior & **species distribution**
  - Very limited information for most mobulids
  - Mainly for aggregation sites



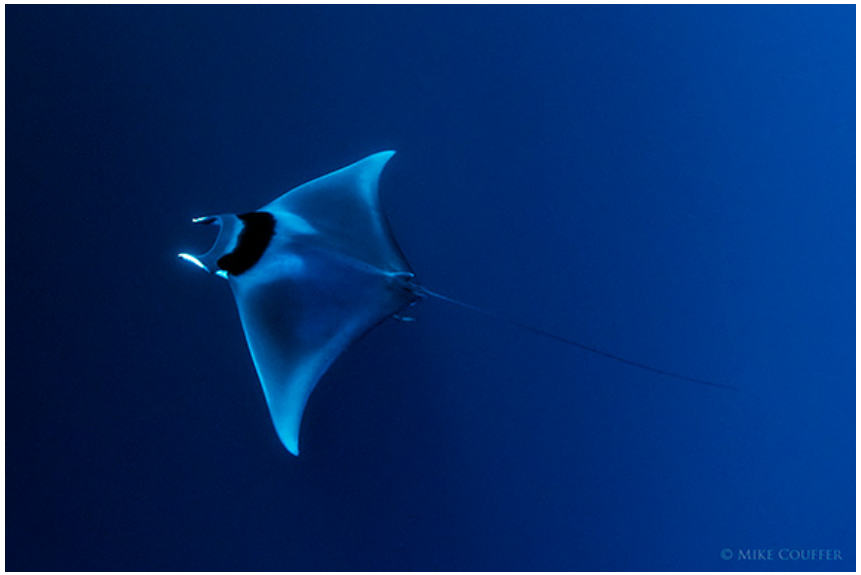
Tag movement distributions
Croll. et al., 2012

Knowledge gaps: Species Distribution Models

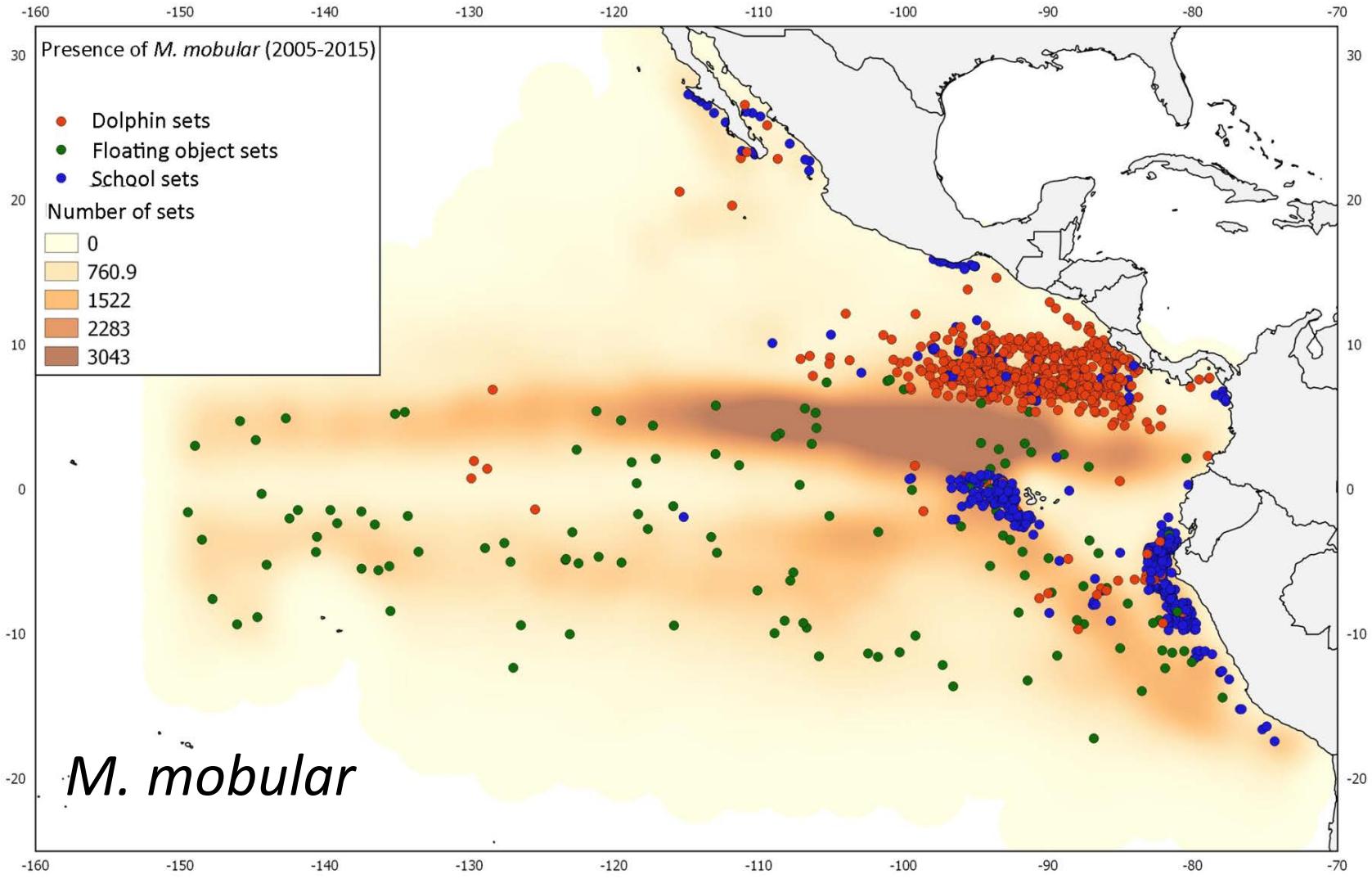
- Species Distribution Models (SDMs)
  - Generalized Additive Models (GAMs)- **Eastern Pacific Ocean**
  - Integrated-Nested Laplace Approximation (INLA)- **Eastern Pacific Ocean**
  - Maximum Entropy (MaxEnt)- **Gulf of California**
- Climate change
  - Predictions under the RCP85 scenario (2100) of climate change (MaxEnt)- **Gulf of California**

Knowledge gaps: Species Distribution Models

- **Species name:** *Mobula mobular** (Spinetail Devil Ray)
- **Taxonomic revision:** changed from *M. japanica* (White et al. 2017)
- **Distribution:** Circumglobal
- **Habitat:** Coastal, pelagic, oceanic
- **Maximum Disc Width (DW):** 310 cm
- **Number of pups:** one
- **Aggregations:** Gulf of California (summer)
- **Diet:** Euphausiids (*Nyctiphanes simplex*)

