Emerging technologies and tools for monitoring fish physiology and energetics

Shin-ichi Ito

Atmosphere and Ocean Research Institute, The University of Tokyo

Today's contents

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2. Artificial tags (biologging)
3. Natural tags (biogeochemical tags)
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What should we monitor?

"Growth–mortality" hypothesis
(Anderson 1988 JNAFS)
survival rate is a function of growth rate and growth in the early life stage is the key for stock fluctuation

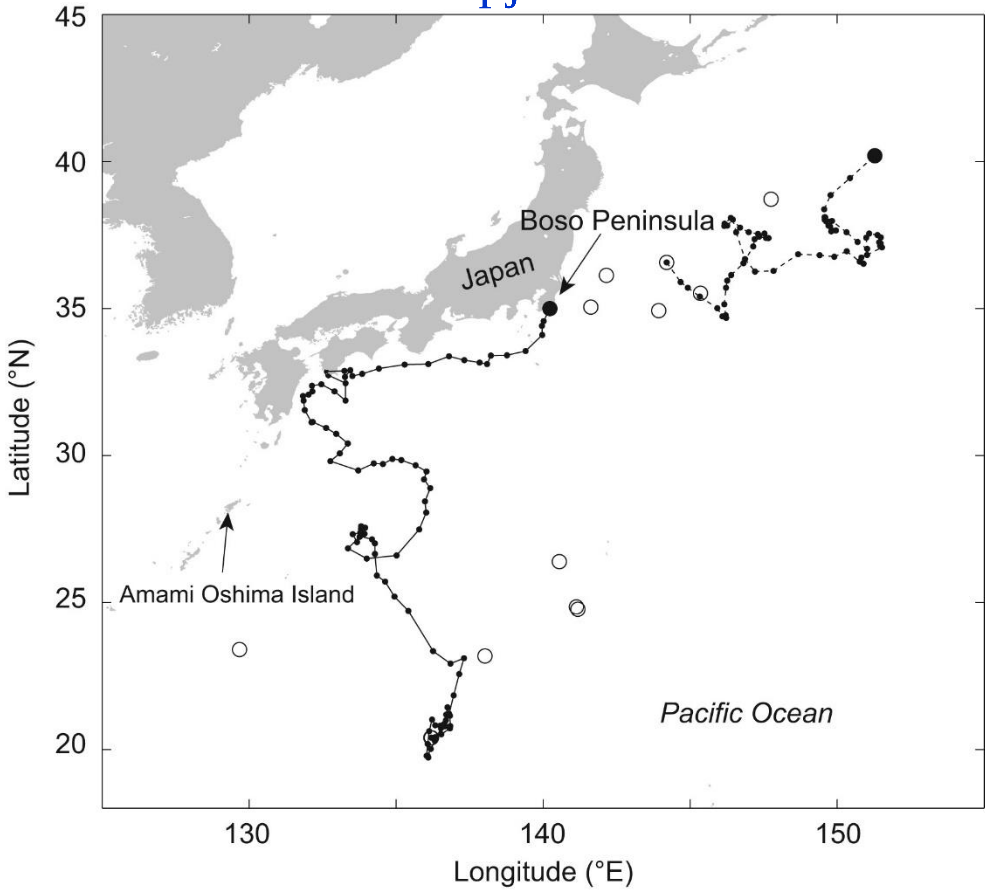
Fish migration has always played an essential role in marine conservation and fisheries management.
(Moulton, 1939)
Feeding & spawning migration

1. **Environments fish experienced**
2. **Prey items fish predated**
3. **Growth of fish**
4. **Behaviors of fish**
5. **Migration route of fish**
6. **Distribution of fish**

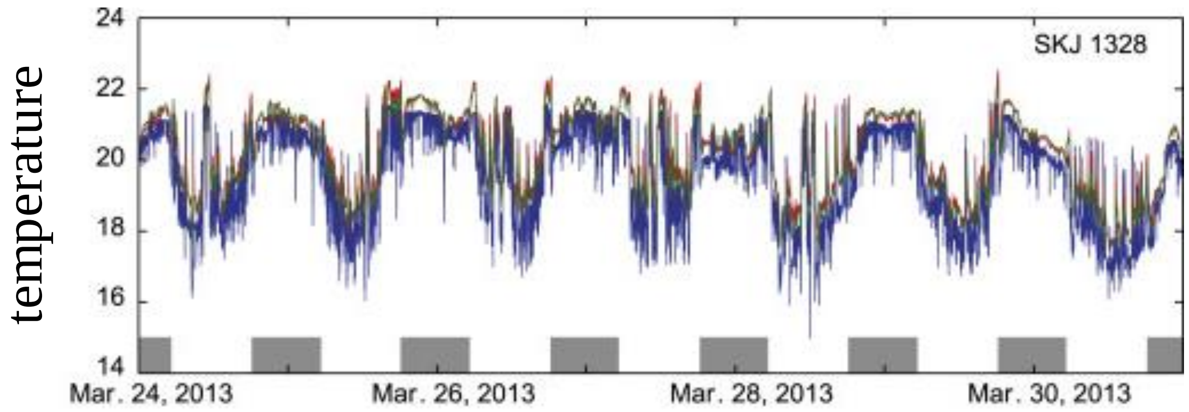
→ **Can investigate their life strategy**

Artificial tags (biologging)

an example for archival tag observation
of skipjack tuna



Aoki et al. (2017, DSR-II)

