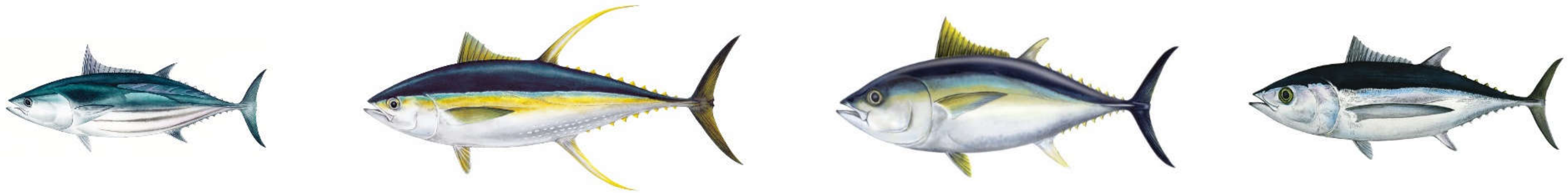
Stock structure of tuna species in the Pacific Ocean: Insight from 'traditional approaches'



Brad Moore

Identifying the Spatial Structure of Pacific Tuna Stocks workshop

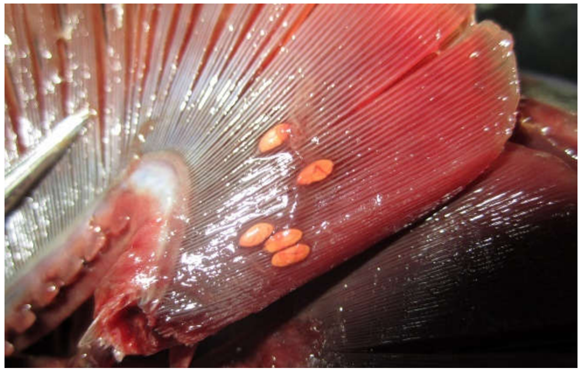
9-12th October 2018

UNIVERSITY of TASMANIA | IMAS INSTITUTE FOR MARINE & ANTARCTIC STUDIES

Today

- ‘Traditional approaches’ to identifying stock structure
  - Conventional tags
  - Electronic tags
  - Otolith chemistry
  - Parasites

- Insight from these approaches into stock structure of SKJ, YFT, BET and ALB in the Pacific Ocean

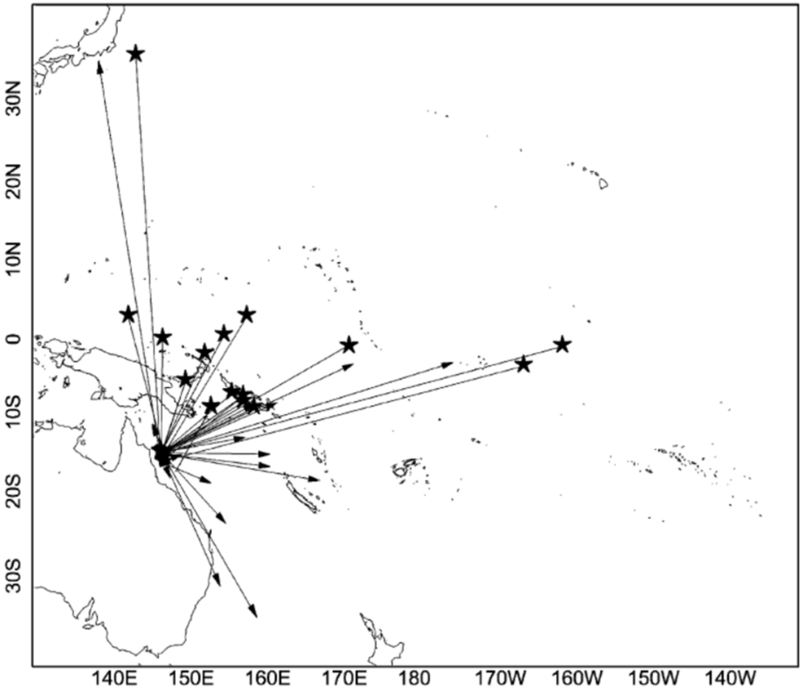


Conventional tags

Principle:

- Information on where tagged fish was release and recaptured provide insights into movement and dispersion of tagged fish

Images from B. Leroy



Hampton & Gunn 1998

Conventional tags

Principle:

- Information on where tagged fish was release and recaptured provide insights into movement and dispersion of tagged fish

Advantages:

- Provide information on more than movement/mixing (growth, natural mortality, fishing mortality, abundance)

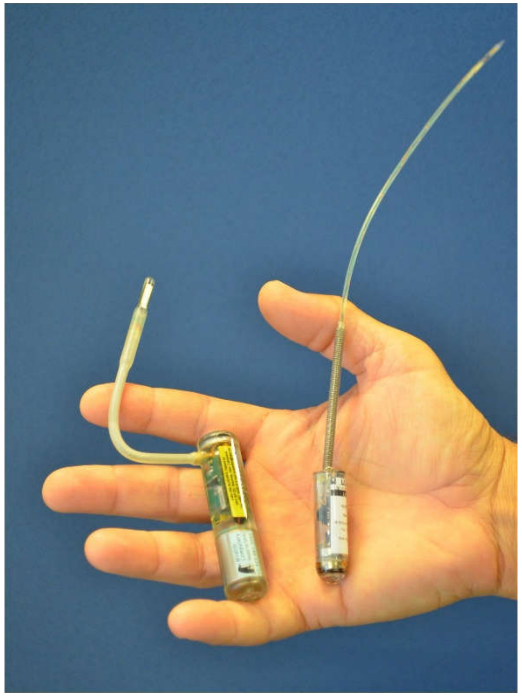
Limitations:

- Point-to-point movement, high cost and effort limitations,
- Limited by
  - the proportion of the population tagged individuals represent,
  - the time at liberty, the distribution of tagging and recapture effort,
  - tag reporting rates,
  - impractical for use on early life history stages such as larvae or small juveniles, most fish tagged in Pacific < 70 cm

Electronic tags

Principle:

- Provides (likely) movement path from which can infer mixing and stock structure



Images from B. Leroy

Electronic tags

Principle:

- Provides (likely) movement path from which can infer mixing and stock structure

Advantages:

- Provides track, can provide fine scale spatial and temporal movements incl. vertical movements, ideal for testing specific movement hypotheses

Limitations:

- High cost, effort limitations,
- Limited by
  - the proportion of the population tagged individuals represent,
  - the time at liberty/time of tag adherence,
  - the distribution of tagging and recapture effort (for archival tags),
  - tag reporting rates (archival tags),
  - impractical for use on early life history stages such as larvae or small juveniles

Otolith microchemistry

Principle:

– Elemental concentrations within otoliths determined by physical and chemical characteristics of environment (as well as diet, metabolism etc)
– Otoliths metabolically inert, providing data ‘log’
– When assessed in conjunction with temporal refences in otoliths (e.g. core or edge material, annual or daily growth rings) can provide information on ontogenetic movements, including natal origins

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- When assessed in conjunction with temporal refences in otoliths (e.g. core or edge material, annual or daily growth rings) can provide information on ontogenetic movements, including natal origins

Advantages:

- Fish only have to be caught once, all fish carry a signal, high precision

Limitations:

- Destructive sampling often required, can be expensive, may be unable to discriminate between discrete groups of fish living in similar environments, no info on gene flow

Parasite as biological tags

Principle:

- Parasites exhibit discontinuous distribution to their hosts
- If source of infection known, can work out subsequent movements
- If source of infection unknown:
  - Where parasites similar, fish either have common history or live in a similar environment
  - Where different, location history of fish different by residence time of parasite examined

Advantages:

- Fish only have to be caught once, little specialist equipment required, cost-effective

Limitations:

- Destructive sampling often required, often young fish have few parasites, may be unable to discriminate between discrete groups of fish living in similar environments, no info on gene flow

Skipjack tuna - Tagging

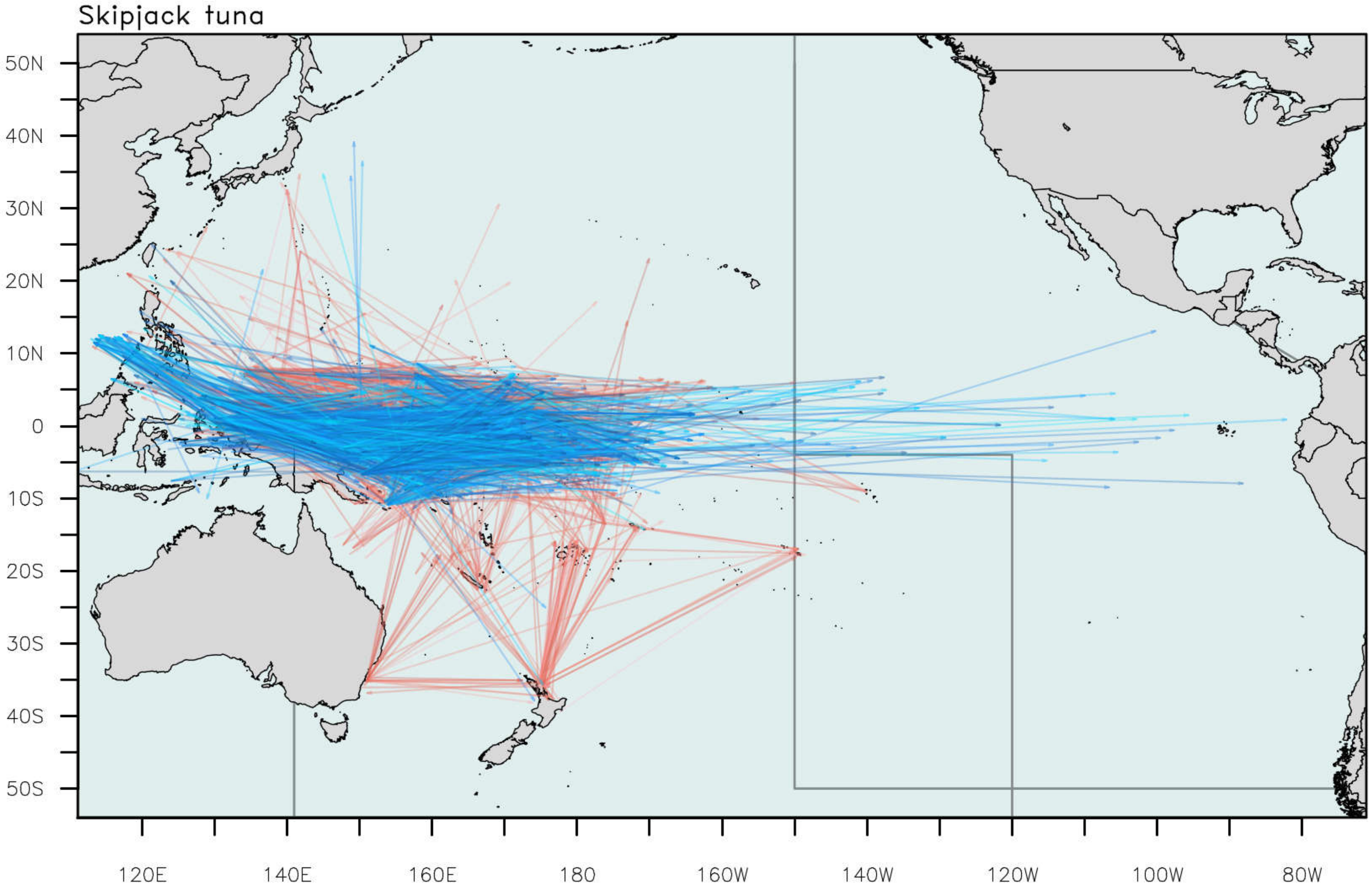
Large numbers of skipjack tagged in WCPO

- Skipjack Survey and Assessment Programme (SSAP) = 147,507 releases, 7,126 recoveries (4.8%)[1]
- Regional Tuna Tagging Programme (RTTP) = 98,401 releases, 12,447 recoveries (12.6%)[1]
- Pacific Tuna Tagging Programme (PTTP) = ~272,000 releases, ~47,000 recoveries[2]
- National initiatives

And in the EPO

- 131,227 tagged in EPO to 2015, 13,294 recoveries[3]
- ~1,400 recoveries considered to be valid for movement analyses by Fonteneau & Hallier (2015)

[1]Leroy et al. (2015)
[2]SPC-OFP (2018)
[3]Fonteneau & Hallier (2015)