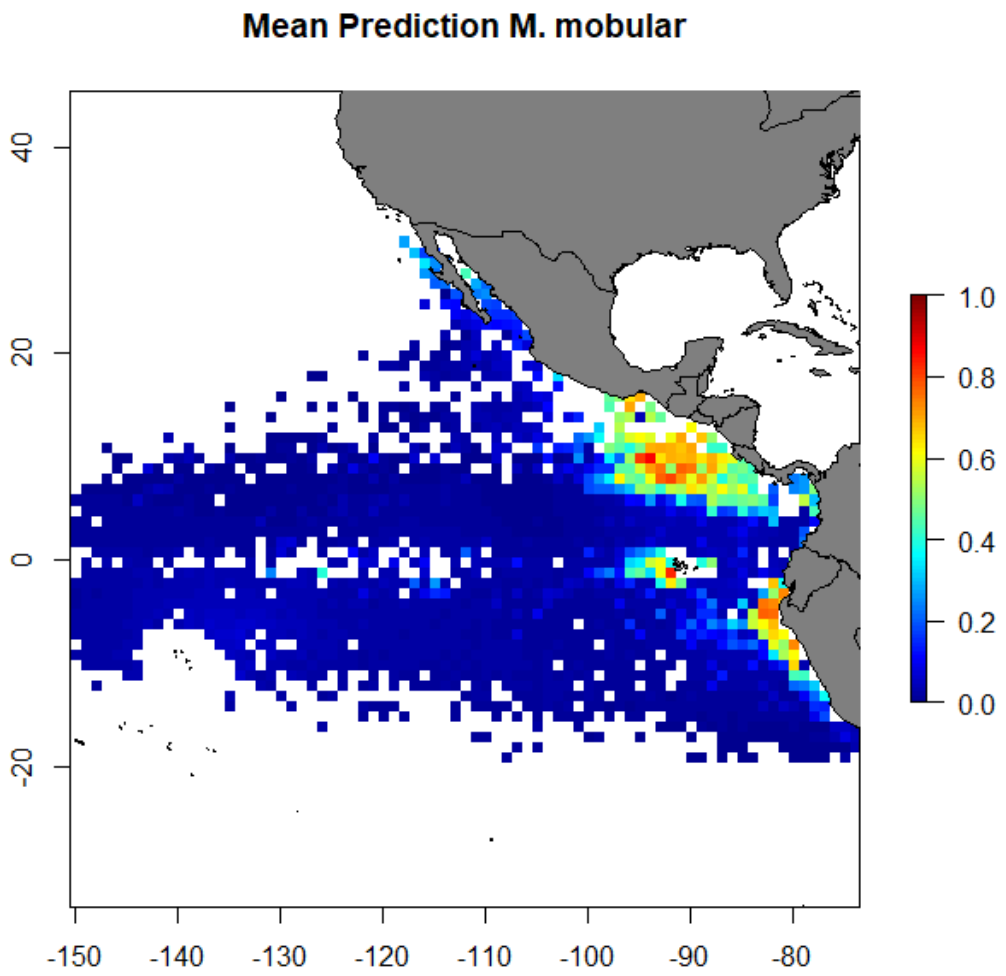


Knowledge gaps: Species Distribution Models

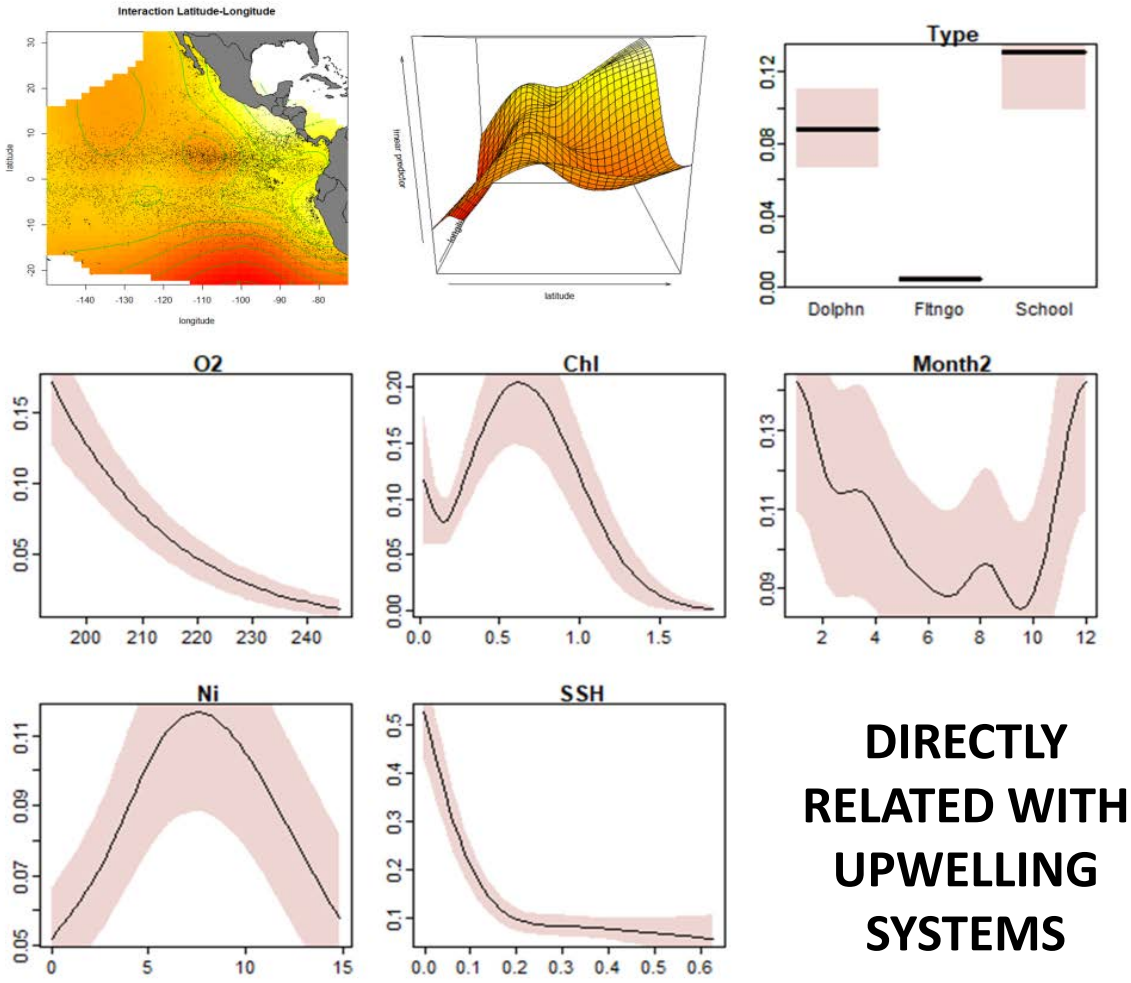


Lezama-Ochoa et al. 2018 (*in preparation*)

Knowledge gaps: Species Distribution Models: GAMs



Lezama-Ochoa et al. 2018 (*in preparation*)



