Effects of Climate Variability and Change on the Population Dynamics of Cephalopods and a Predictive and Forecast Framework to Inform Fisheries Management

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&

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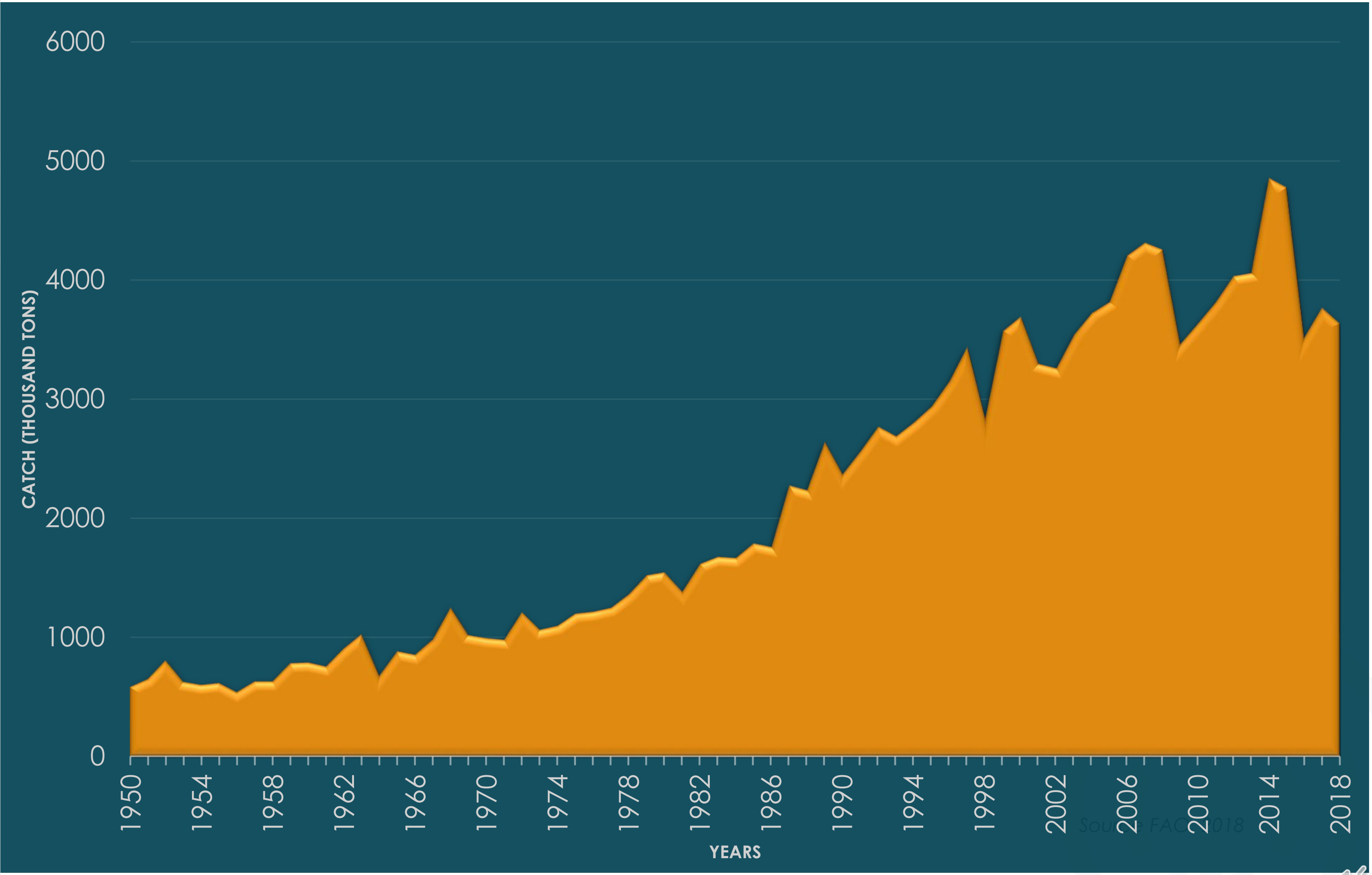
Global Cephalopod Catch (FAO, 2020 Stats)