Movement > 1,000 nm from release point, based on SPC holdings

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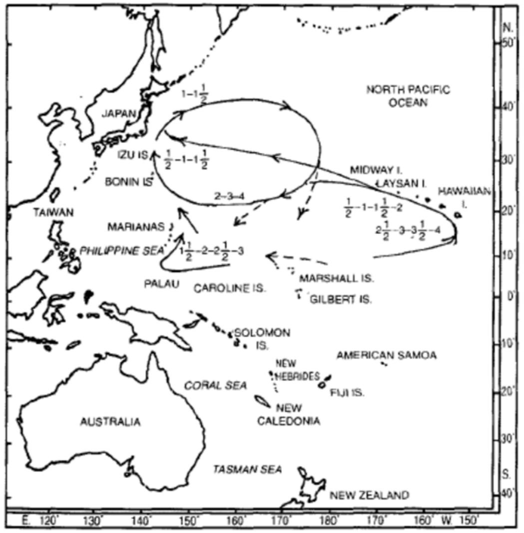
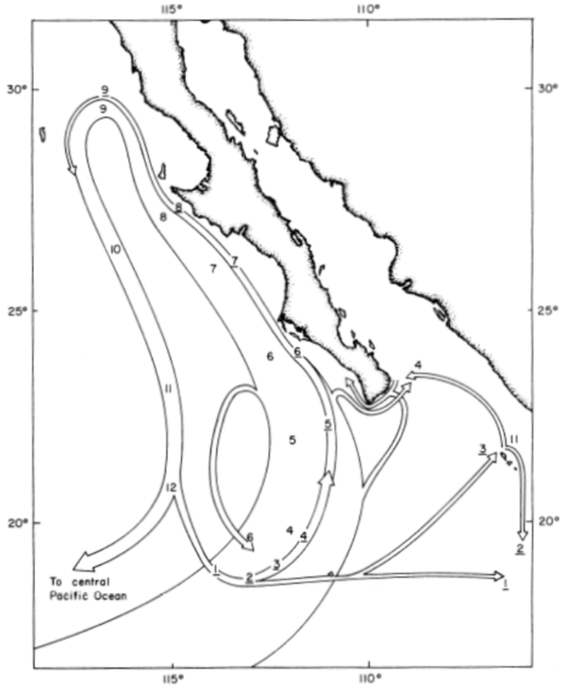
Cyclical movements of skipjack tuna

WCPO

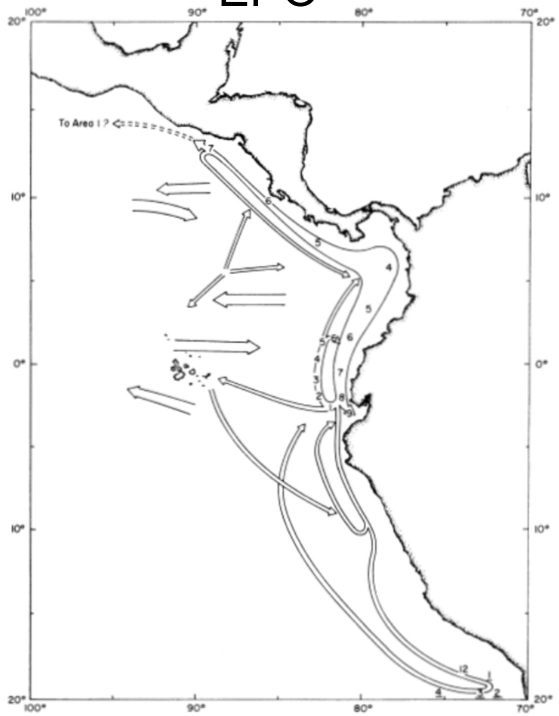


Fujino 1996

EPO



EPO



Fink and Bayliff 1970

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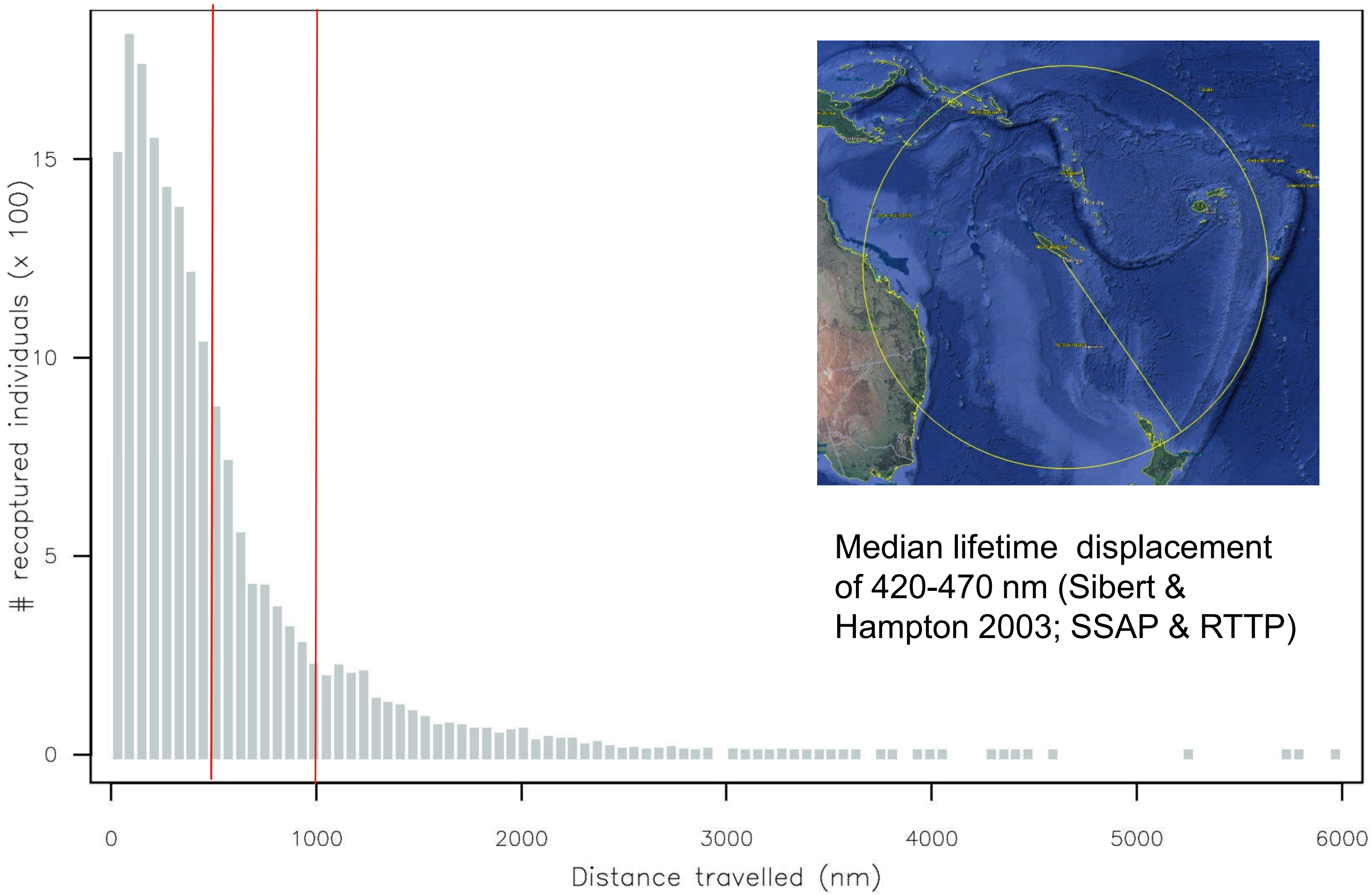


(Based on fish at liberty ≥ 3 months)

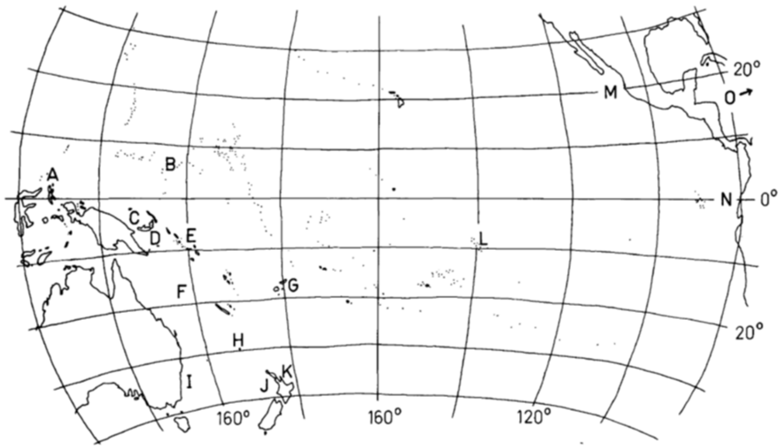
Skipjack tuna - Parasites

Lester et al. (1985)

– Examined parasites of SKJ sampled across the Pacific

– No evidence of discrete stocks

– Data suggested schools maintain their integrity for weeks but not for life



Skipjack tuna – Otolith microchemistry

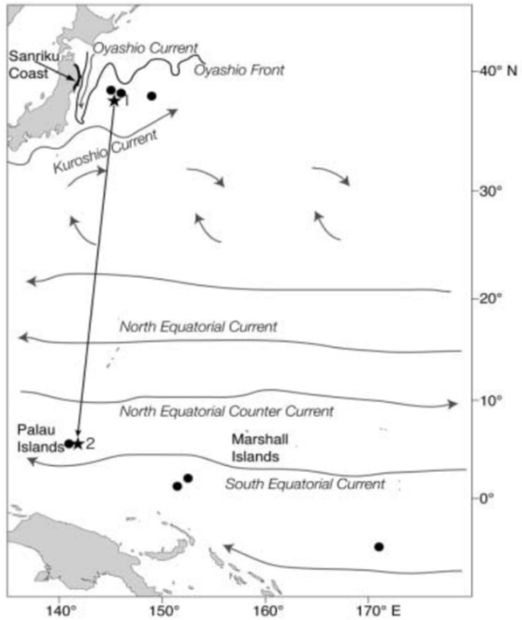
Arai et al. (2005)

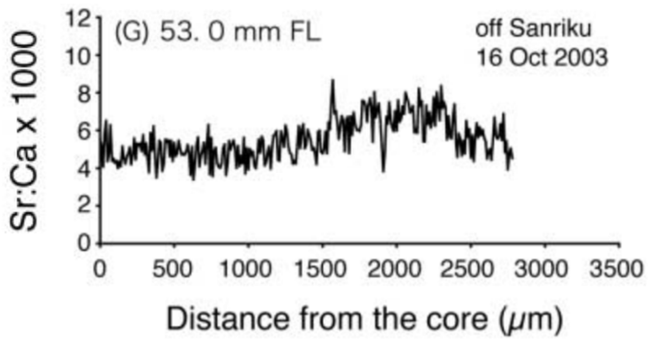
– Examined Sr:Ca profiles in SKJ otoliths collected from western tropical Pacific (Marshall Is and Palau) and Japan

– Most (14 of 15) SKJ sampled from Marshall Is deemed to be tropical residents

– One individual deemed to have moved to temperate waters after hatching in tropics, then moved back to tropics

– Most SKJ from Japan deemed to have originated in tropics, indicating northward migration





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Yellowfin tuna - Tagging

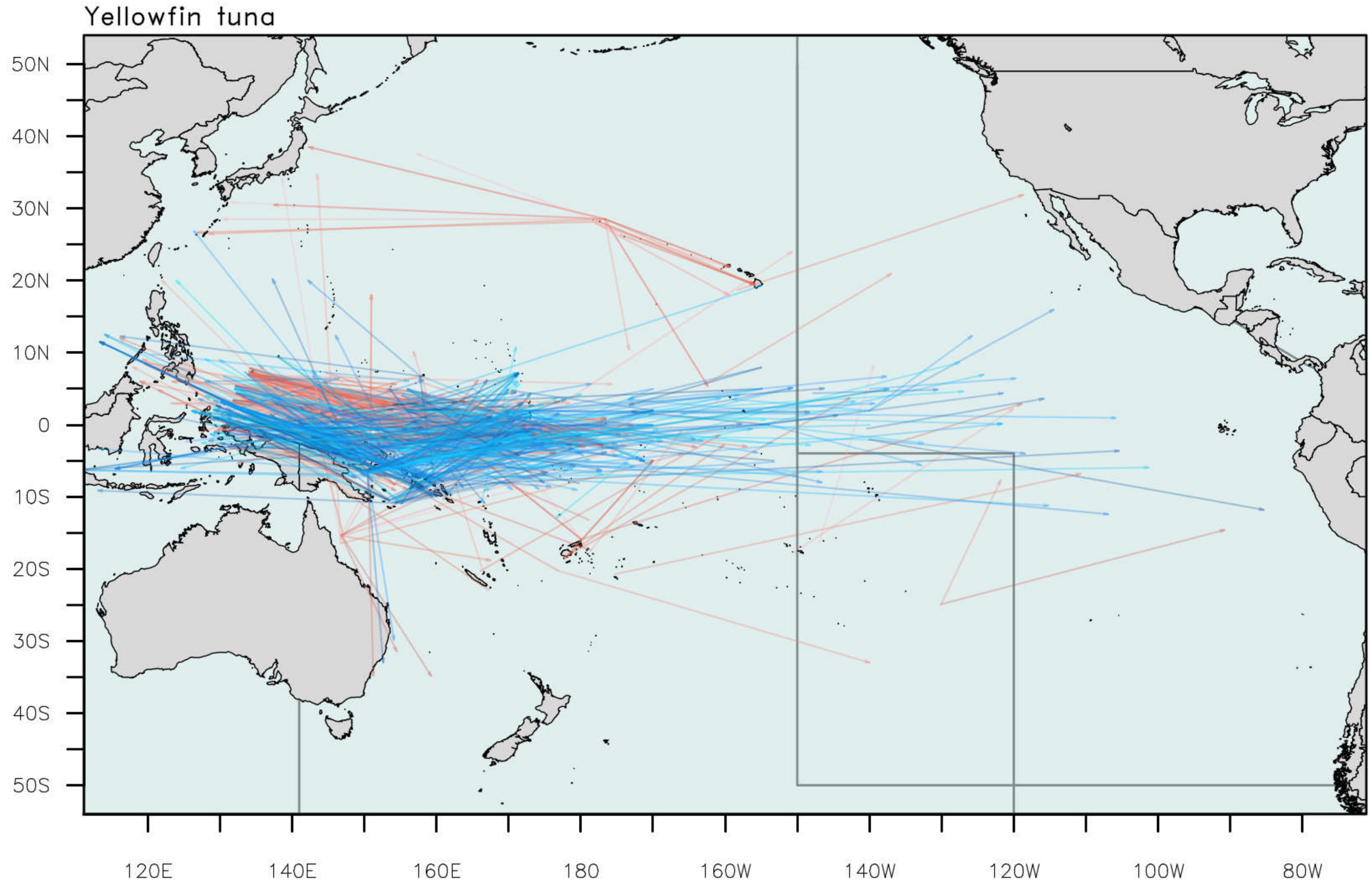
Large numbers of yellowfin tuna tagged in WCPO