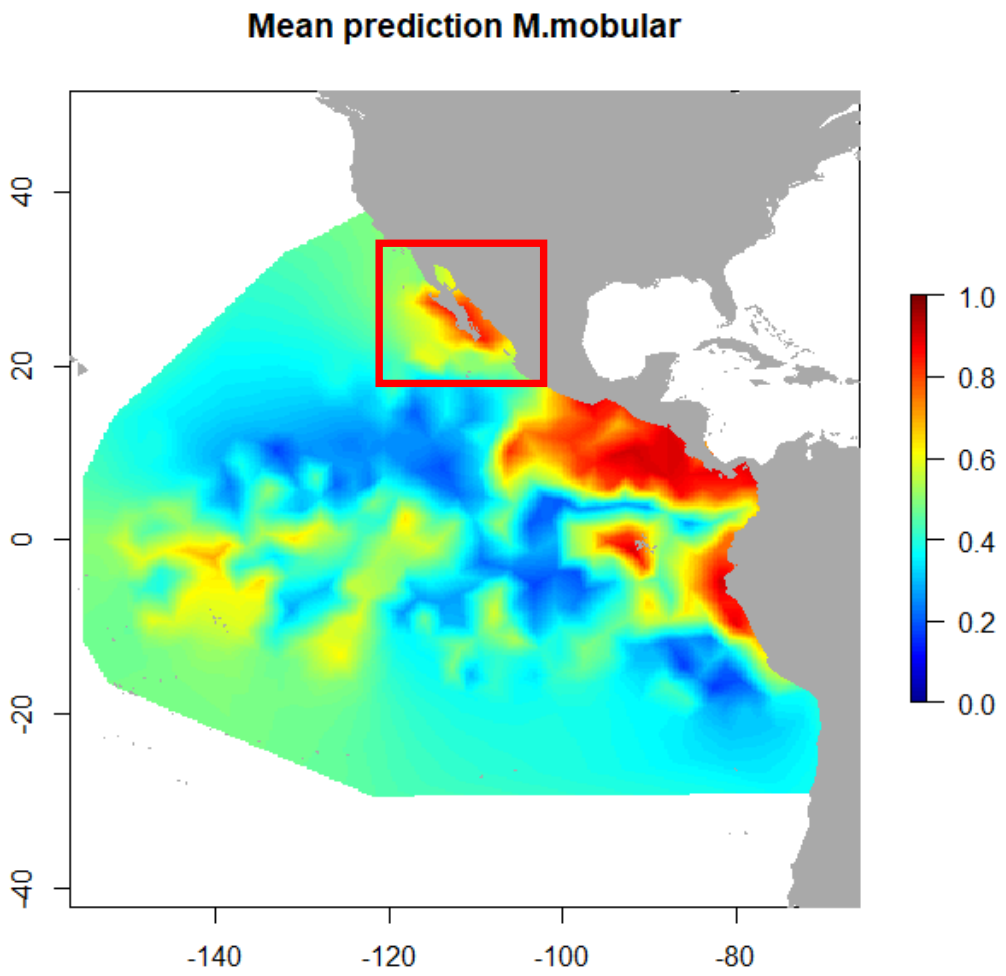
DIRECTLY RELATED WITH UPWELLING SYSTEMS

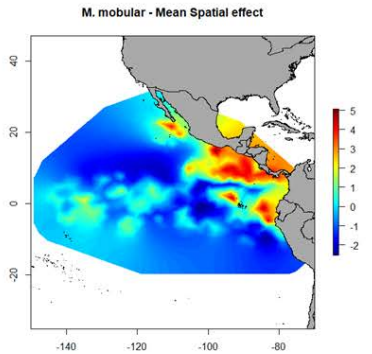
Type: 37.3%

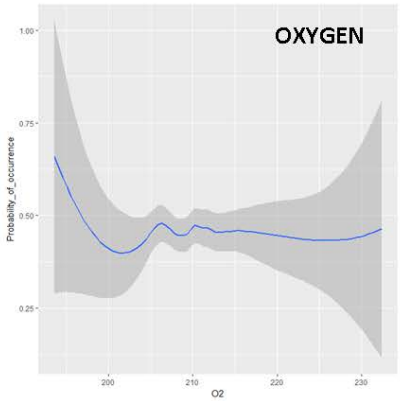
Chl: 13%

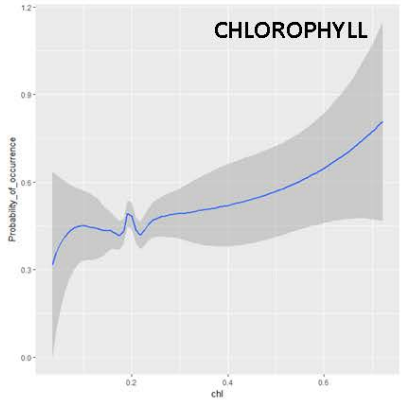
SSH: 13.5%

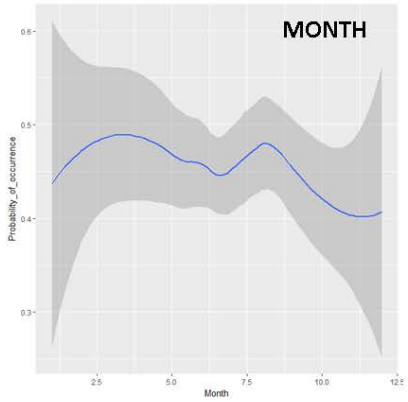
Knowledge gaps: Species Distribution Models: INLA