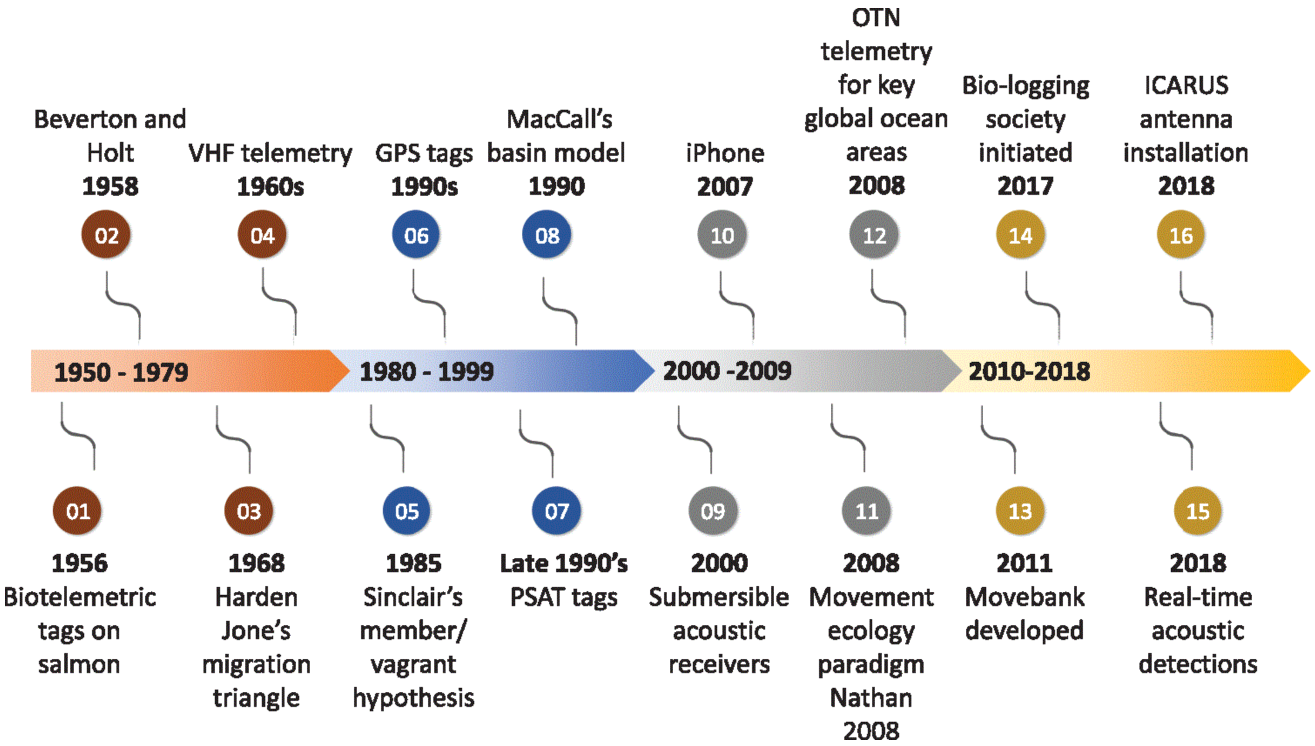


can record
ambient temperature, body temperature,
depth, light (position and moving speed),
acceleration, video, etc.

an example for archival tag
observation of salmon

Kitagawa et al. (2016)

Artificial tags (biologging)



Lowerre-Barbieri et al. (2019)

- Biologging has been developed for long time and the applications have been extended.
- For larger fishes, biologging is the best approach to observe fish behaviors.

limitation

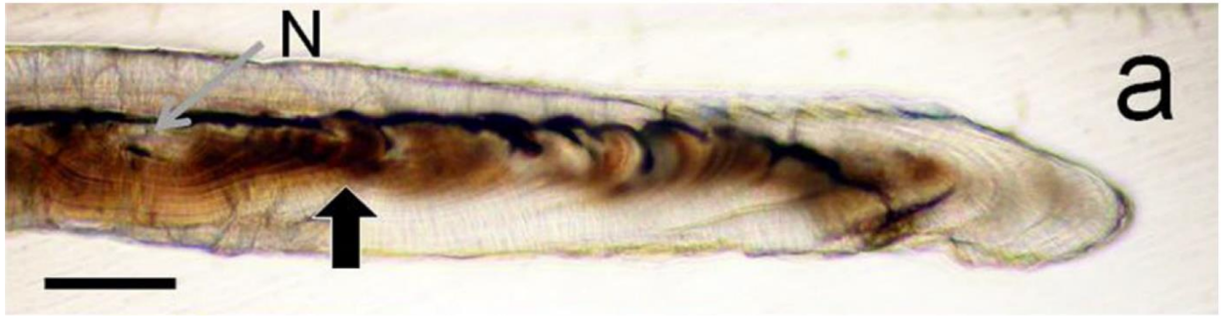
influence of tag for behaviors
position determination
lifetime of sensor
size

Application for smaller fish is still limited.

It is also impossible to apply to critical life stages (larvae & juvenile stages).

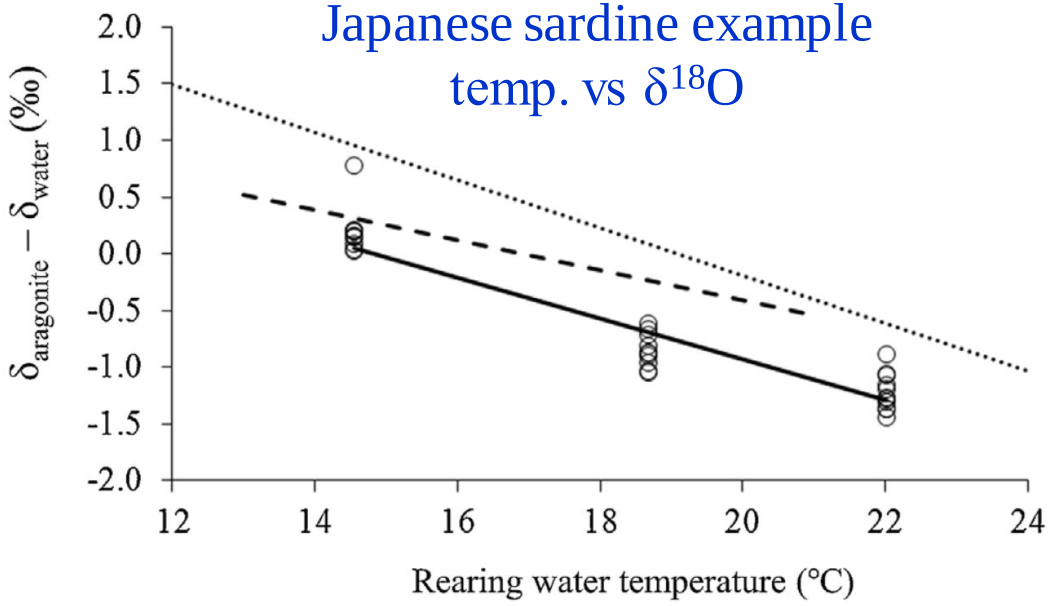
Natural tags (otolith)

otolith of chub mackerel



Takahashi et al. (2013)