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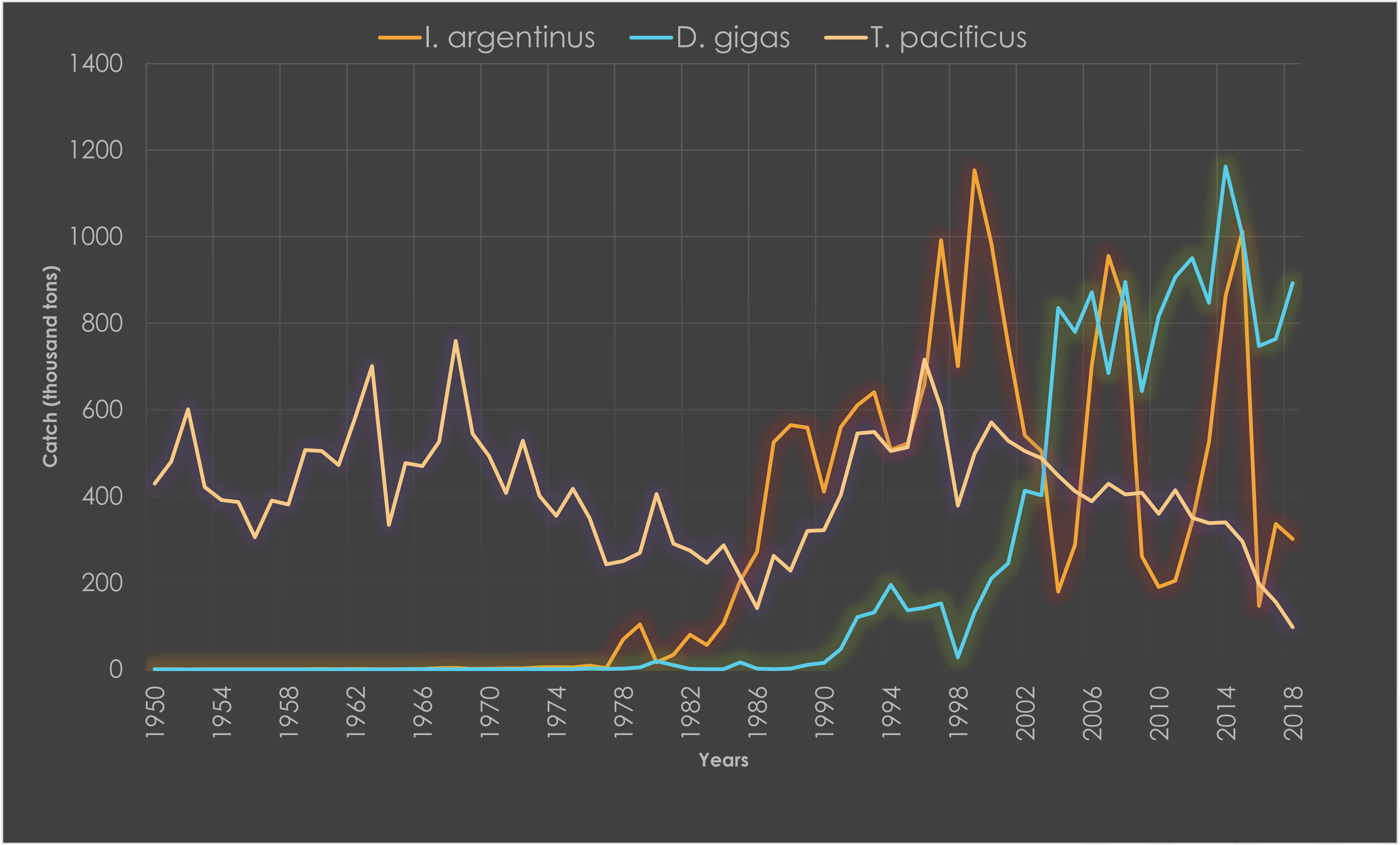
Annual catches for the three largest squid fisheries (*I. argentinus*, *D. gigas* and *T. pacificus*) during 1950-2018