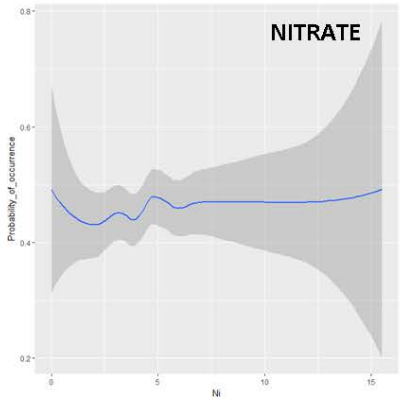


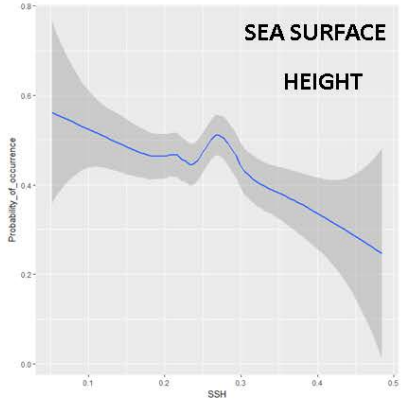






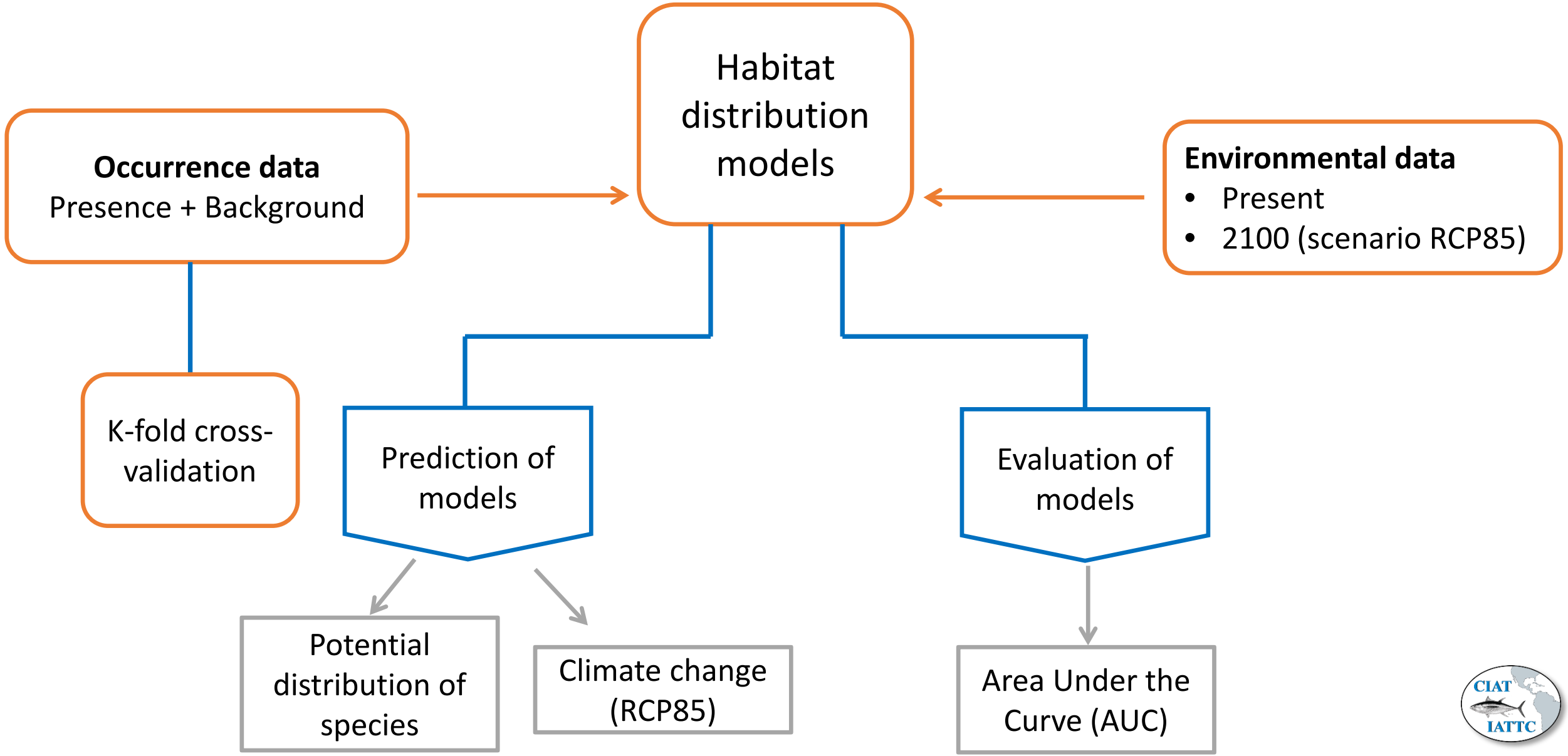




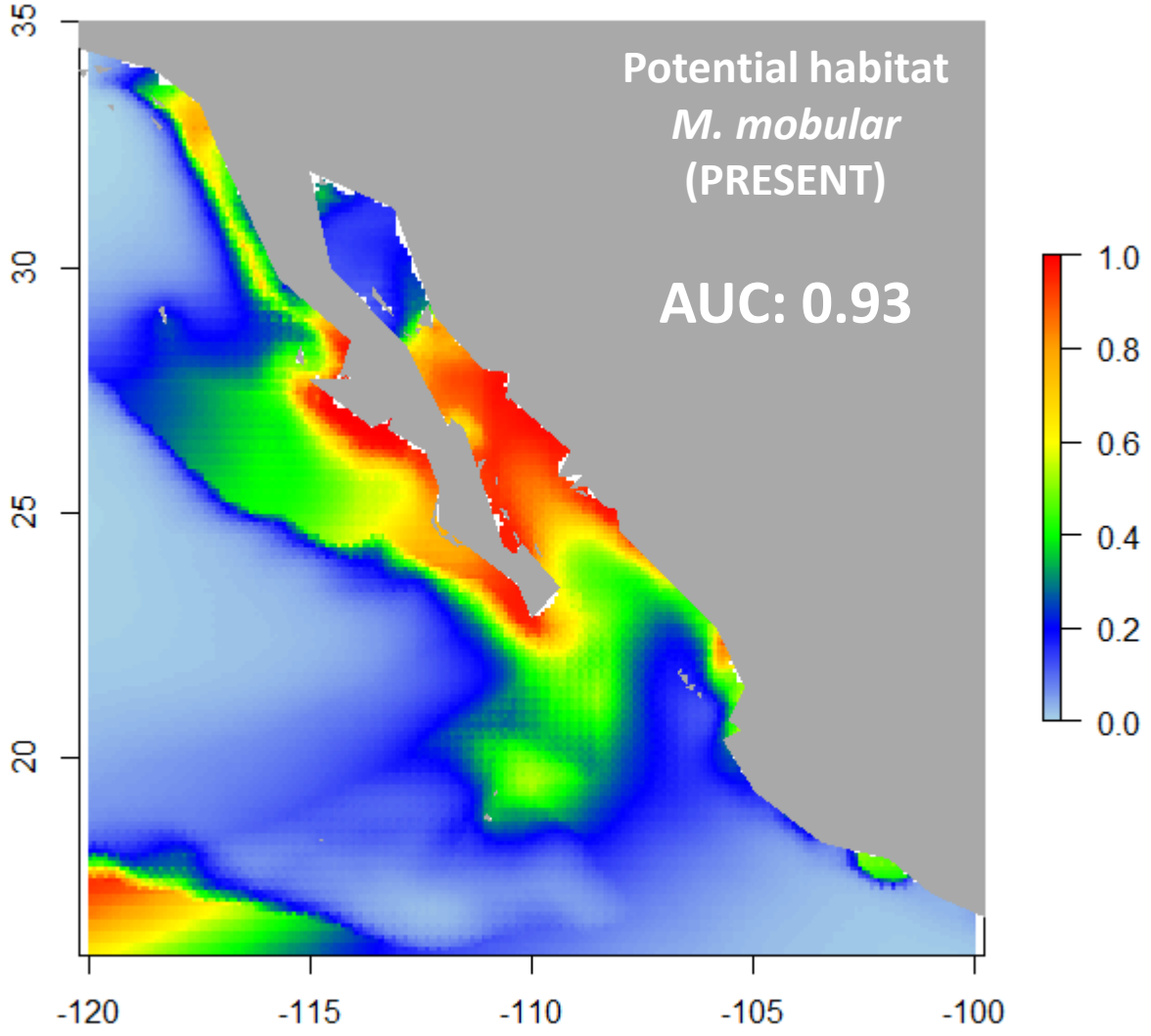


Lezama-Ochoa et al. 2018b (*in preparation*)

Knowledge gaps: Species Distribution Models: MaxEnt



Knowledge gaps: Species Distribution Models: MaxEnt



Lezama-Ochoa et al. 2018c (*in preparation*)