- SSAP (1977-1981) = ~9,880 releases, ~280 recoveries (2.8%)[1]
- RTTP (1991-1996) = ~40,075 releases, ~4,950 recoveries (12.4%)[1]
- PTTP (2006-present) = ~110,000 releases, 18,770 recoveries (16.6%)[2]
- National initiatives

And in the EPO

- 109,487 YFT tagged to 2015, 15,429 recoveries (Fonteneau & Hallier 2015)[3]
- ~4,599 recoveries considered to be valid for movement analyses by Fonteneau

[1]Leroy et al. (2015)
[2]SPC-OFP (2018)
[3]Fonteneau & Hallier (2015)



Movement > 1,000 nm from release point, based on SPC holdings

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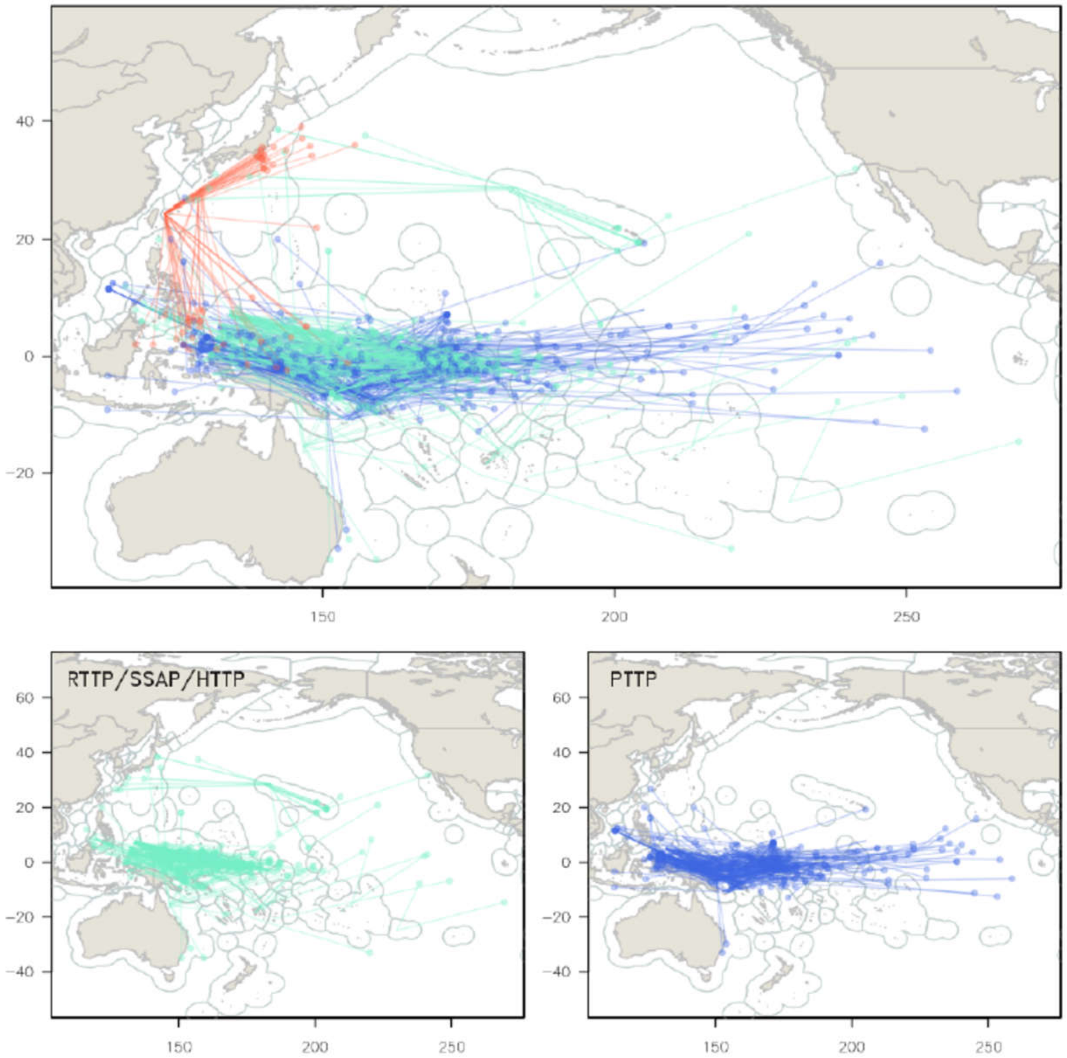
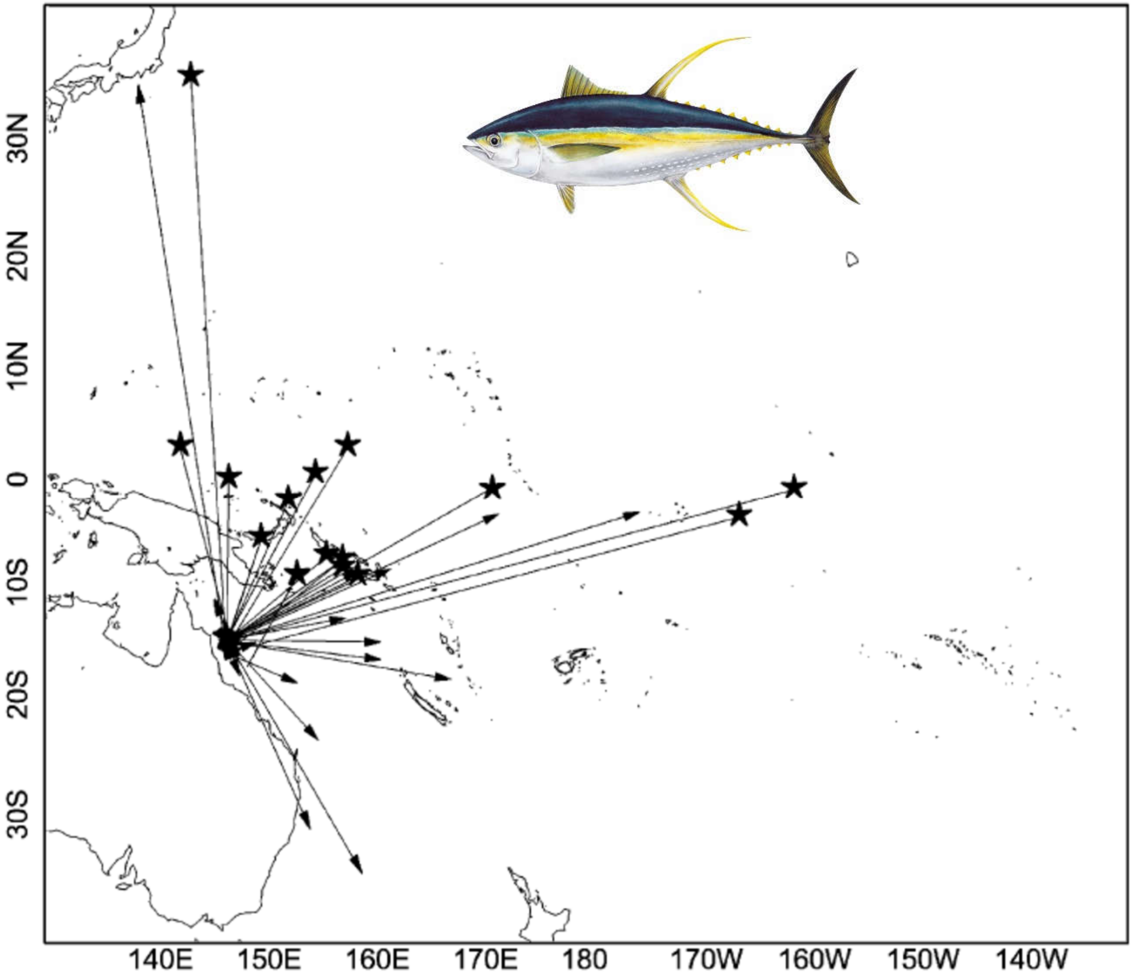
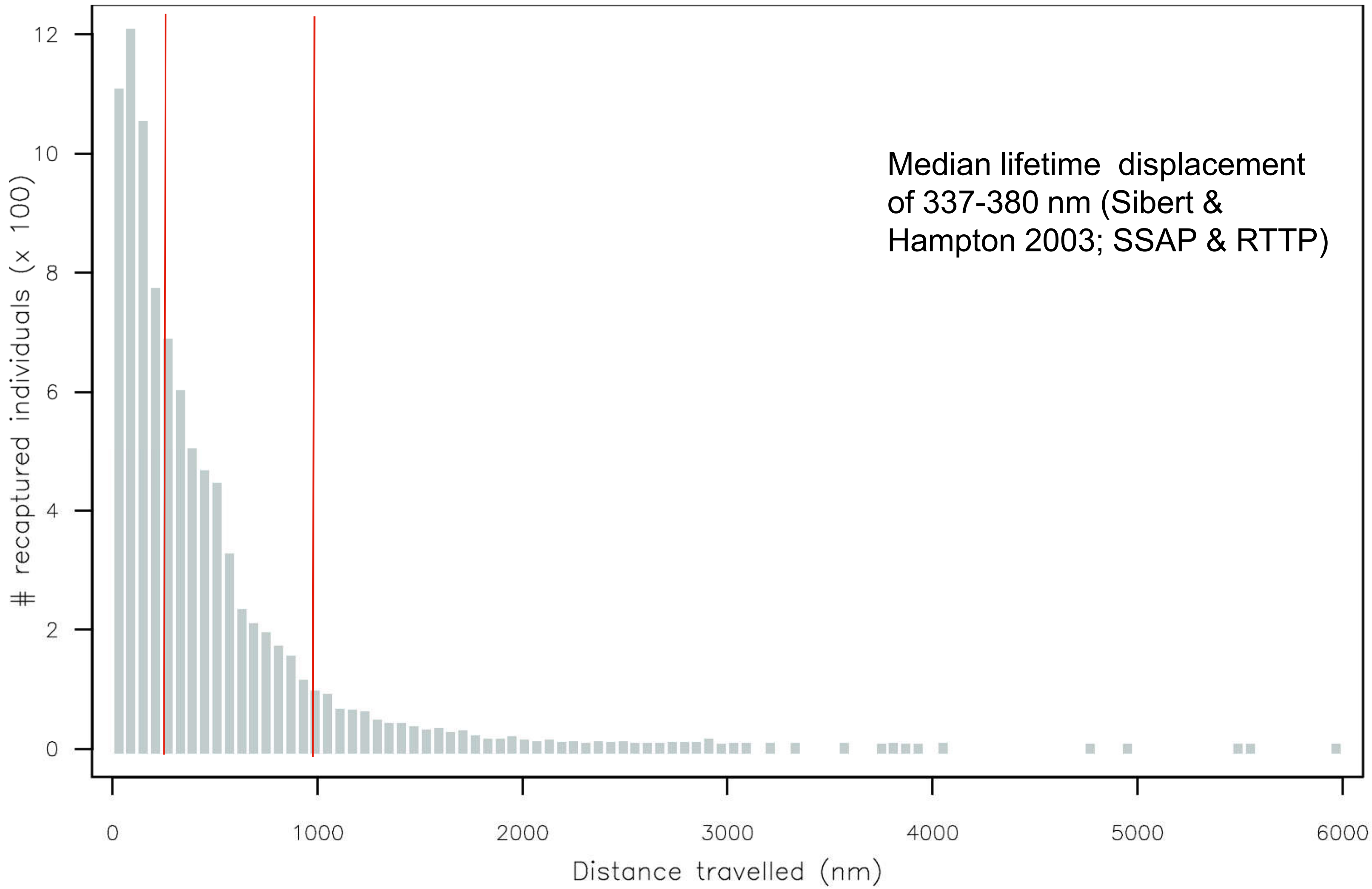
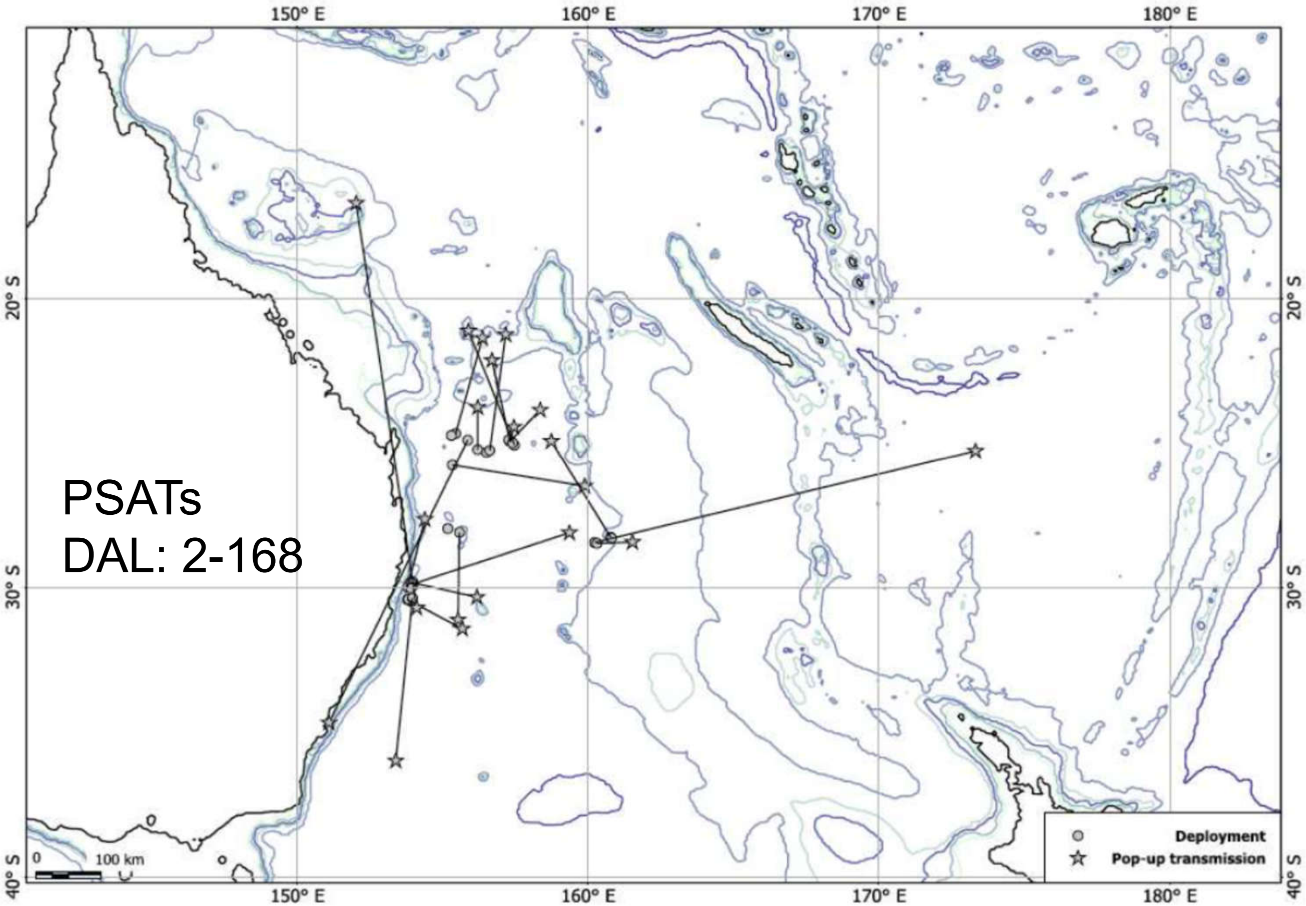