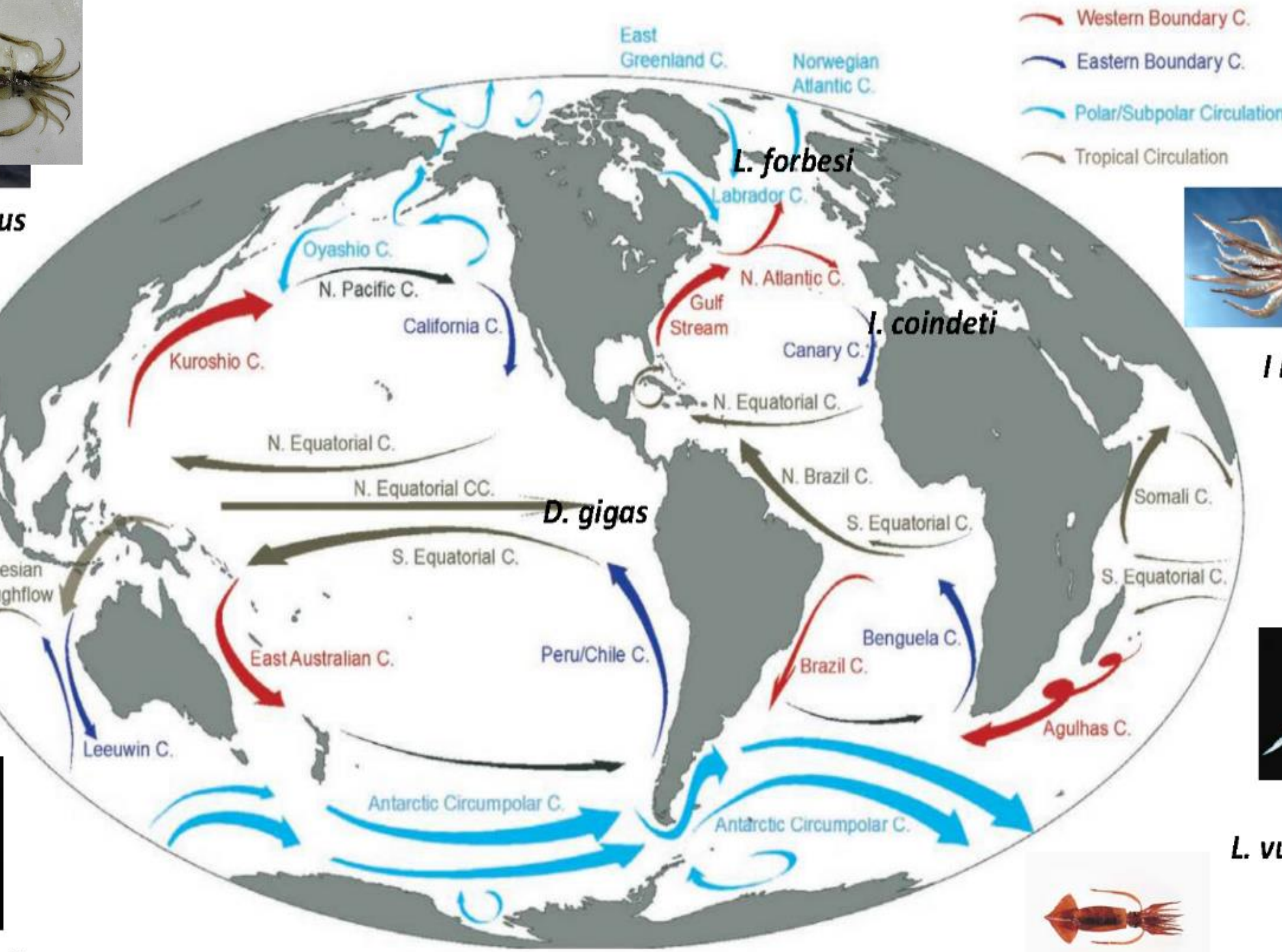
(FAO, 2020)

Why squid?

- Short-lived (annual or sub-annual), Respond quickly to environmental changes
- Early life history of some species is associated with WBCs
- Such species have wide lat. ranges and in both hemispheres
- Support large, valuable fisheries
- Population dynamics = high variability -> need forecasts for adaptive management
- Key ecosystem component

WBCs and their supported Cephalopod populations.