CONTRIBUTION

Warm waters
18-26ºC

42.6%

High salinity waters
≈ 35.4 PSU

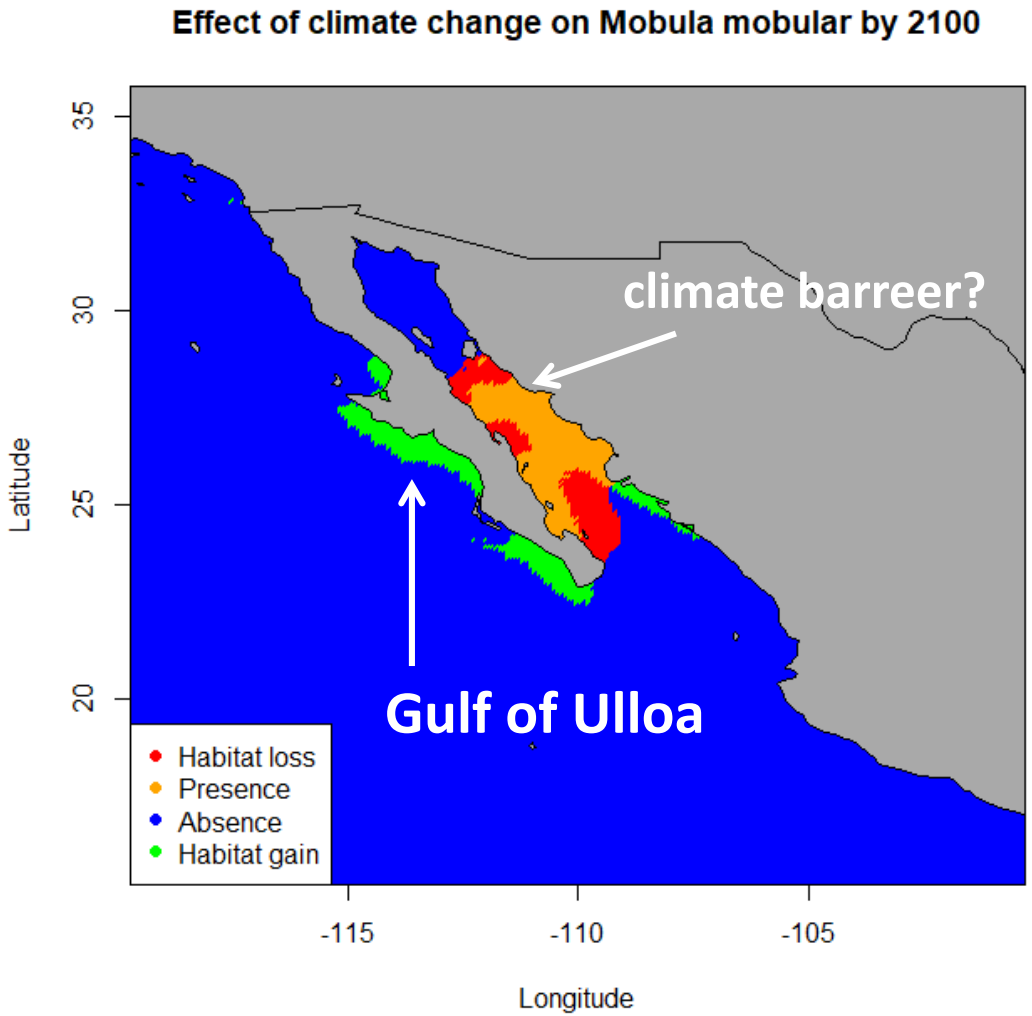
5.5%

Primary production

Productive waters
≈ 30 $mg^{-3} \cdot day^{-1}$

39.7%

Knowledge gaps: Species Distribution Models: MaxEnt



Habitat loss: >20%

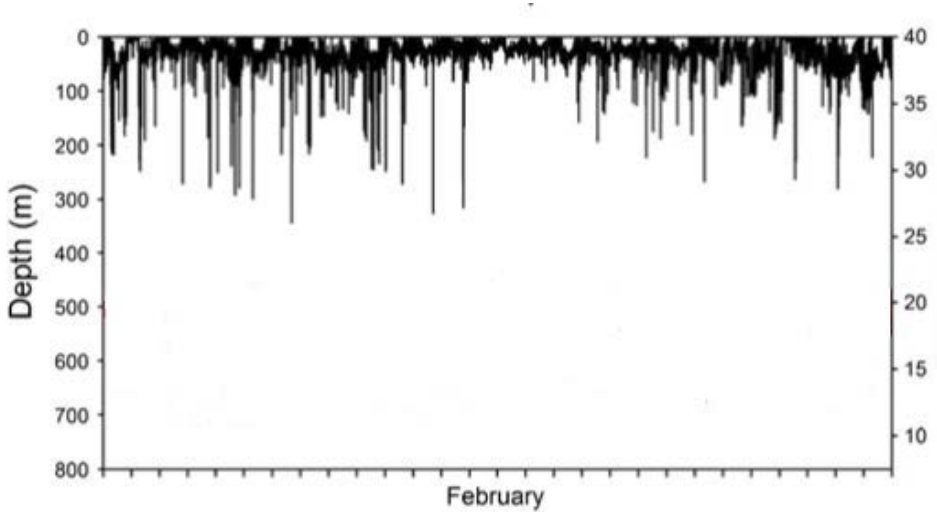
Habitat gain: 5%

Gulf of Ulloa: potential habitat also for turtles and marine mammals *(Etnoyer et al. 2016)*

The habitat of *Mobula mobular* could be affected by the effect of climate change

Knowledge gaps

- Post release mortality
  - IATTC currently considers every mobulid capture to be a mortality
  - Some evidence to suggest that, for at least some species, some proportion survive



Francis & Jones 2016:

–Tuna purse-seine fishery: skipjack
–*M. japanica* tagged from purse seines in New Zealand.
–3 out of 7 (43%) tagged rays survived

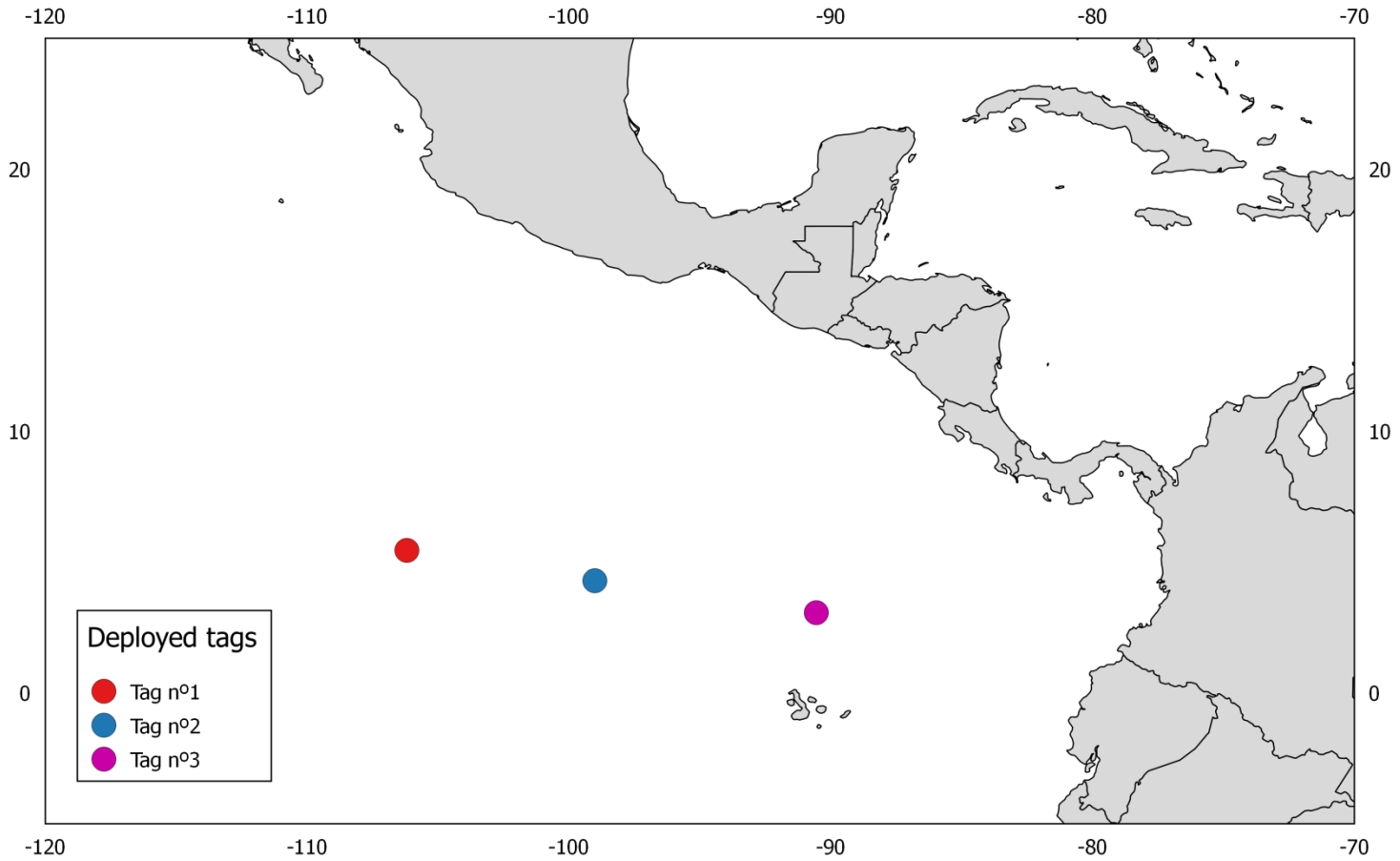
Knowledge gaps: Survival estimates, pilot project

Survival estimates: pilot project

Observers were trained to:

- Deploy survivorship tags SAFELY
- Collect relevant covariate data
- Collect a tail sample for genetic analyses
- Refresher course on mobulid species ID

Survival estimates: pilot project

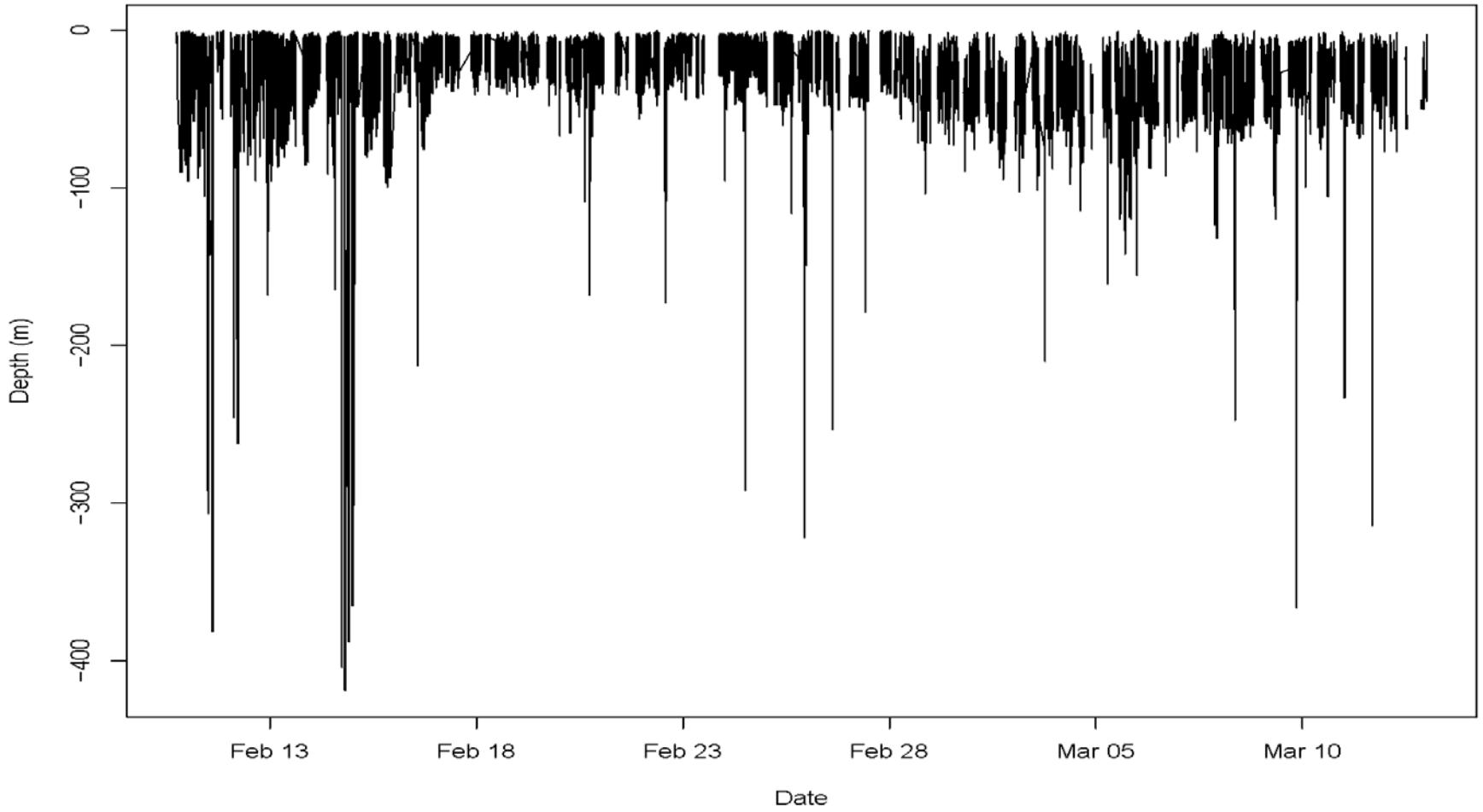


Deployed tags

Tag nº1 (FAD set): 5.44N/106.19W
Tag nº 2 (FAD set): 4.28N/99.01W
Tag nº 3 (FAD set): 3.06N/90.55W