40
20
0
−20
150
200
250
RTTP/SSAP/HTTP
60
40
20
0
−20
−40
150
200
250
PTTP
60
40
20
0
−20
−40
150
200
250



Hampton & Gunn 1998

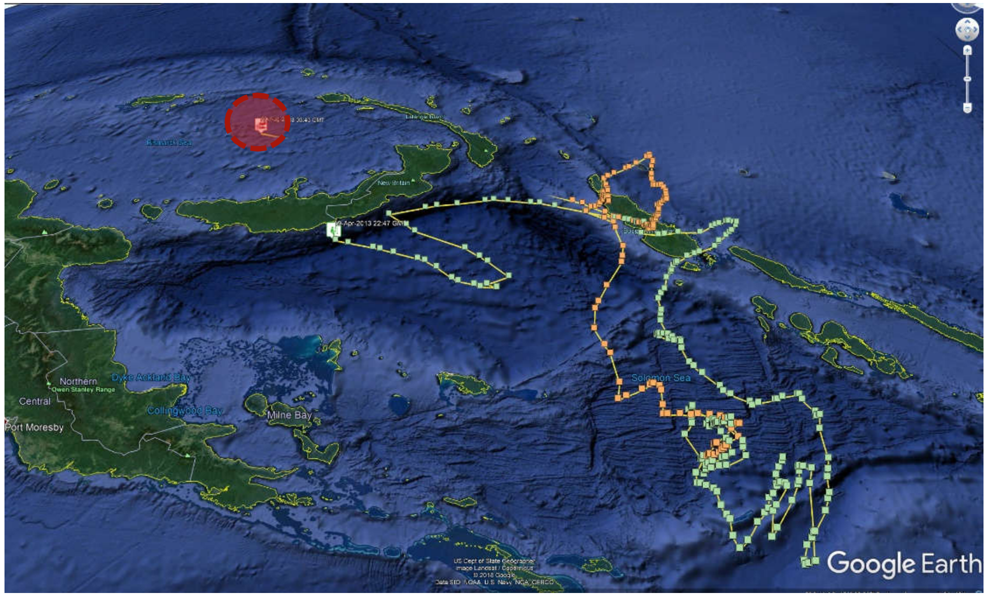


(Based on fish at liberty ≥ 3 months)

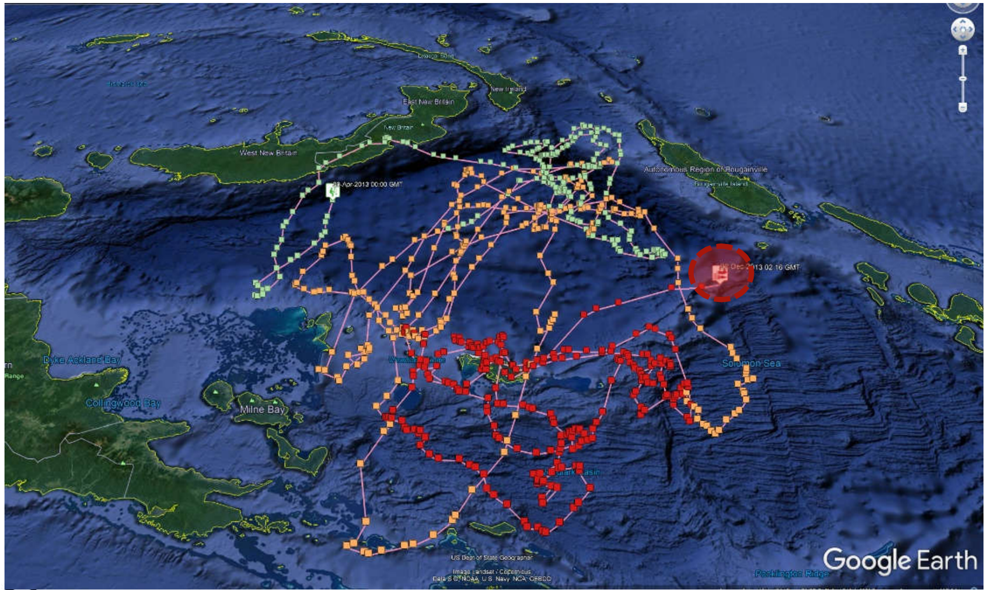


PSATs
DAL: 2-168

Evans et al (2011)



72 cm YFT
Released 23/04/2013
Recaptured 30/08/2013
At liberty for 132 days



71 cm YFT
Released 23/04/2013
Recaptured 22/12/2013
At liberty for 246 days

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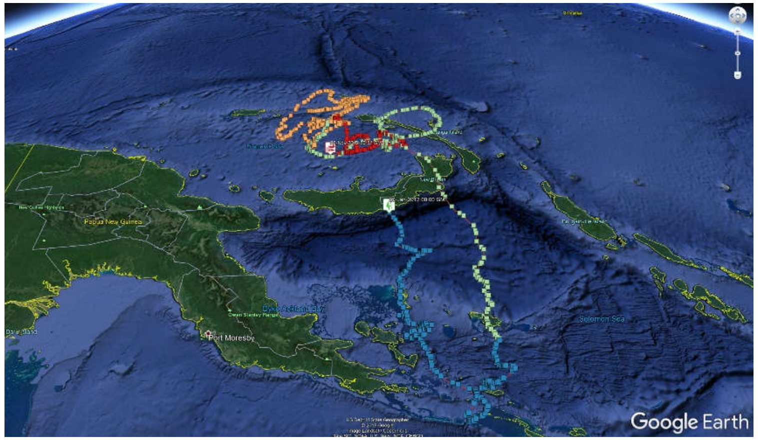
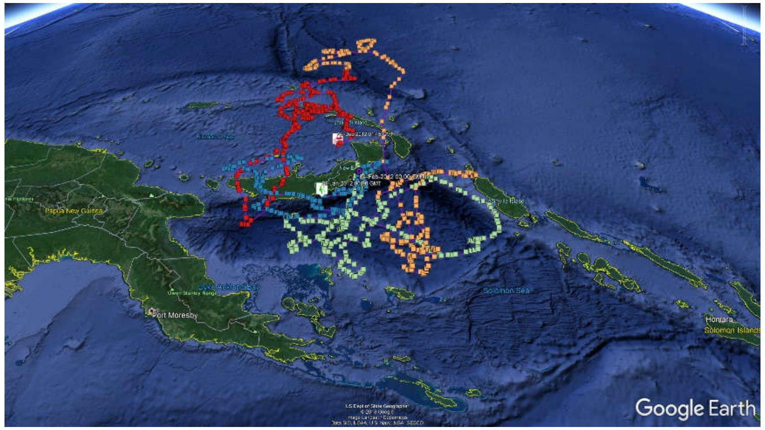
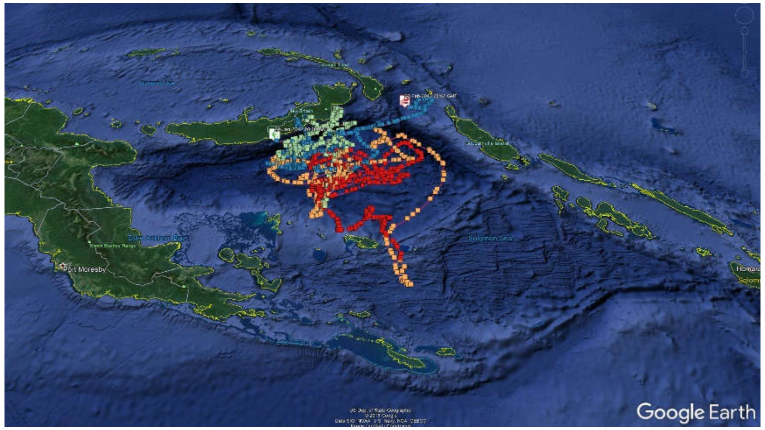