T. pacificus

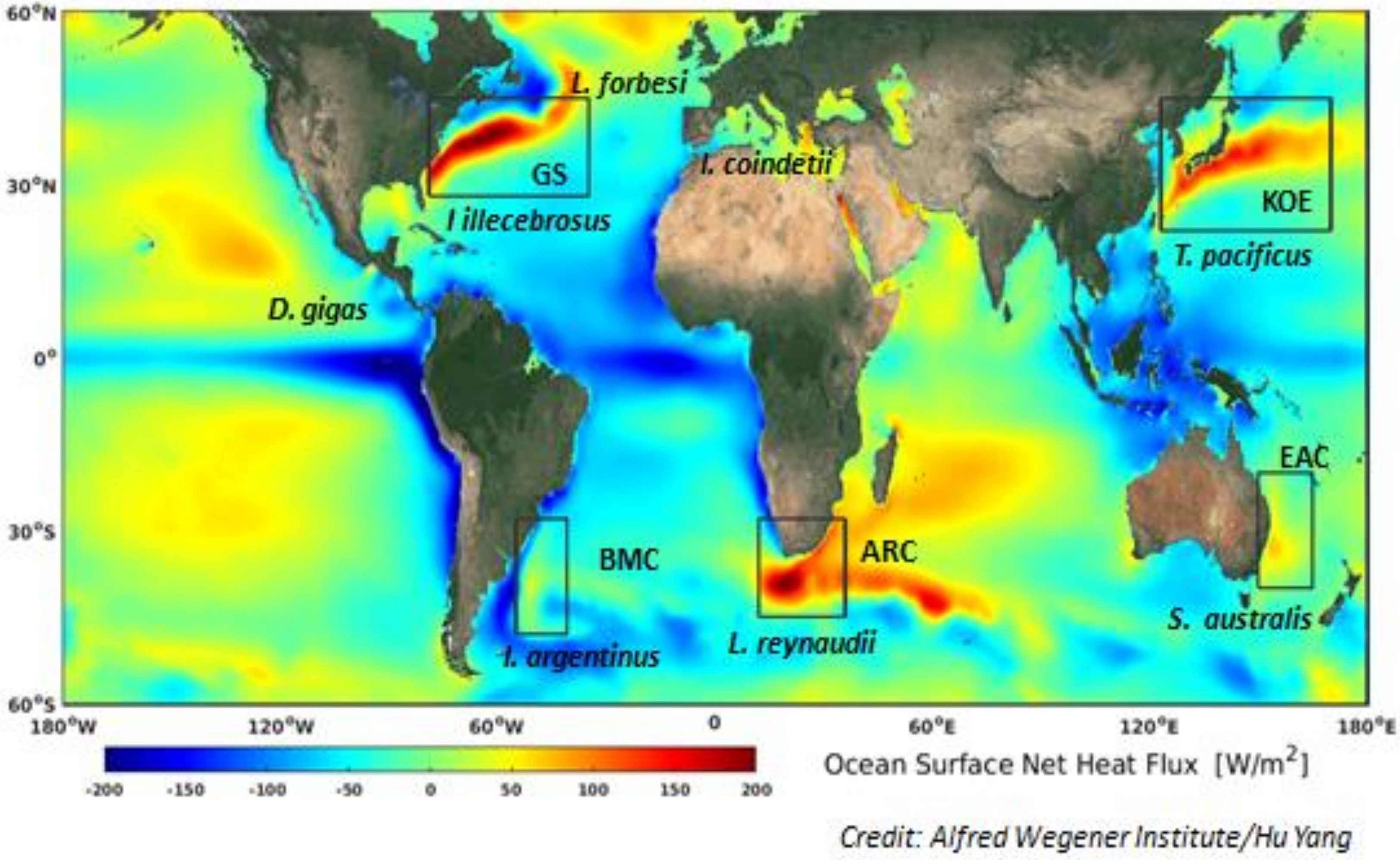


I illecebrosus

L. vulgaris reynaudii

S. australis

I. argentinus

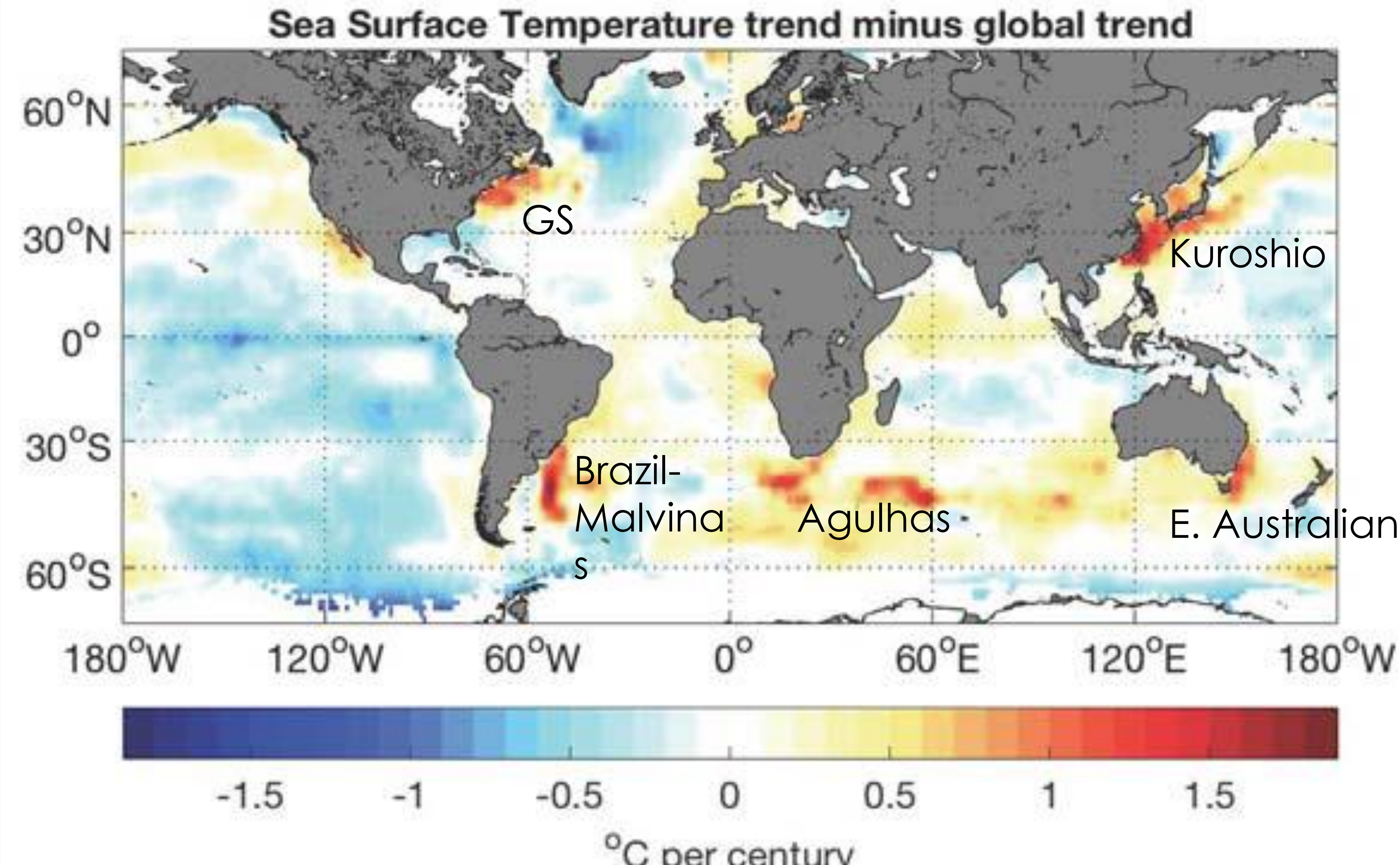


Yang et al. (2016)

Five squid species (boxes) and Western Boundary Currents

Annual mean ocean surface net heat flux (1958-2001)

Is Warming of Global WBCs Impacting Squid Stocks?



inear SST trend anomalies 1900-2016 (global trend of 0.56 ◦C per century removed) Source: monthly HadISST2 reanalysis (Rayner et al., 2003).