Japanese sardine example
temp. vs $\delta^{18}O$

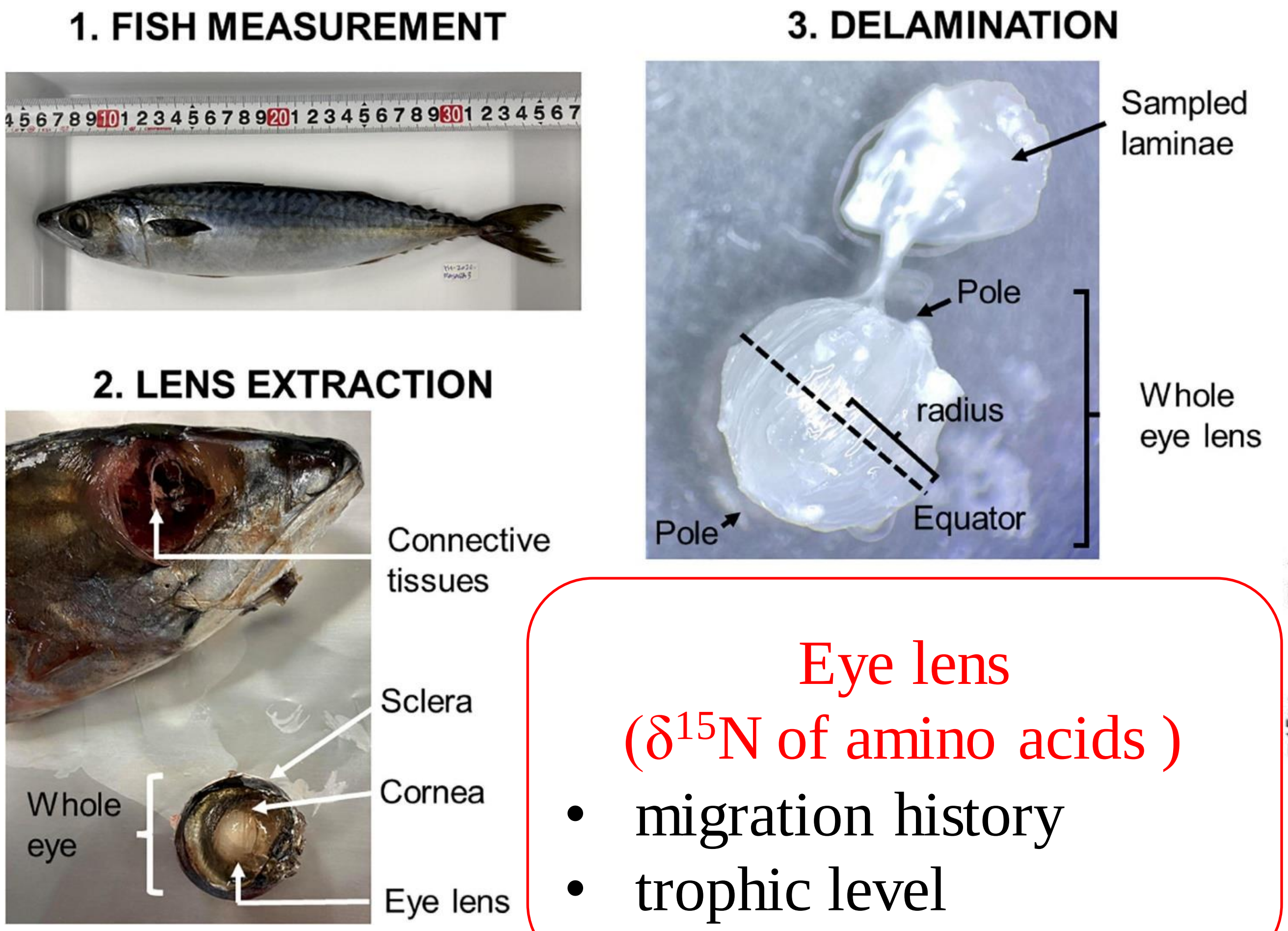


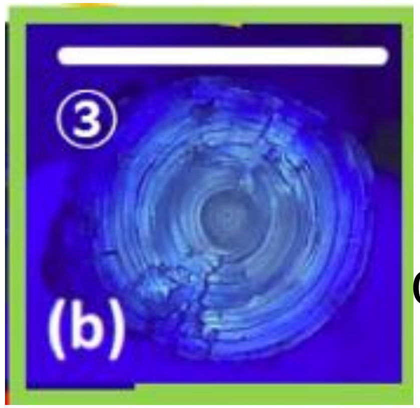
Sakamoto et al. (2017)

Otolith

- a calcium carbonate structure in the inner ear.
- Daily rings are formed and growth of otolith indicates somatic growth.
- It is possible to estimate day age, if a hyaline zone is not formed.
- Chemical component analysis can be applied to reconstruct environmental history fish experienced.

Natural tags (eye lens)