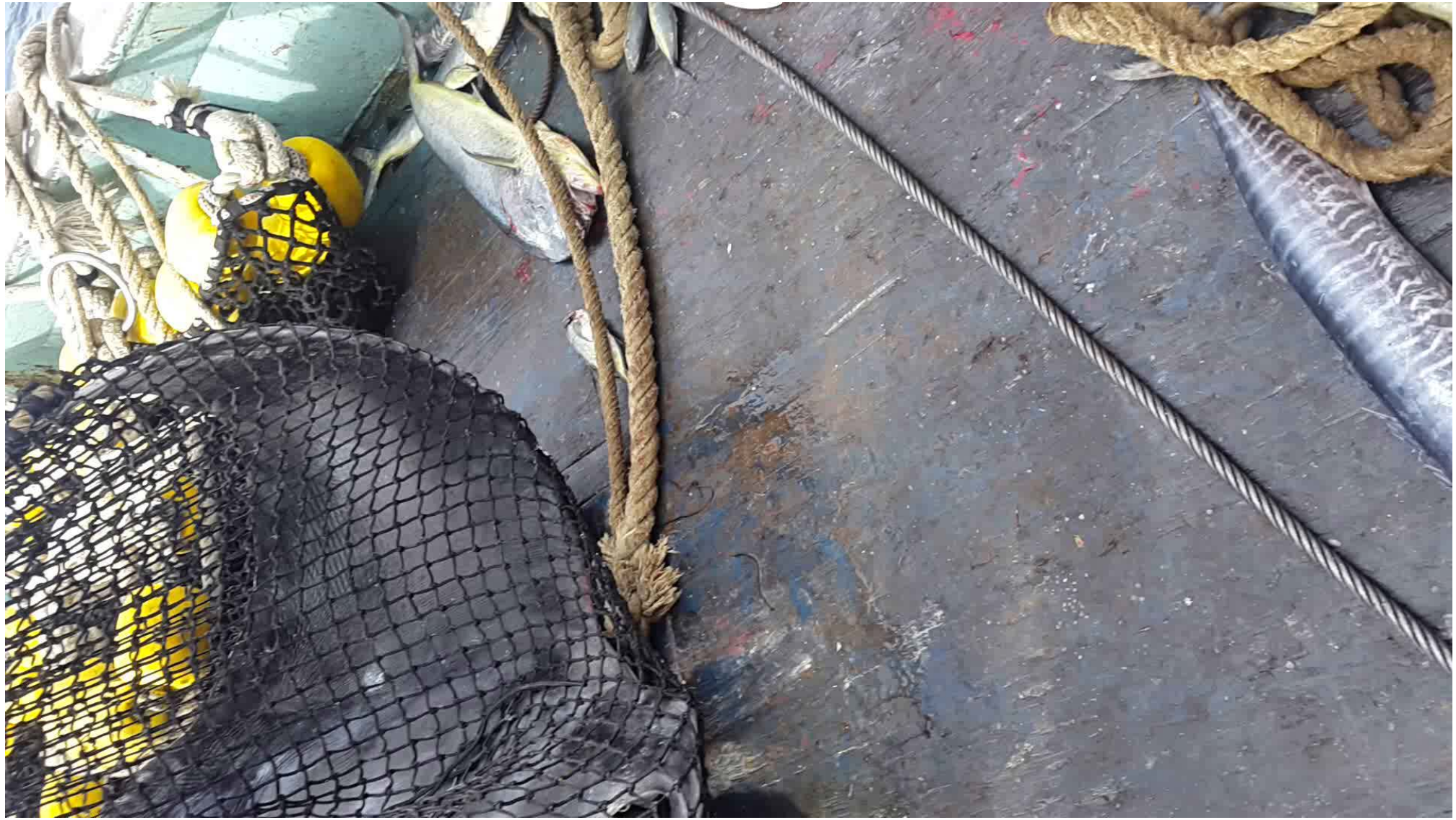
Survival estimates: pilot project

Survival estimates: pilot project

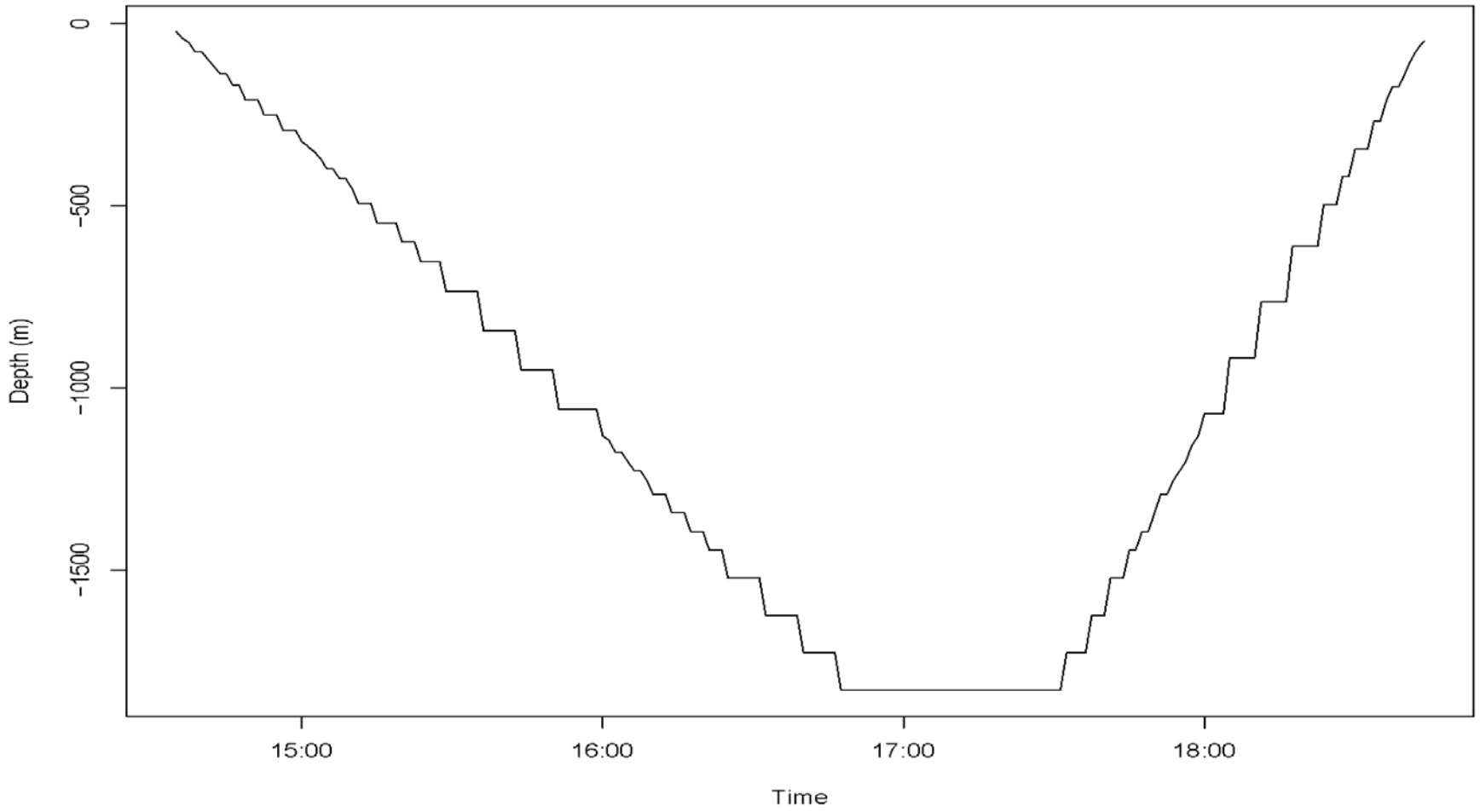


Survival estimates: pilot project

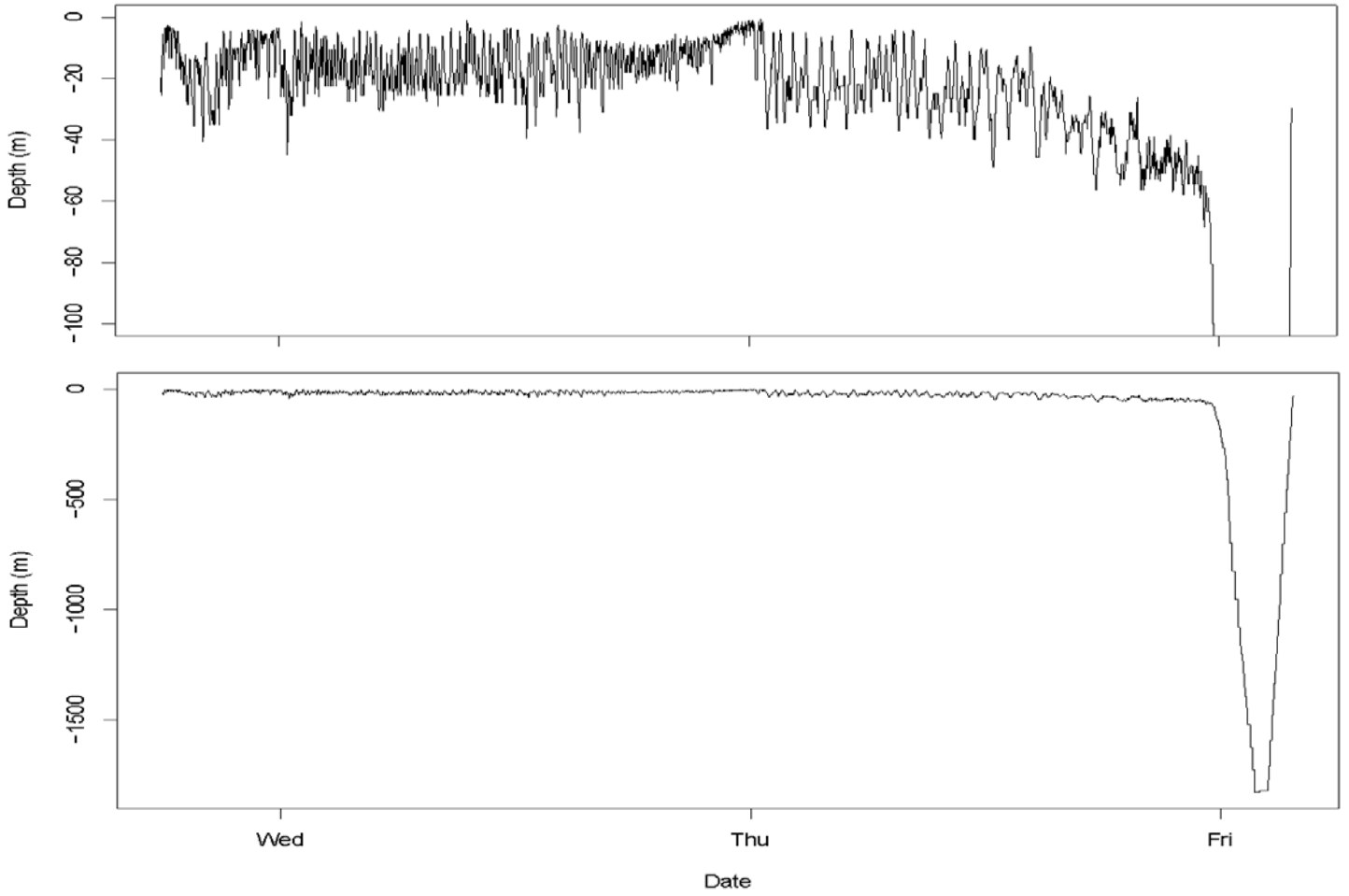
Survival estimates: pilot project



Survival estimates: pilot project



Survival estimates: pilot project



Survival estimates: pilot project

- 3 out of 5 mobulids in pilot study survived (mix of species)
  - Good for the fleets; reduces mortality estimate from 100%
  - Allows for a more robust estimate of impacts on stocks
- Full-scale implementation will support handling guidelines
  - Which release method contributes most to post-release survival?
  - What handling covariates have the greatest impact on mortality?
    - e.g. time spent in net, time spent on deck, number of brailer
  - Use results to develop a best-practices handling and release guide

Survival estimates: pilot project

What handling covariates could have the greatest impact on mortality?

- SPECIES
- SIZE
- SEX
- TIME IN NET
- TIME ON DECK
- BRAILER SEQUENCE
- BRAILER SIZE
- POSITION ON BRAILER
- SEA SURFACE TEMPERATURE
- WEATHER CONDITIONS
- BODY CONDITION BEFORE RELEASE
- RELEASE METHOD
- TUNA CATCH QUANTITY
- TYPE OF SET

Rev Fish Biol Fisheries
https://doi.org/10.1007/s11160-018-9517-2

CrossMark

RESEARCH PAPER

Post-release fishing mortality of blue (*Prionace glauca*) and silky shark (*Carcharhinus falciformes*) from a Palauan-based commercial longline fishery

Michael K. Musyl · Eric L. Gilman

Survival estimates: pilot project

- Contribute to ecological studies that benefit management
  - Observer-collected tail samples allow for stock structure and population size analyses