Yang et al. 2016

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Potential effects of changing WBCs on associated squid species

1. Temperature – Embryo/paralarvae growth rates
2. Velocity – Egg/paralarvae transport rates
3. Water density – Paralarvae metabolic rates and egg/paralarvae transport rates
4. Meandering – juvenile transport and distribution patterns
5. Latitudinal movement – favorable/unfavorable water mass properties, distance for juvenile travel

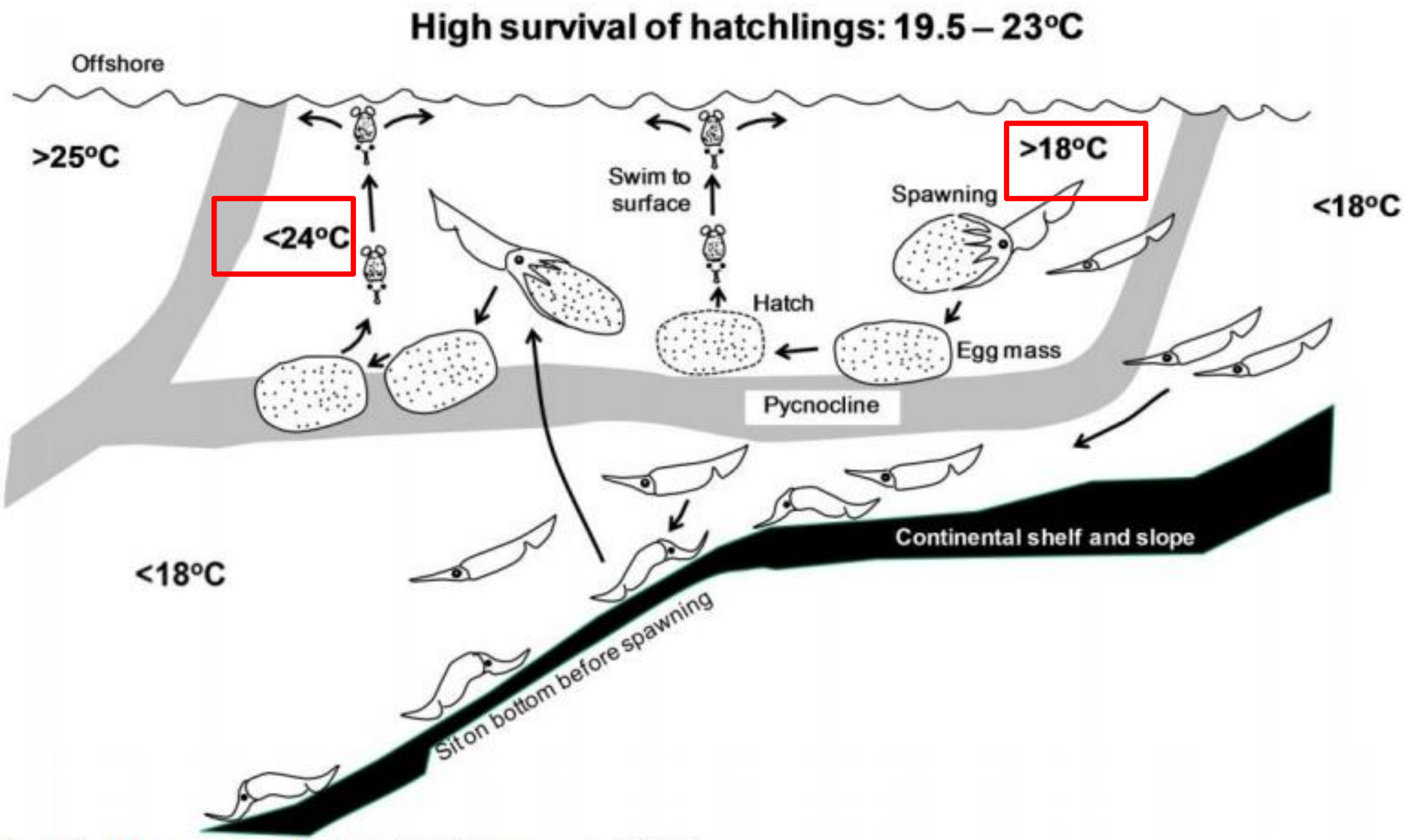
Squid Abundance and Environmental Variability Relationships