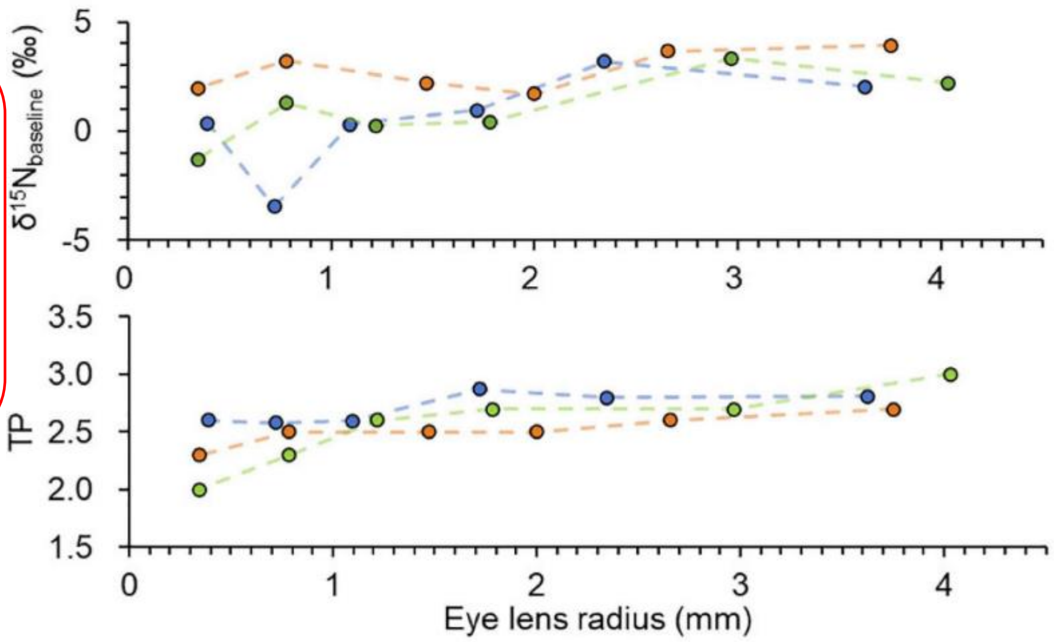


Quaeck Davies et al. (2018)

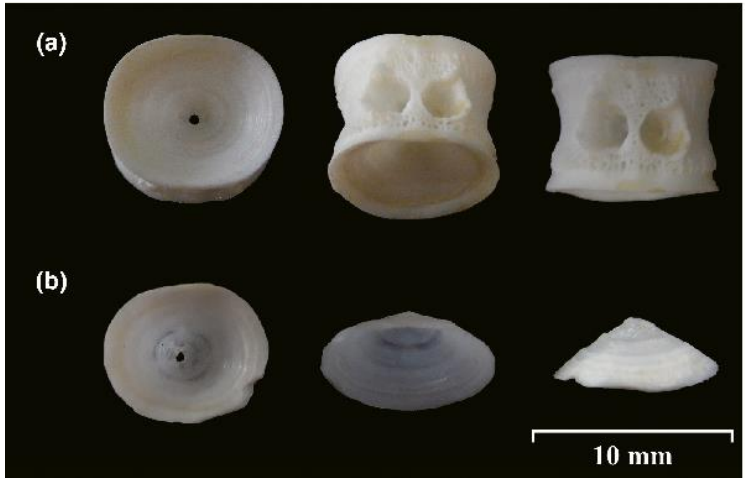
Eye lens
($\delta^{15}N$ of amino acids)

- migration history
- trophic level

Harada, Ito, et al. (2022)

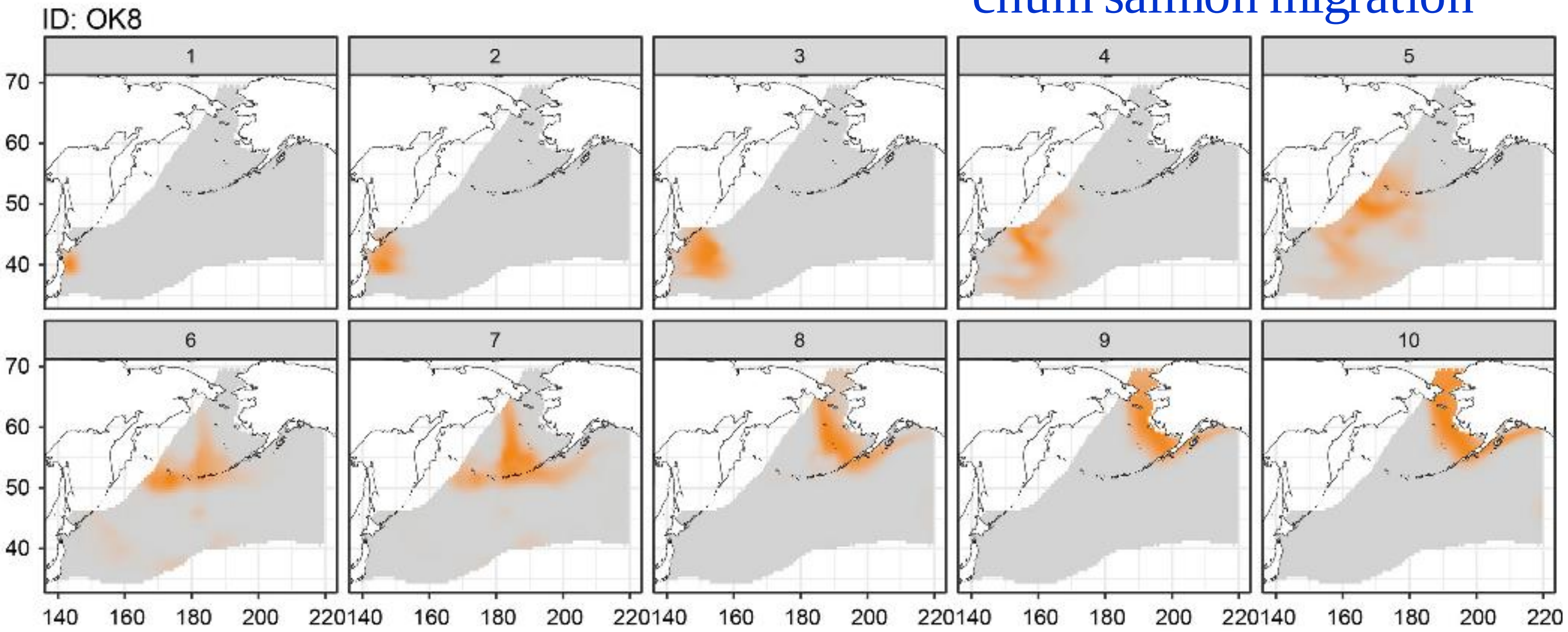


Natural tags (bone: vertebral centra)