  - Movement data from tagged survivors will help identify mobulid hotspots
  - Diving behavior from tagged survivors will provide information on bycatch risk

Conclusions

- *Observer can provide a cost-efficient way to study survival of species with infrequent captures*
- *With good handling and release techniques, we can reduce bycatch mortality*
- *Release can be performed without major operational interference*

- *Full support from:*
  - *Government*
  - *Industry organizations TUNACONS, OPAGAC, ATUNEC*
  - *Industry + NGOs: ISSF*
  - *<u>Skippers and crews</u>*

  - *<u>Multi-disciplinary team</u>*

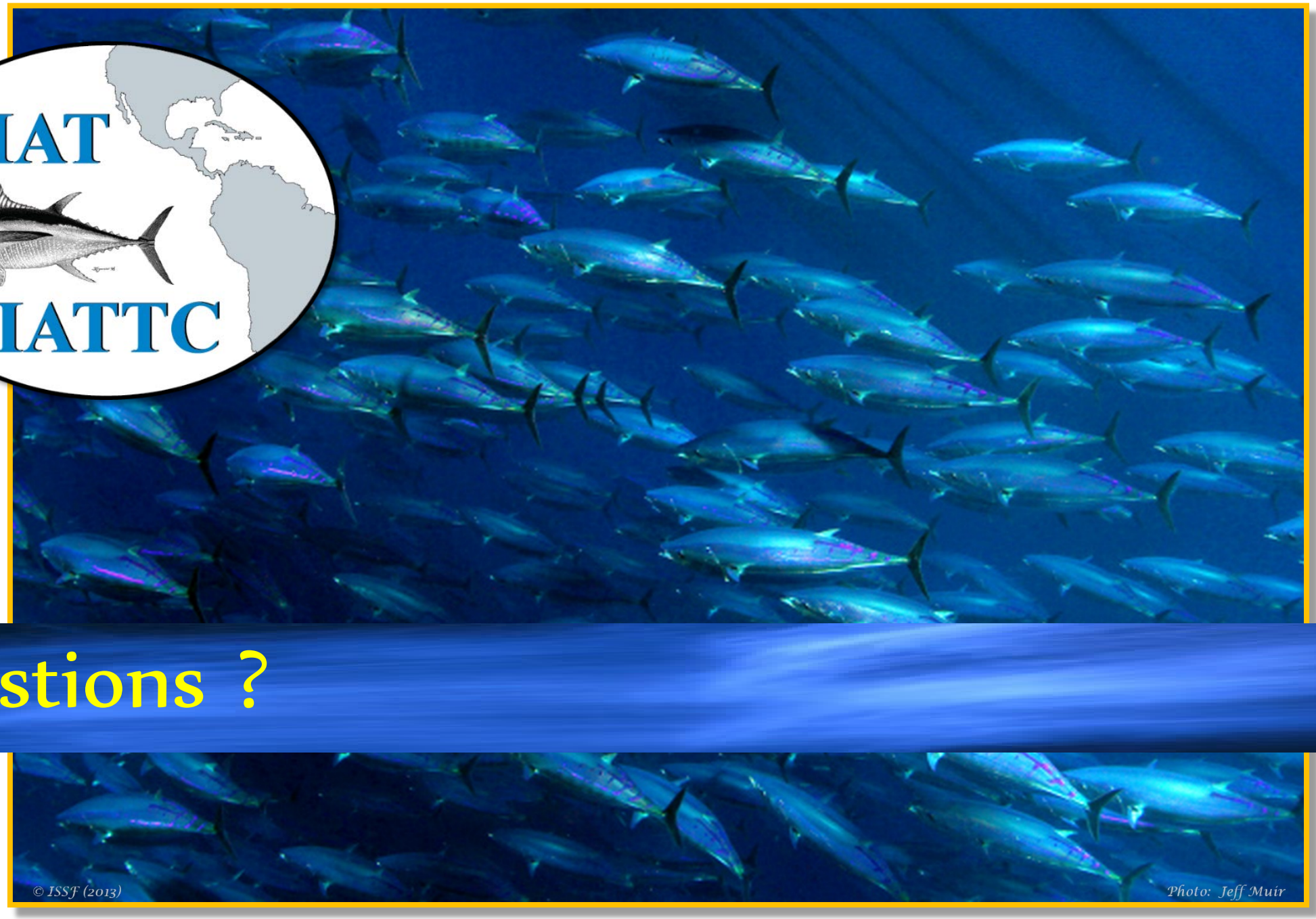
Future directions

- Deploy 150 survivorship tags
  - Evaluate post release mortality of different species
  - Develop best practices handling and release guidelines based on results
  - Use archival tag data from surviving mobulids to study horizontal and vertical movements, habitat use, and mobulid hotspots

- Genetic analyses from tail samples
  - Improve species identification, sex determination and verify observer ID
  - Population abundance estimation with close kin mark recapture
  - Evaluate population structure throughout the eastern Pacific

Partners/Collaborations

- AZTI
  - Nerea Lezama-Ochoa (habitat models & climate change)
- Scripps Institution of Oceanography & Manta Trust
  - Joshua Stewart (mobulid ecology and telemetry)
- UC Santa Cruz
  - Donald Croll (mobulid ecology & telemetry)
  - Kelly Newton (mobulid ecology & telemetry)
  - Giacomo Bernardi (genetics)
- Monterey Bay Aquarium (funder of pilot study)
  - Salvador Jorgensen (elasmobranchs & telemetry)
  - John O'Sullivan (mobulid husbandry & survival)



Questions ?