63 cm YFT
Released 29/01/2012
Recaptured 04/11/2012
At liberty for 280 days



64 cm YFT
Released 29/01/2012
Recaptured 24/12/2012
At liberty for 330 days

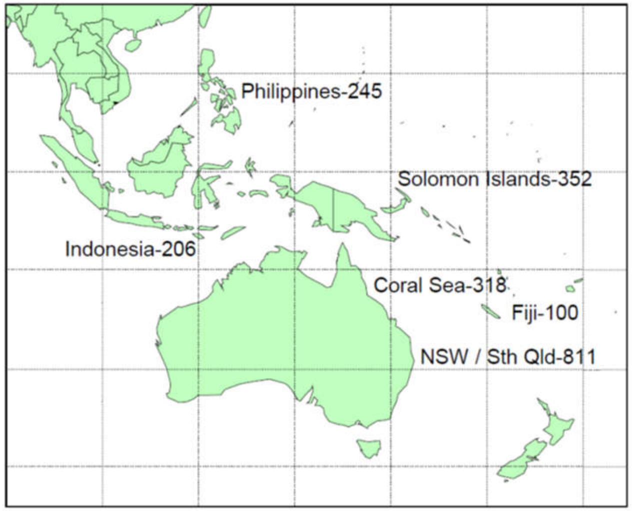


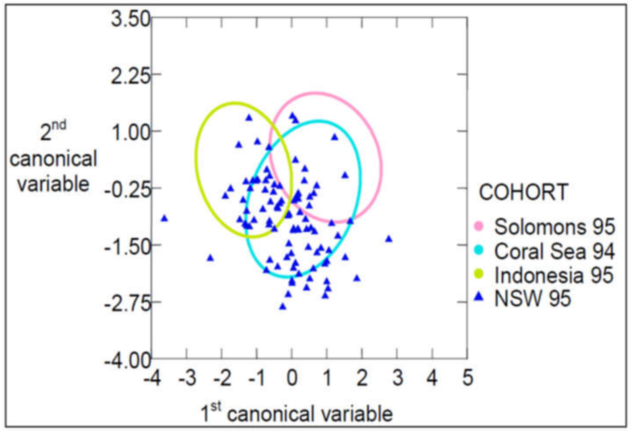
64 cm YFT
Released 29/01/2012
Recaptured 22/02/2013
At liberty for 390 days

Yellowfin tuna - Otolith microchemistry

Gunn et al. (2002)

- Used otolith elemental concentrations of core-adjacent material to examine origins of YFT to NSW/Sth Qld
- 74% of YFT from 1994 cohort sampled off NSW/Sth Qld were most similar to those from Coral Sea, with lesser contributions of Fiji (11%) and Philippines (15%)
- 63% of YFT from 1995 cohort sampled off NSW/Sth Qld were most similar to 1994 cohort from Coral Sea, with lesser contributions from 1995 Indonesia (27%) and Solomon Islands (10%)
- Results suggest tuna caught of NSW/Sth Qld derived mainly from Coral Sea, with lower contributions from WPO, conributions variable year to year

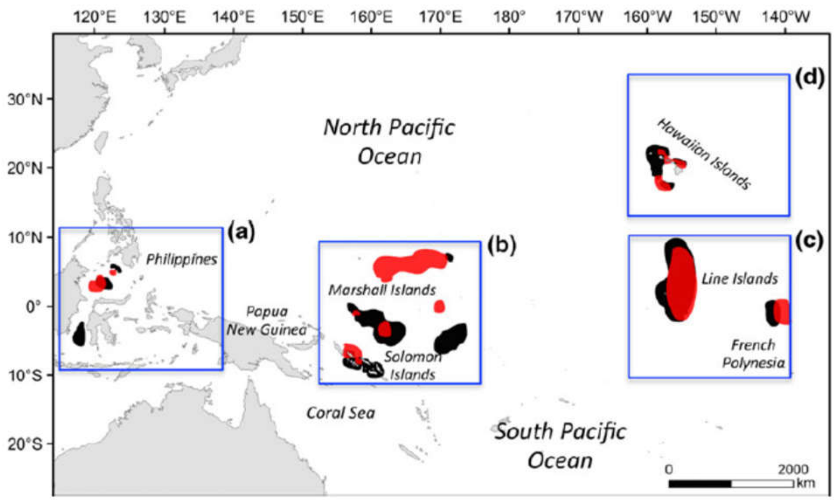




Yellowfin tuna - Otolith microchemistry

Rooker et al. (2016):

– Examined stable isotopes ($\delta^{13}C$ and $\delta^{18}O$) and trace elements in otoliths of YOY YFT from four regions, and in 1-2 year old YFT from Marshall Is and Hawaii



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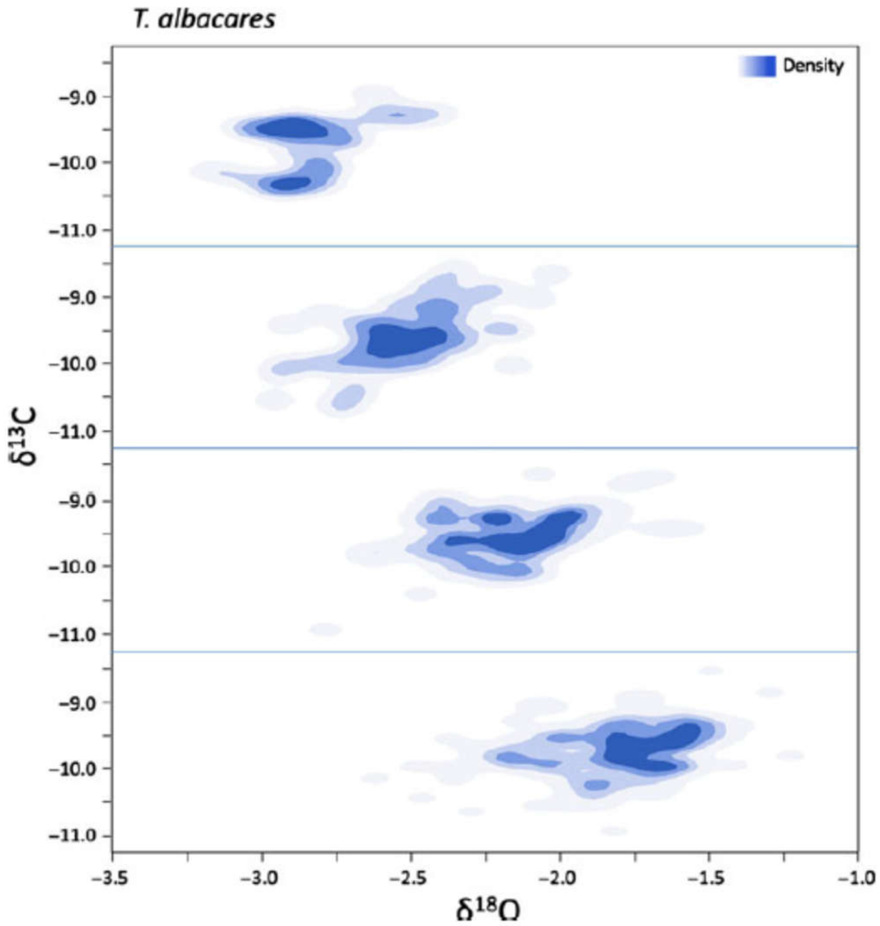
– YOY YFT from four regions had differing otolith chemistries



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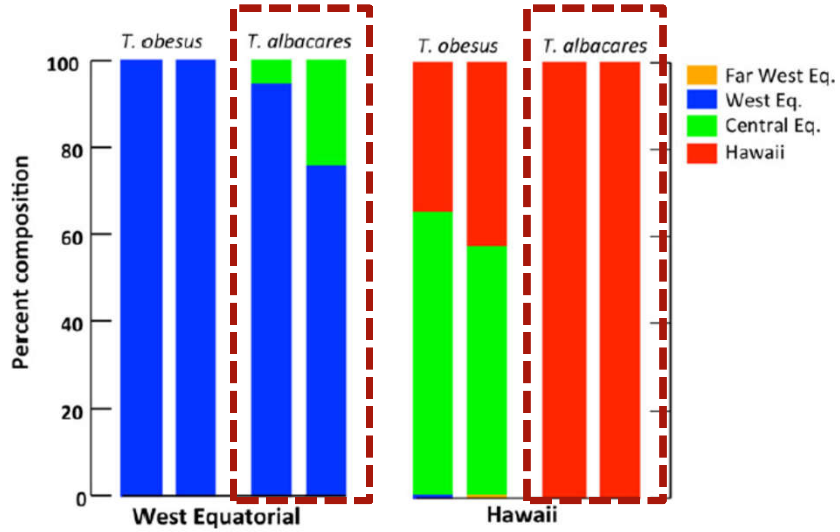
– YOY YFT from four regions had differing otolith chemistries
– Mixed stock analysis suggests most 1-2 year old fish in Marshall Islands originated from Marshall / Solomon Islands
– All 1-2 year old YFT in Hawaii deemed to have resulted from local spawning



Bigeye tuna - Tagging

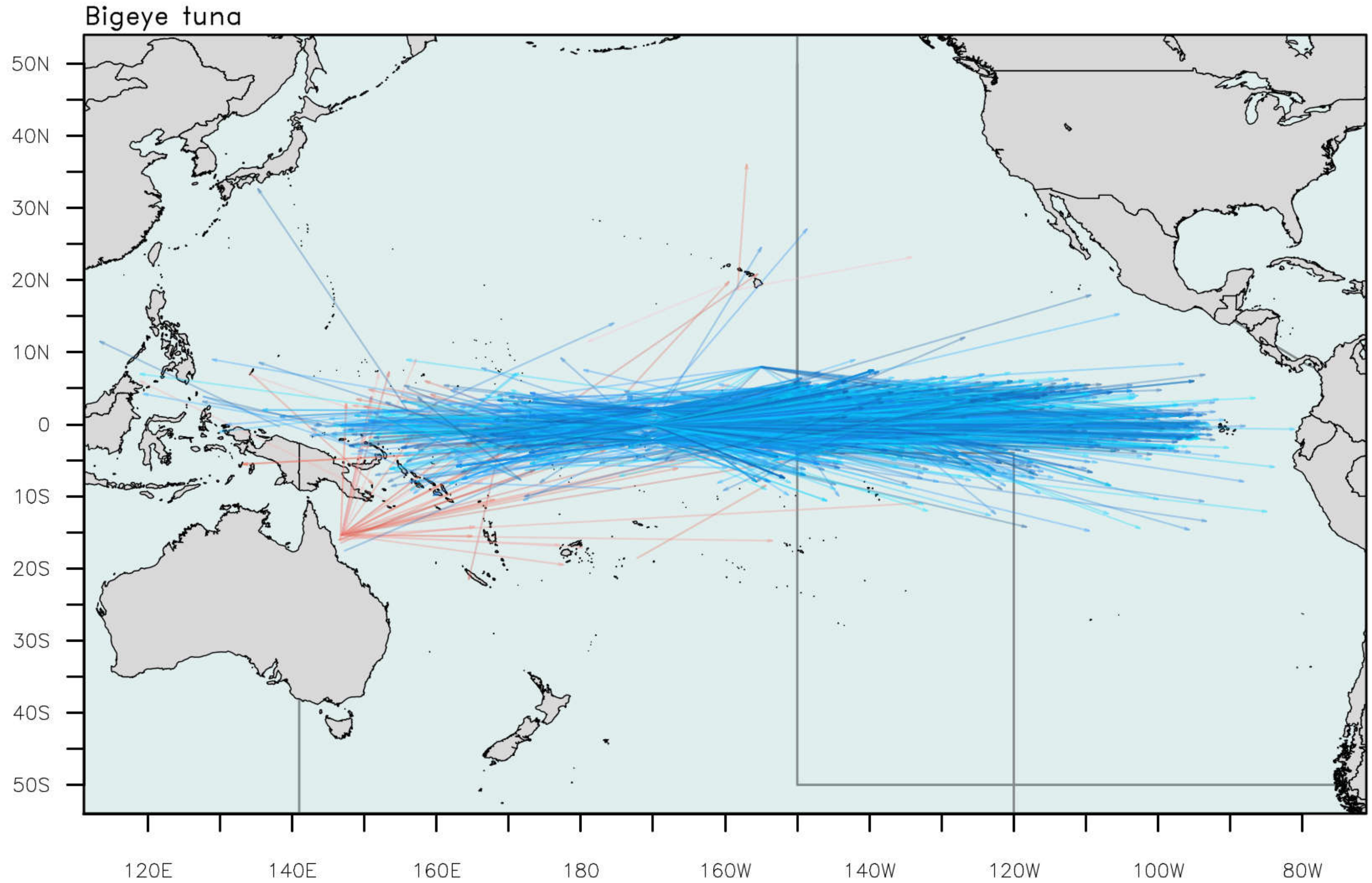
Relatively fewer bigeye tuna tagged in WCPO

- SSAP (1977-1981) = 65 releases, 0 recoveries[1]
- RTTP (1991-1996) = 8,074 releases, 975 recoveries (12.1%)[1]
- PTTP (2006-present) = ~48,000 releases, ~13,000 recoveries[2]
- National initiatives

And in the EPO

- 20,115 tagged in EPO to 2015, 8,468 recoveries[3]
- 5,950 recoveries considered to be valid for movement analyses by Fonteneau and Hallier (2015)

[1]Leroy et al. (2015)
[2]SPC-OFP (2018)
[3]Fonteneau & Hallier (2015)