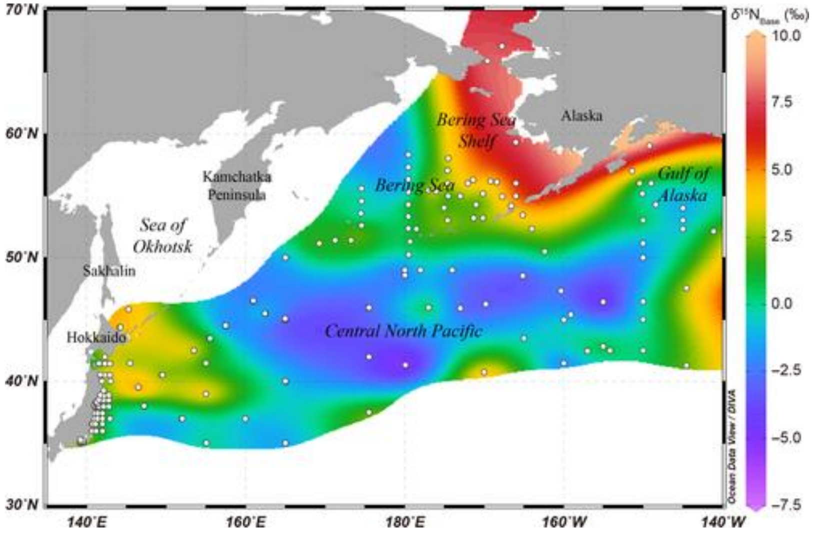


Matsubayashi et al. (2017)

chum salmon migration



Matsubayashi et al. (2020)



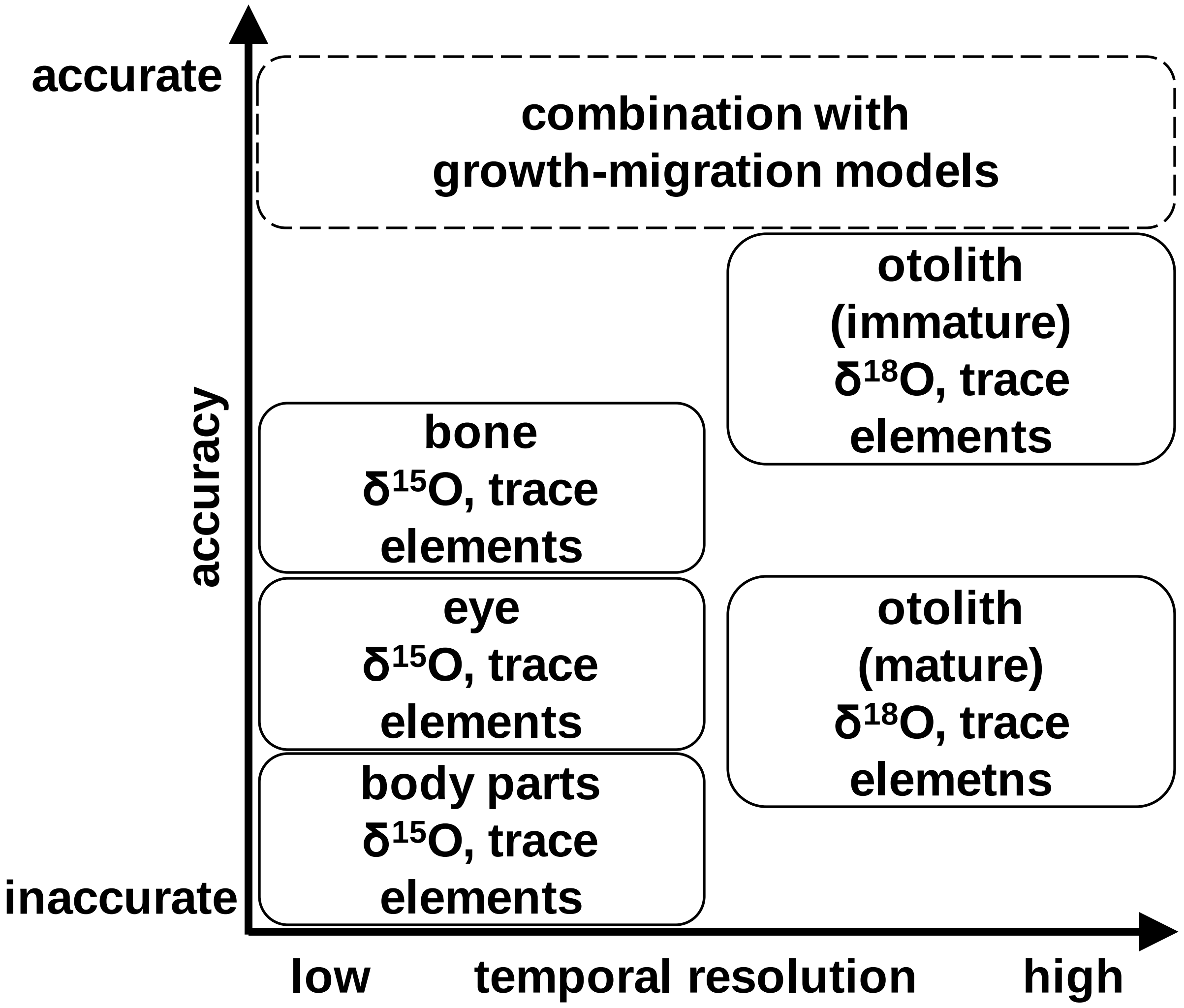
isoscape of zooplankton $\delta^{15}N$

Matsubayashi et al. (2020)

Bone collagens
($\delta^{15}N$ of amino acids)