Movement > 1,000 nm from release point, based on SPC holdings

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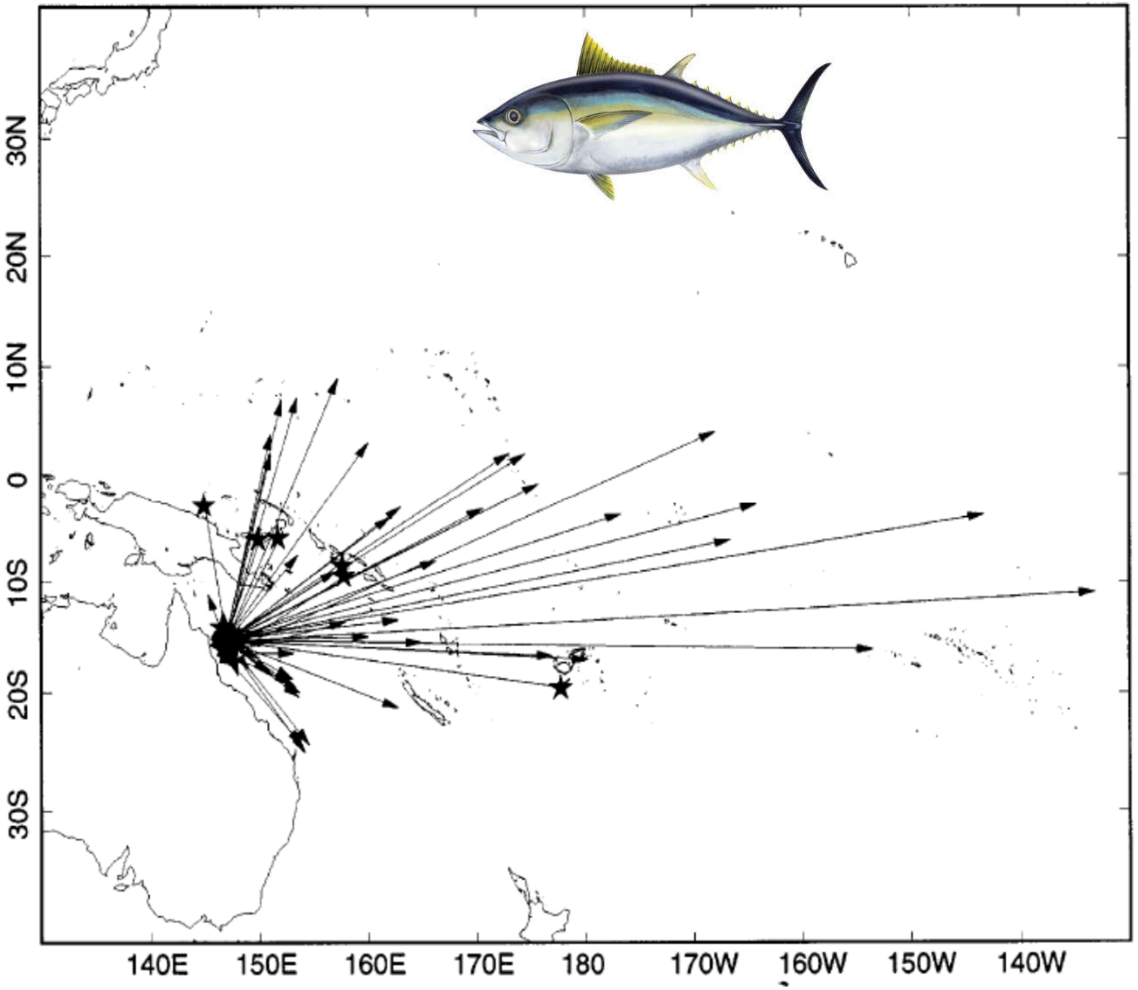
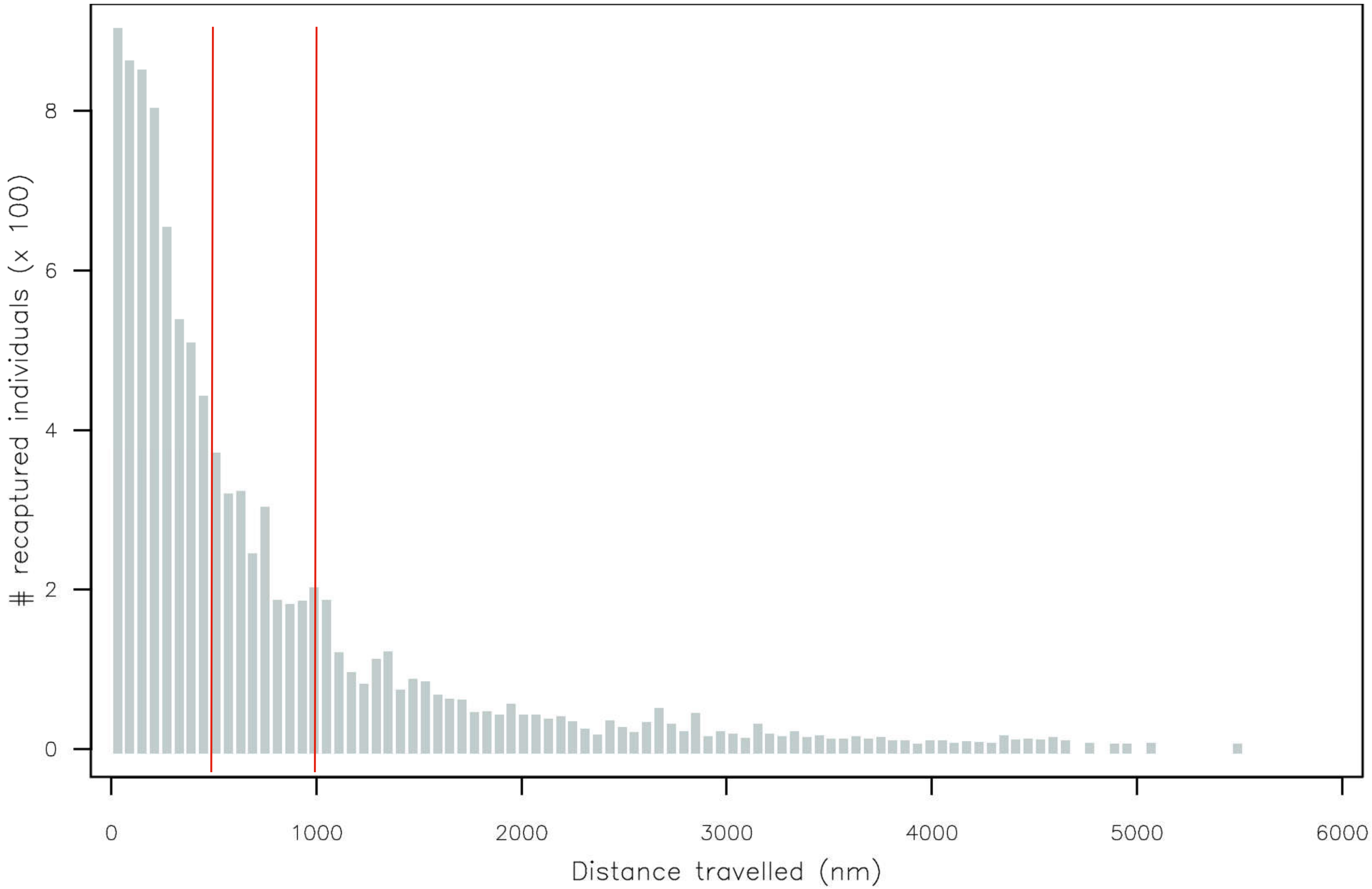
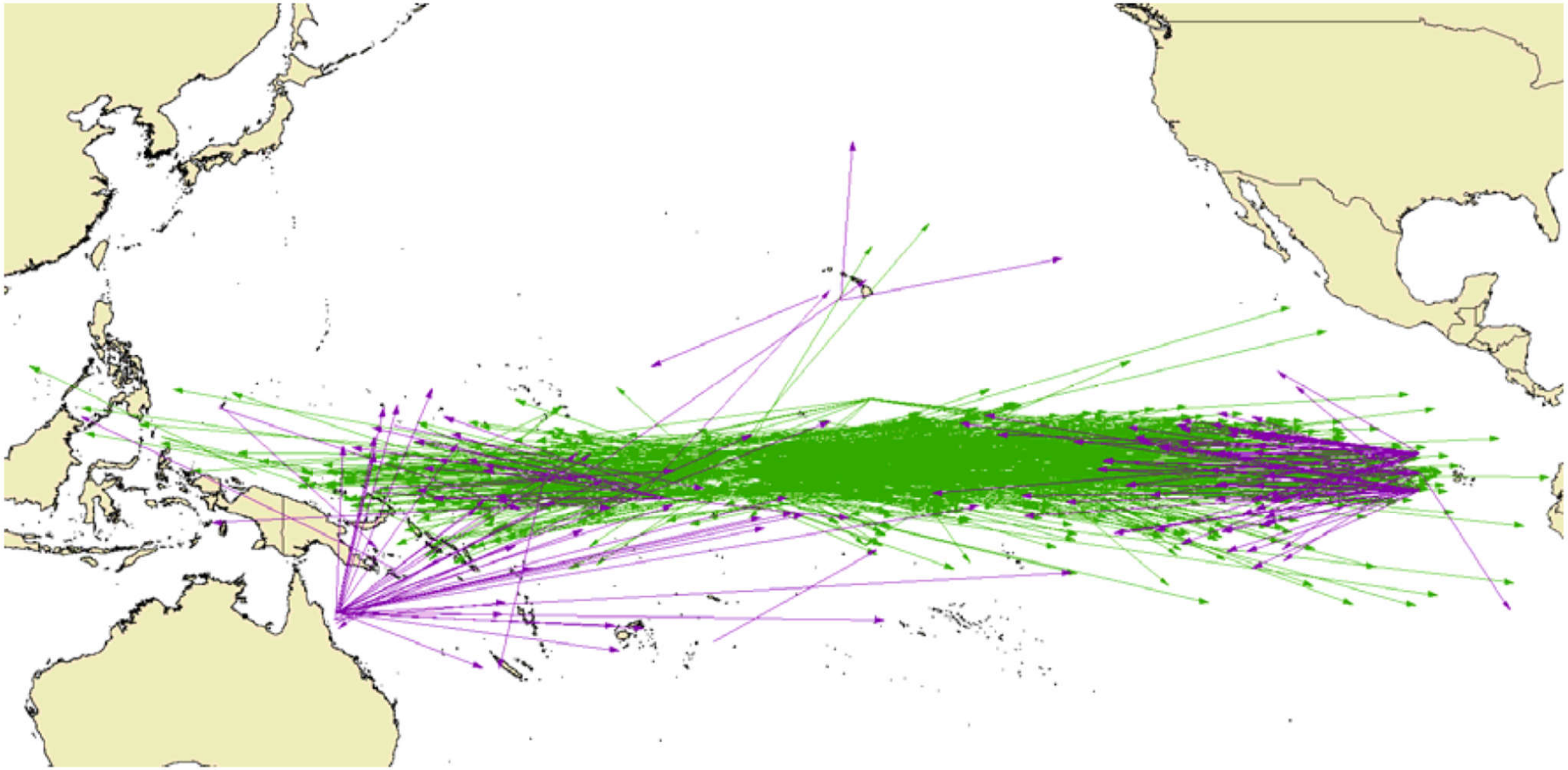


Hampton & Gunn 1998



(Based on fish at liberty ≥ 3 months; data from SPC holdings)

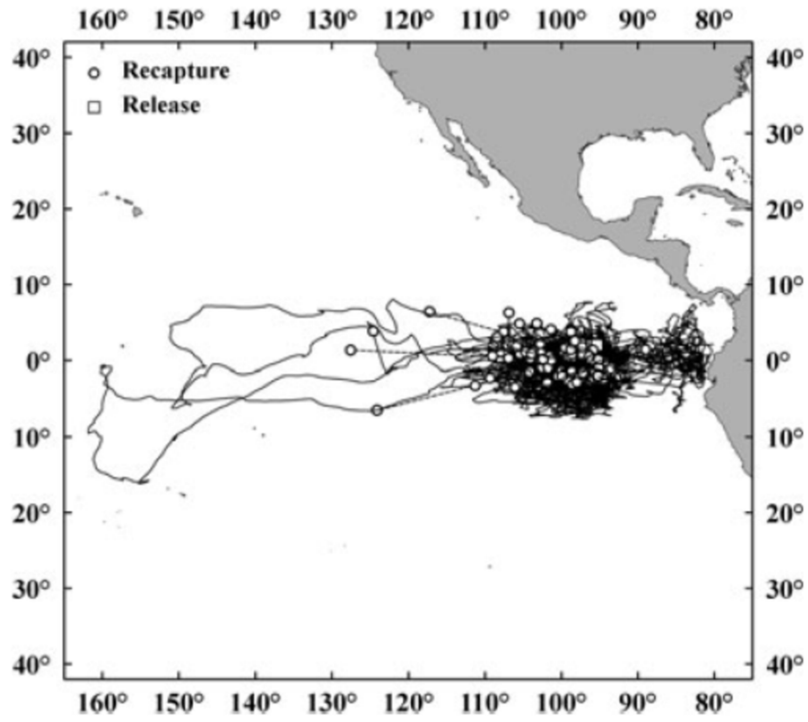


Long-distance (> 1000 nm) displacements of tagged BET in the Pacific Ocean. Green arrows are data from PTTP to 2014, purple arrows are from RTTP in the western Pacific, the IATTC in the EPO and University of Hawaii (from Harley et al. 2014)

In EPO:

Schaefer & Fuller 2009; 2010

- Strong regional fidelity
- Limited westward movement



Schaefer & Fuller 2010

Three types of movement?