- migration history
- trophic level

Natural tags



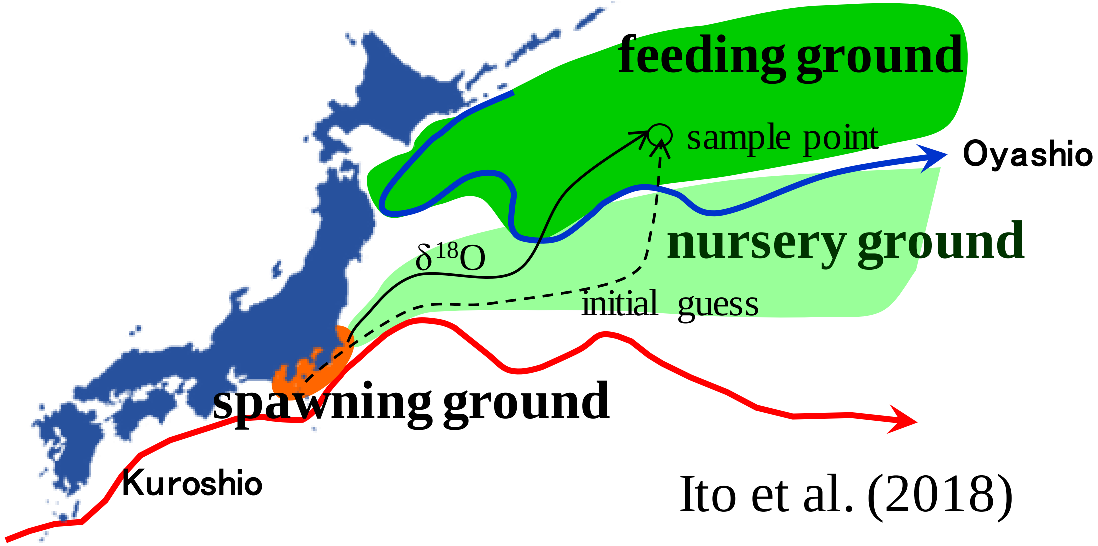
strong points

1. no stress to fish
2. no size limitation
3. long record

weak points

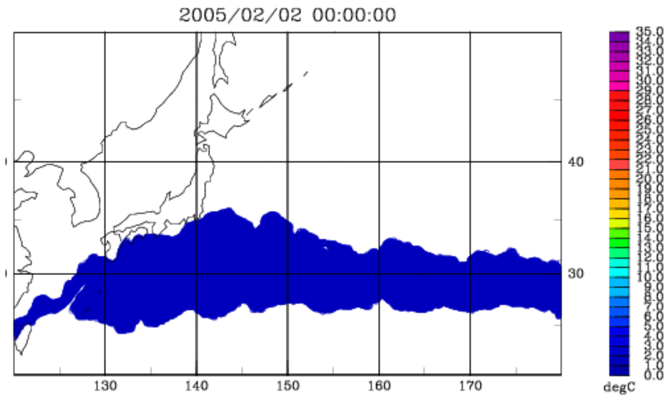
1. limitation of temporal resolution
2. limitation of accuracy
3. limitation of spatial resolution

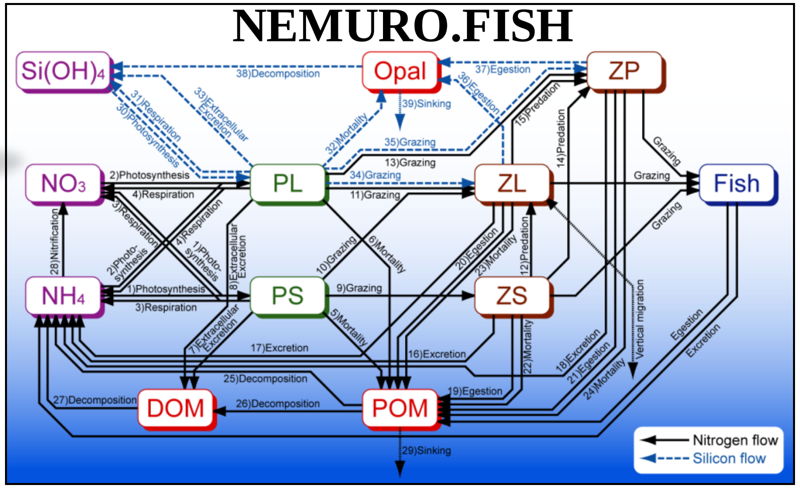
Combination with fish growth-migration models



Ito et al. (2018)

Combination of a fish growth-migration model (NEMURO.FISH) with natural tag chemical analysis enables precise estimation of migration routes and environments fish experienced.
To build models, we need laboratory experiments.