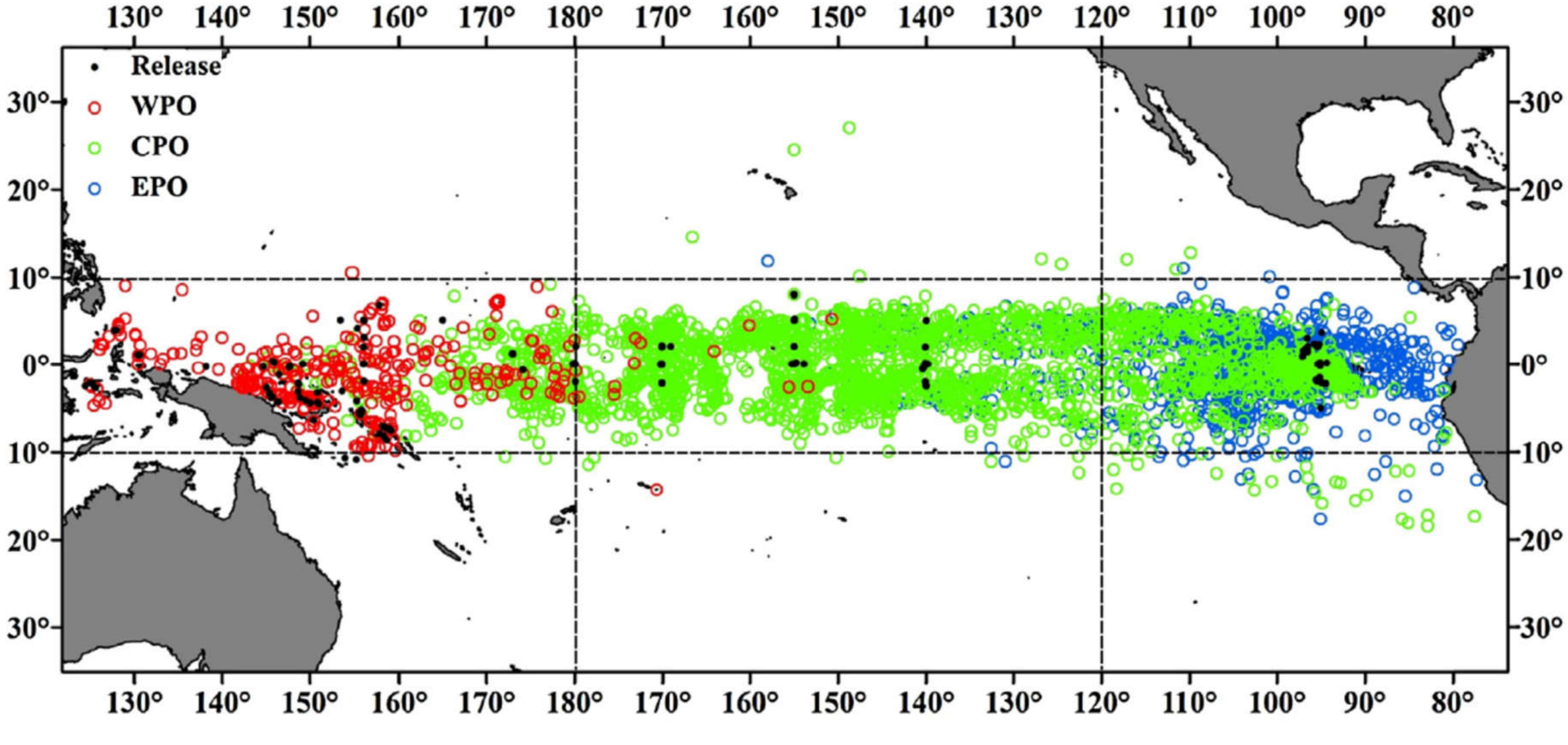
Schaefer et al. (2015):

– 1) residents (within 1,000 nm of release)

– 2) residents that take cyclical excursions outside of residency area

– 3) nomads

Schaefer et al. 2015



Schaefer et al. 2015

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Bigeye tuna - Otolith microchemistry

Rooker et al. (2016)

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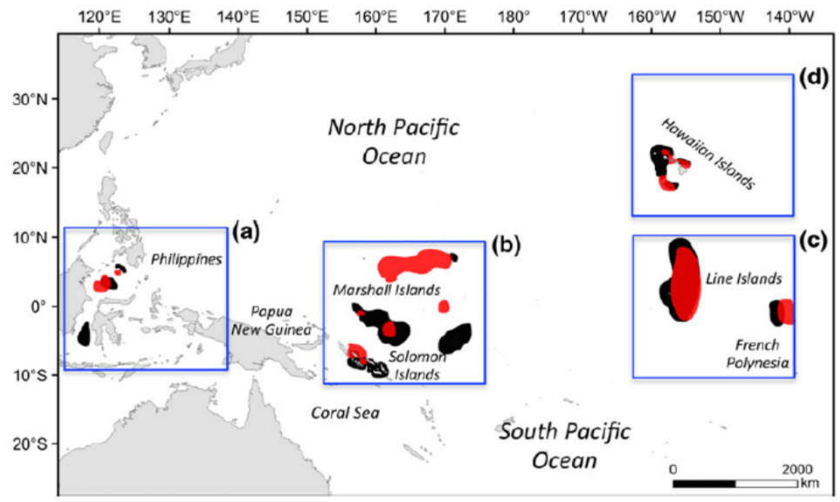

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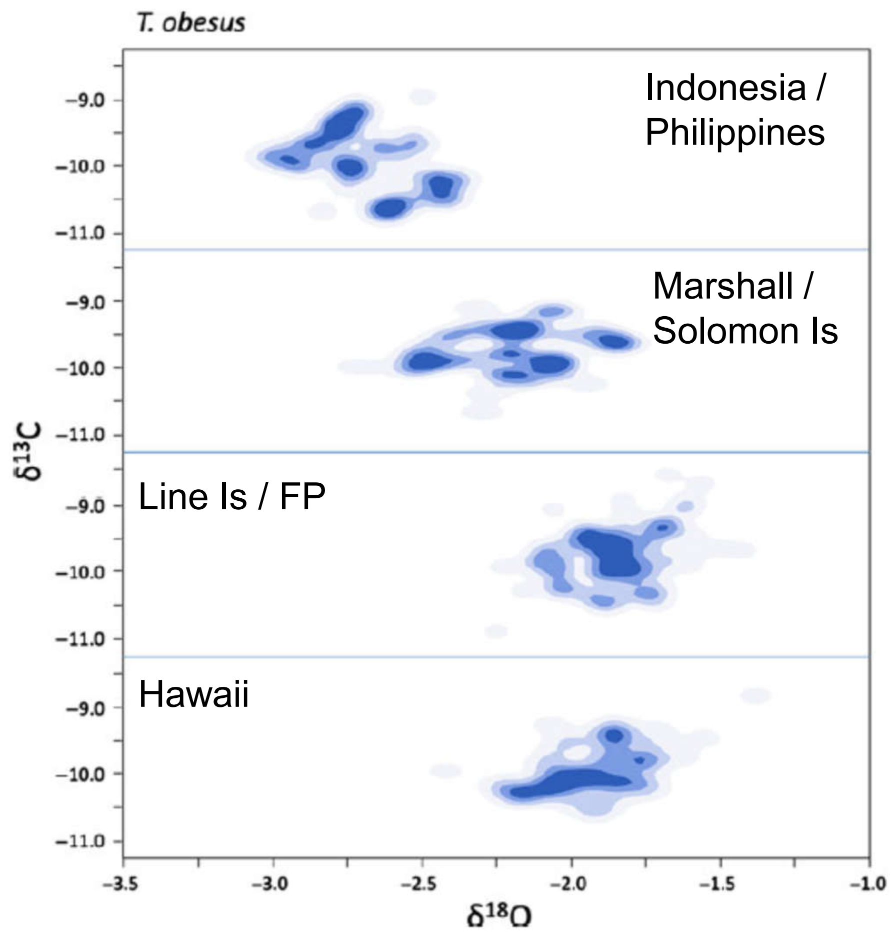

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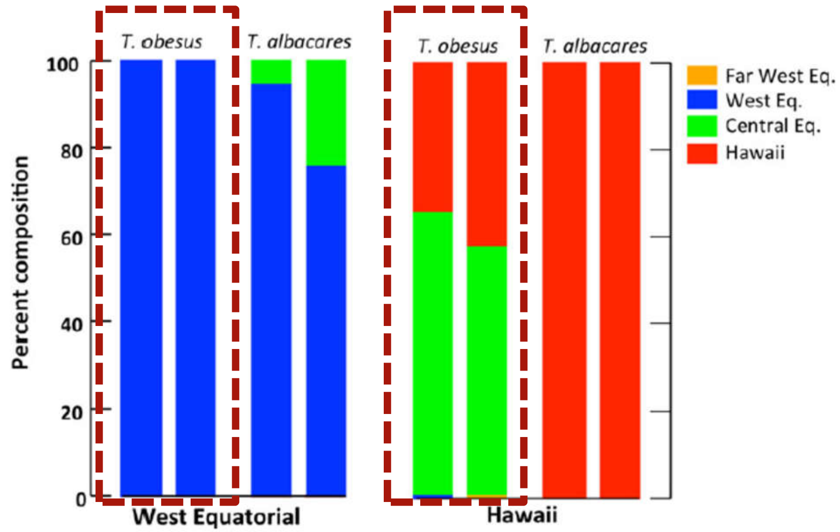
- YOY BET from four regions had differing otolith chemistries
- Mixed stock analysis suggests 1-2 year old fish in Marshall Islands originated from Marshall / Solomon Islands
- Large proportion of 1-2 year old BET in Hawaii deemed to have originated in Line Islands/FP



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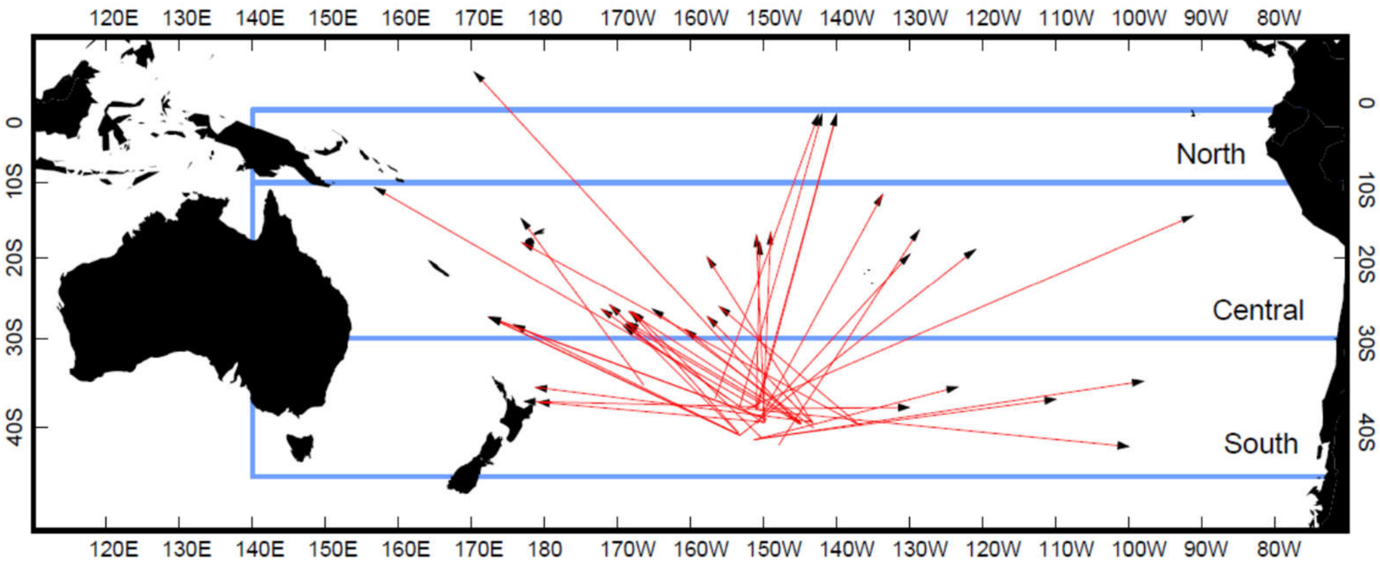
South Pacific albacore tuna - Tagging

Relatively few ALB tagged

- SPC-OFP albacore tagging program 1990–1992 in SW Pacific: 9,691 releases, 163 recoveries