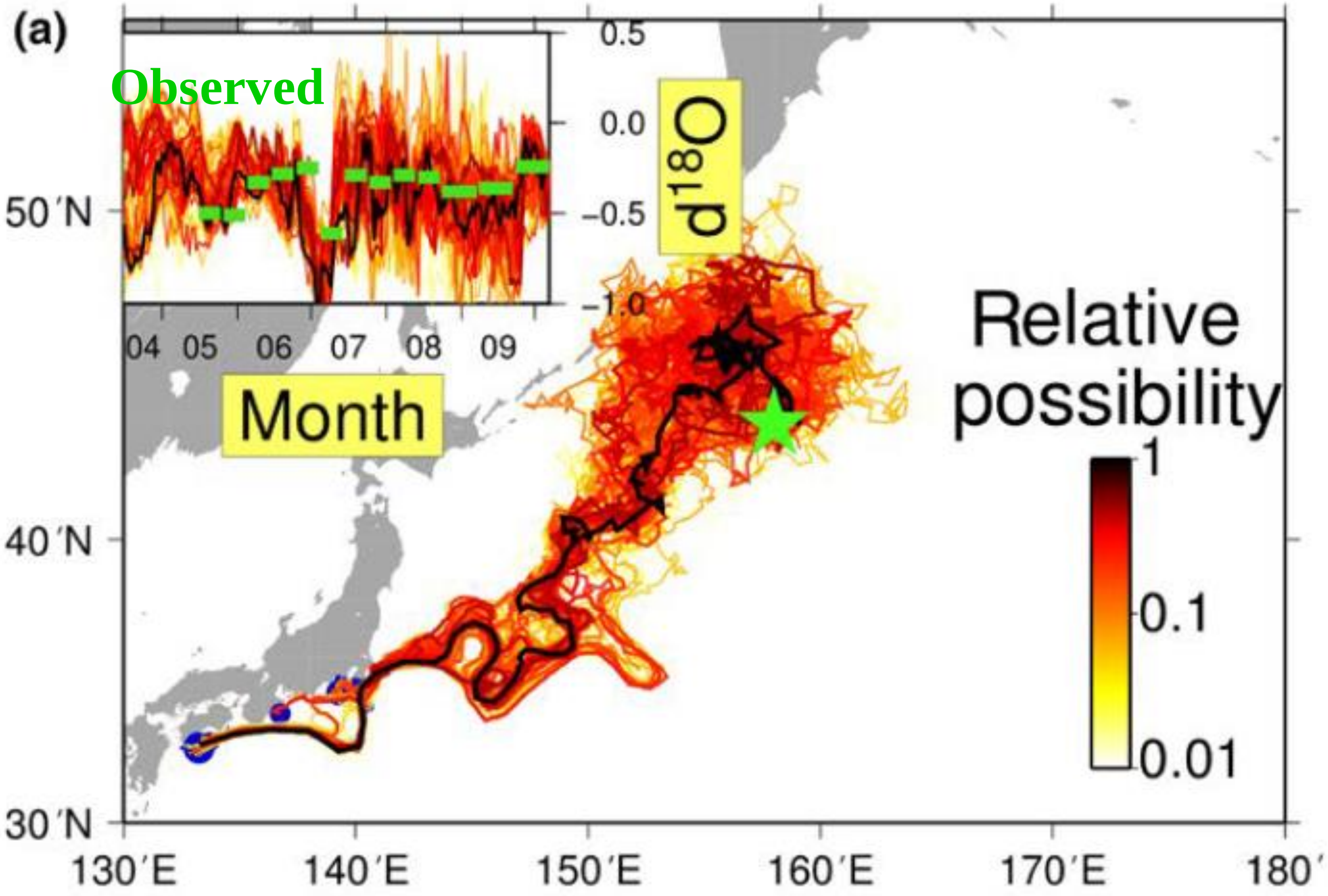




Ito et al. (2004, 2007, 2010, 2013) etc.
Megrey et al. (2007),

Guo, Ito et al. (2020, Fisheries Oceanography)
Guo, Ito et al. (2021, Frontiers in Marine Science)

Application for Japanese sardine



Sakamoto et al. (2018, Methods Ecol. & Evol.)

Early life migration history was estimated using otolith stable oxygen isotope history.

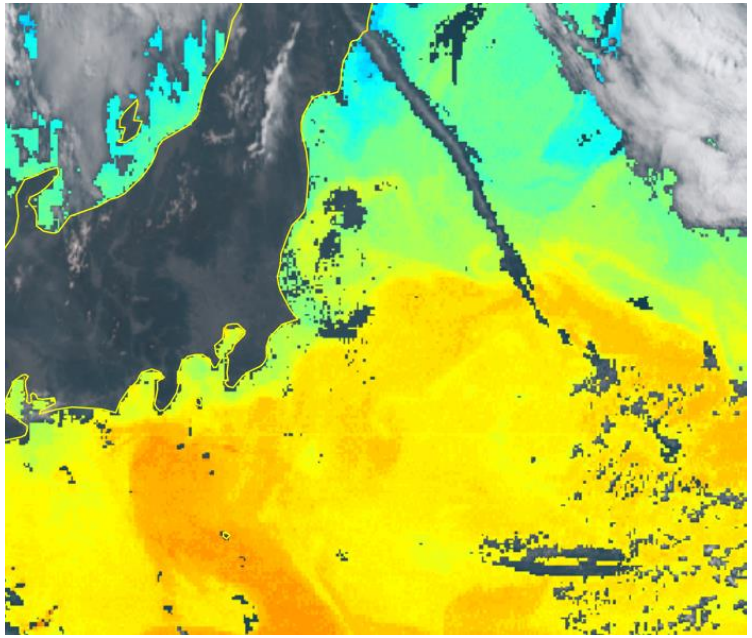
Temperature and salinity distribution estimated by a data assimilated ocean circulation model was used to estimate possible $\delta^{18}O$ in otolith.

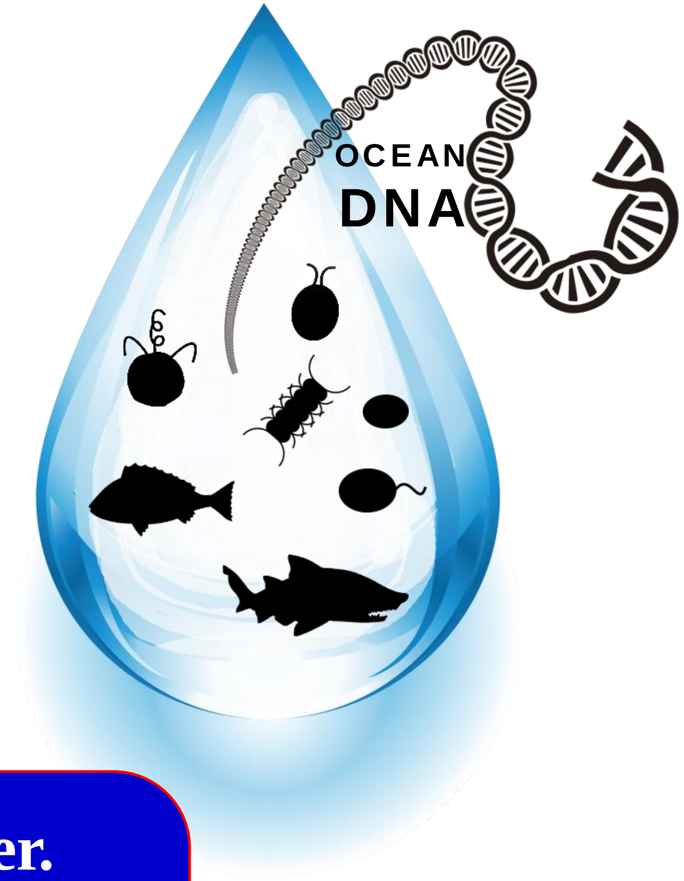
Random swimming fish was used to estimate possible migration route.

Using model and natural tag chemical component analyses,
fish migration route and experienced environment
can be determined.

We want to confirm whether
fish exist on the estimated migration route or not.