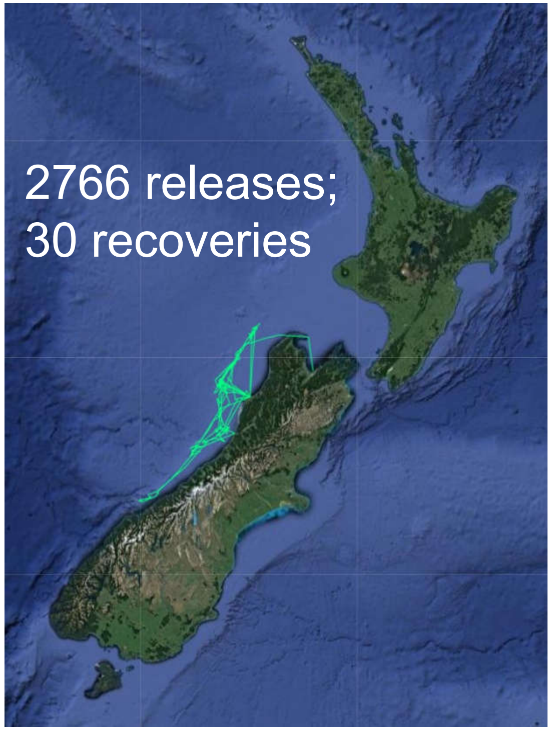
(from Labelle and Hampton 2003)

South Pacific albacore tuna - Tagging

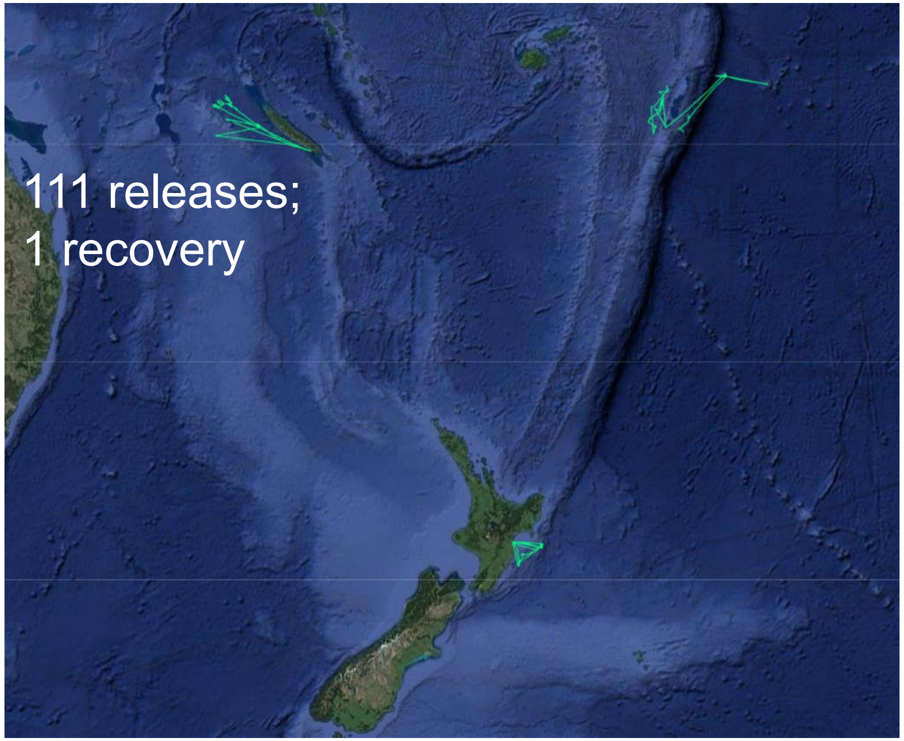
Relatively few ALB tagged

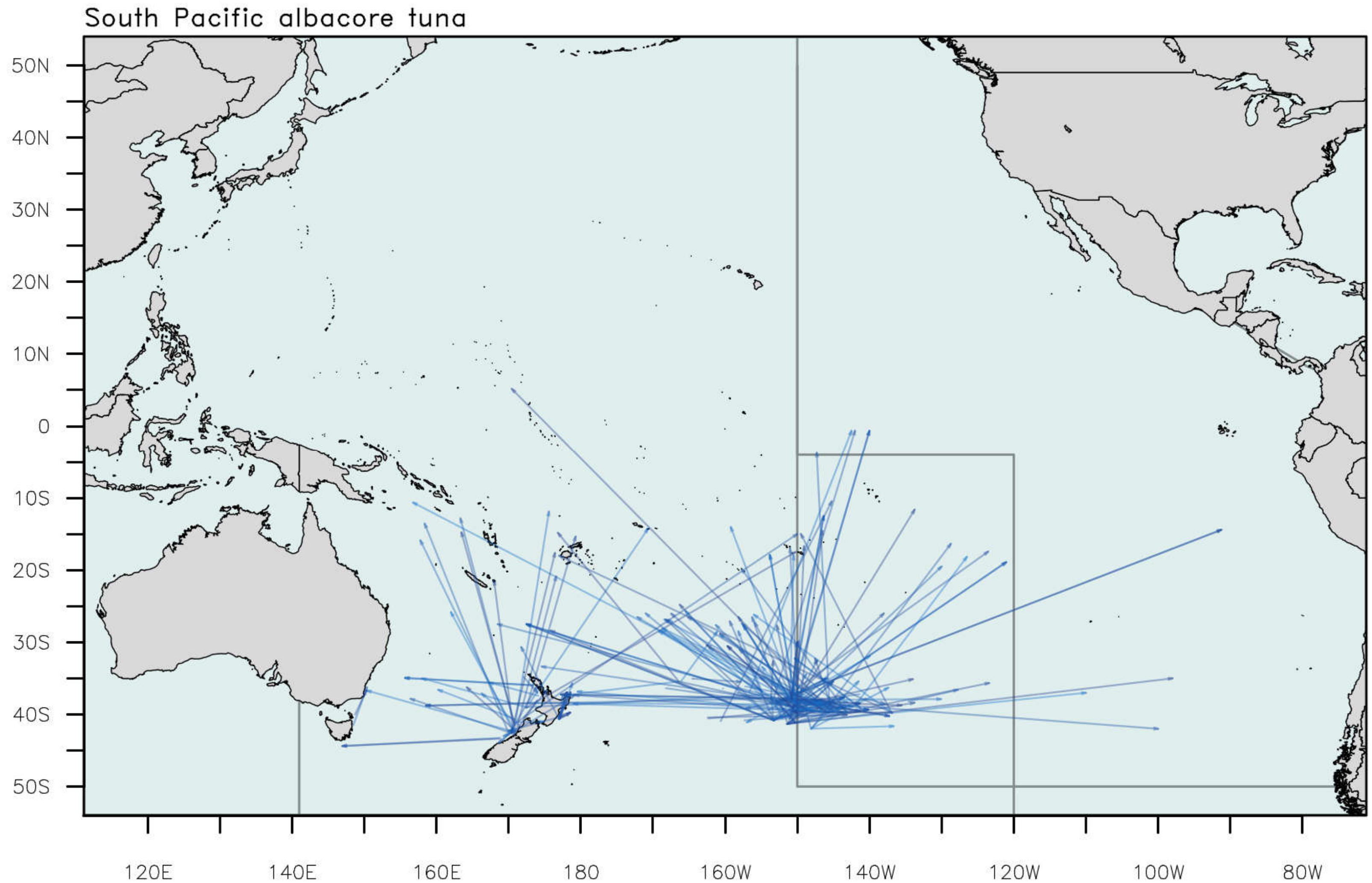
- SPC-OFP albacore tagging program 2009-2010:

2009:



2010:





All recaptures, based on SPC holdings

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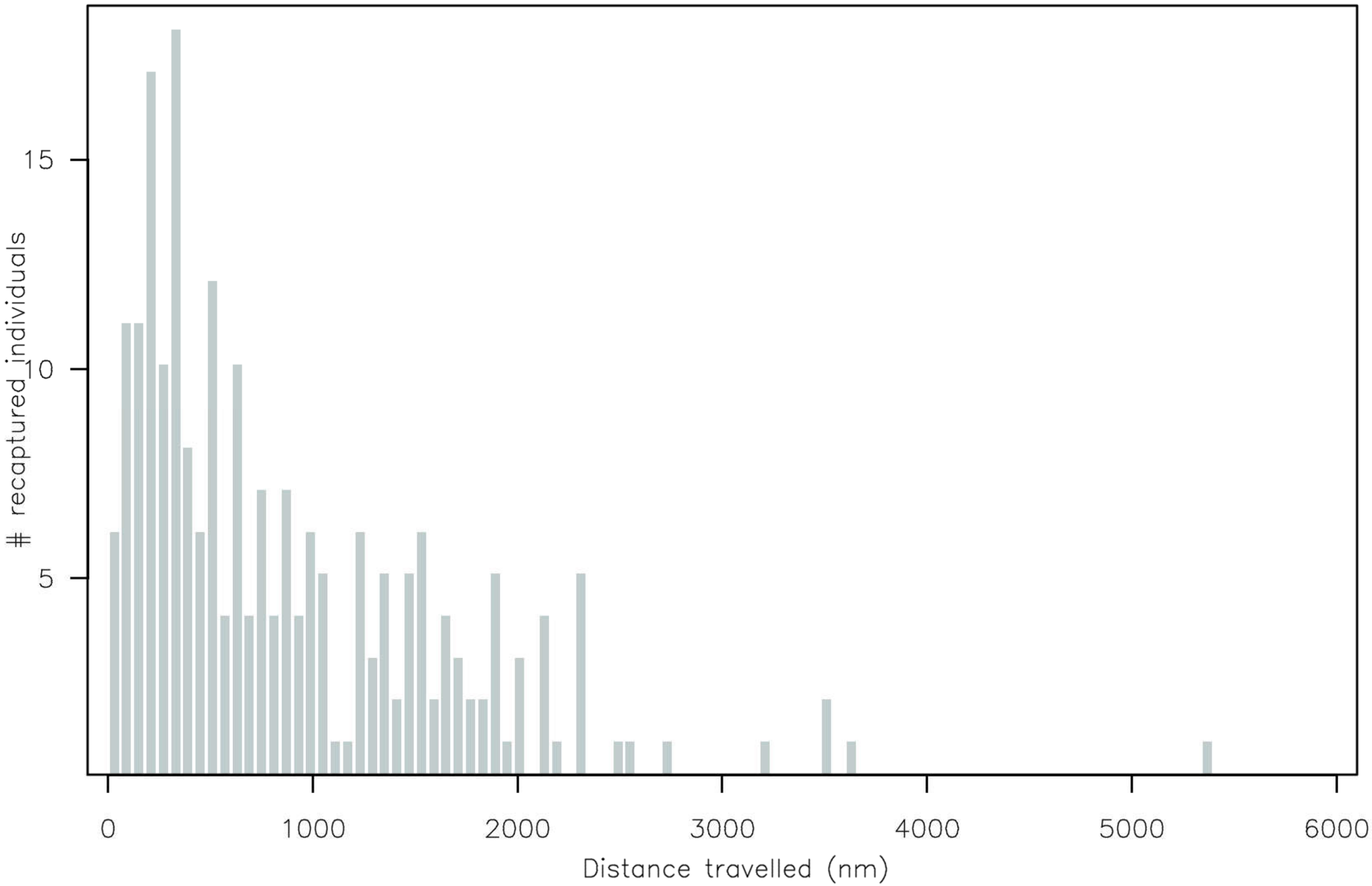
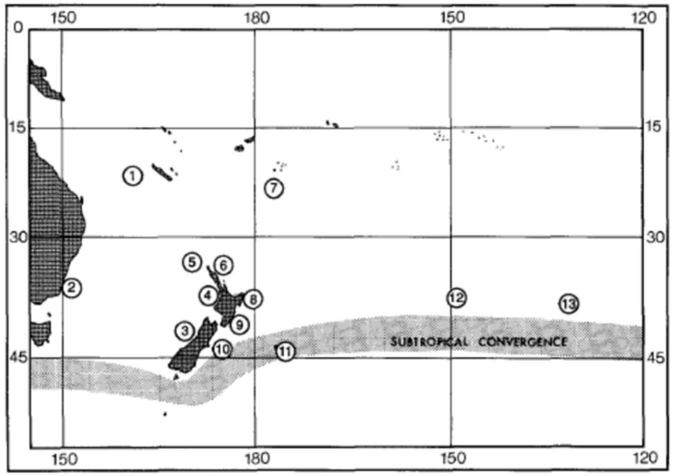

15
10
5
recaptured individuals
0
1000
2000
3000
4000
5000
6000
Distance travelled (nm)

South Pacific albacore tuna - Parasites

Jones (1991)

- Examined parasite abundance and prevalence in ALB collected from SW pacific
- Abundance and prevalence of didymozoids (tropical-area parasites) indicate ALB move south from tropics to NZ, then return to tropics to spawn
- Evidence to suggest ALB may also move along sub-tropical convergence zone



South Pacific albacore tuna - Otolith microchemistry

Macdonald et al. (2013)

– Examined trace elements in otoliths of ALB from French Polynesia, New Caledonia and New Zealand
– ALB captured off NC and NZ had similar core chemistries, suggesting they had spawned in areas of similar water chemistry)
– ALB captured of FP had different core chemistry to NC & NZ samples suggesting they had a different origin
– But from where?