OceanDNA

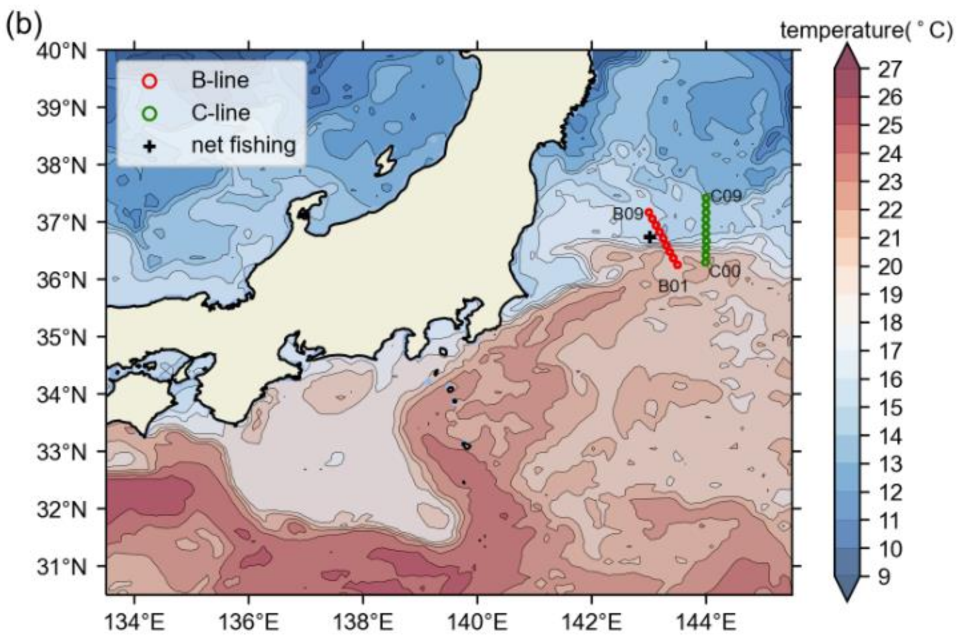


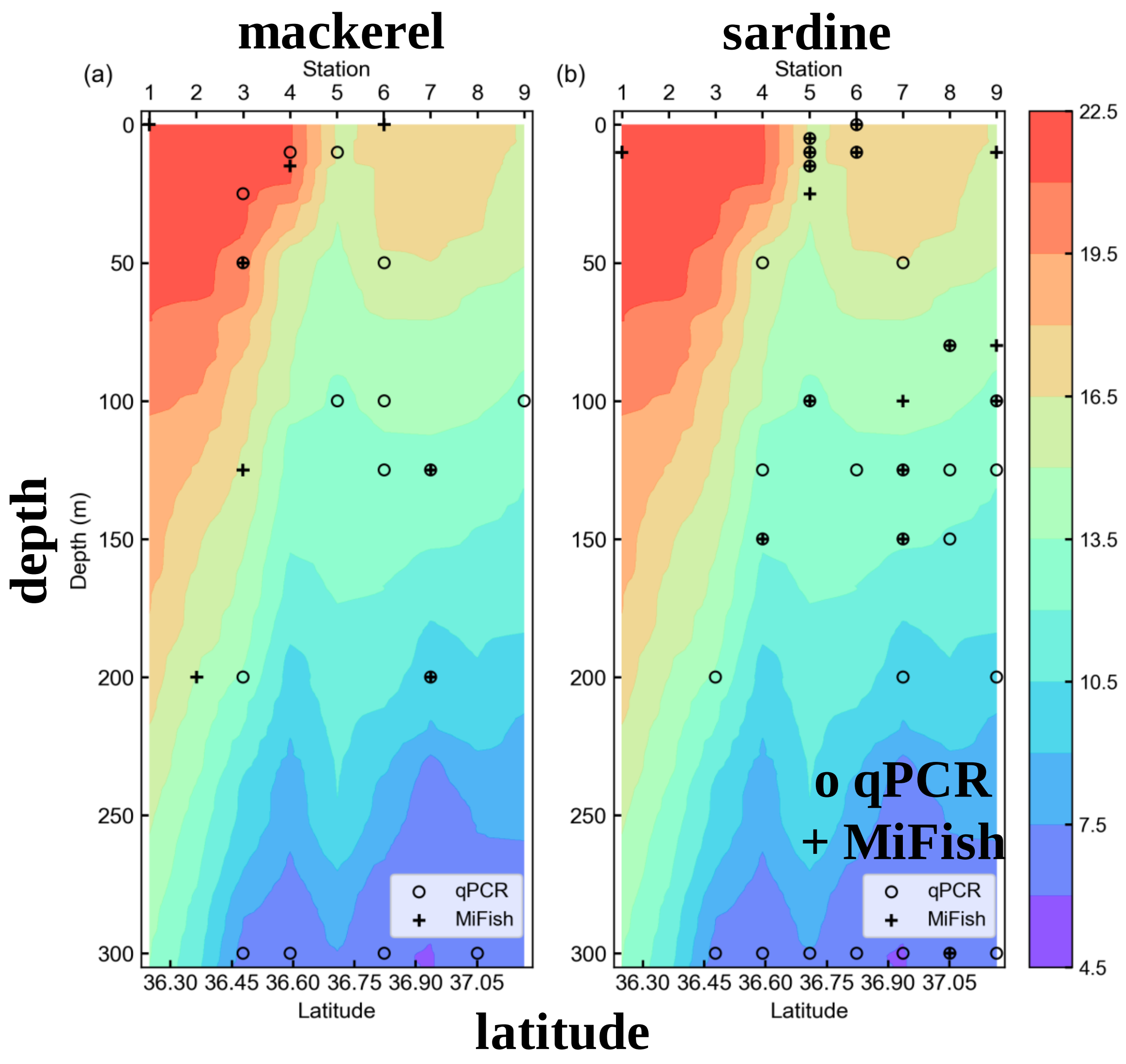


- Fish are releasing many types of creatures to the ocean water.
- Environmental DNA in the sea water (OceanDNA) can be used to detect fish distribution.
- Model derived fish migration accompanied with sub-mesoscale ocean structure can be observed used Ocean DNA.

Wong et al., Ito (2022, Environmental DNA)

OceanDNA for distribution survey





High resolution fish distribution survey using OoceanDNA is possible.

Yu et al., Ito (in revision)

Conclusion

- A new integrated method to elucidate environmental histories of larvae and juveniles, using natural tag chemical component analyses and fish growth–migration models, is proposed.

- The new integrated method can be used to elucidate the fish migration and life strategy and to build up improved fish growth-migration model.

- The improved model can be used to assess and project fish response to climate change.

The new integrated approach will improve our understanding on climate impacts on marine ecosystem.
It will contribute to better sustainable use of marine ecosystem services.

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