1. Differ by life history stage
2. Short time scales, but broad spatial scales with differing environmental conditions
3. Environ. relationships have been identified, but may not be stable due to global impacts on WBCs from climate change

Example: Impacts of Kuroshio Current Changes on

Todarodes pacificus

Life History of *Todarodes pacificus*



(Modified from Sakurai *et al*., 2000, Sakurai, 2006).

From Sakurai et al. 2013

Temperature preferences vary by life history stage

Environmental Predictors

Population dynamics change due to <u>temperature</u> regime shifts

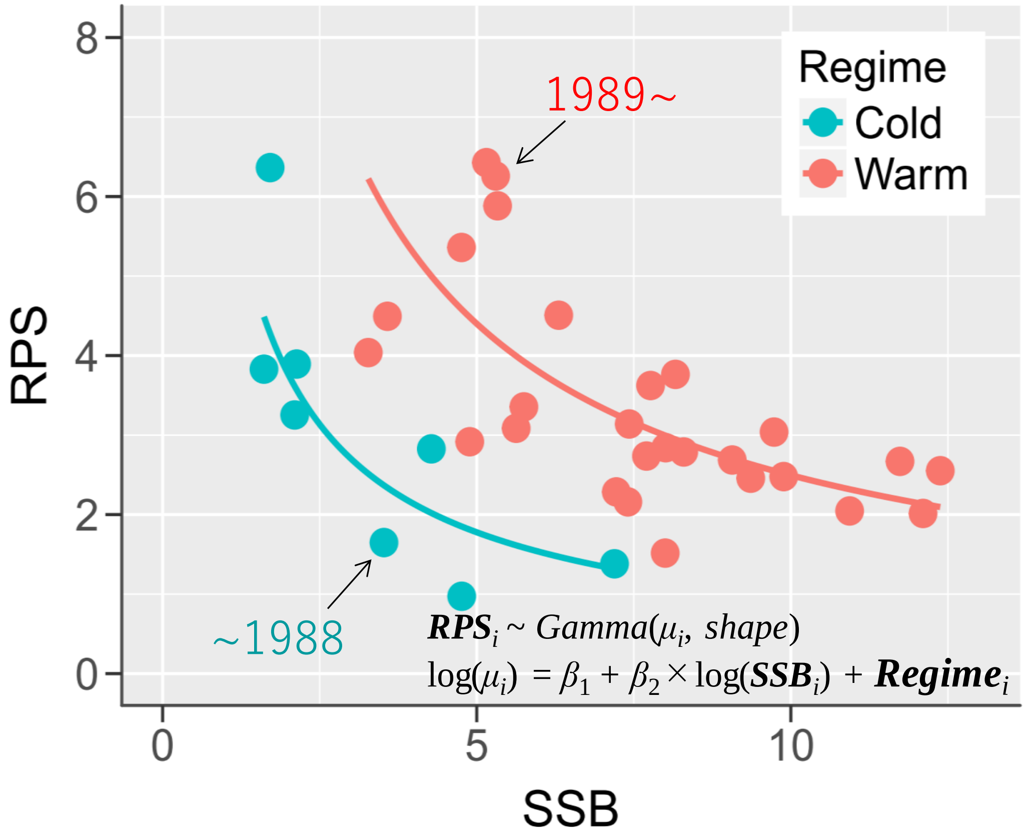
Cool regime (1977-1988) - stock size decreases, small winter spawning area

Warm regime (1989-current) - stock size increases, fall and winter spawning areas larger and overlap

Forecast modeling and issues

- In the developmental stages for most squid stocks, some data gaps
- Even short-term (1 yr) forecasts have very wide confidence limits
- May need two sets of harvest control rules: for low vs high productivity regimes
- Need buy-in of fishers/managers (e.g., quota reductions during low prod. Years)

T. pacificus BRPs

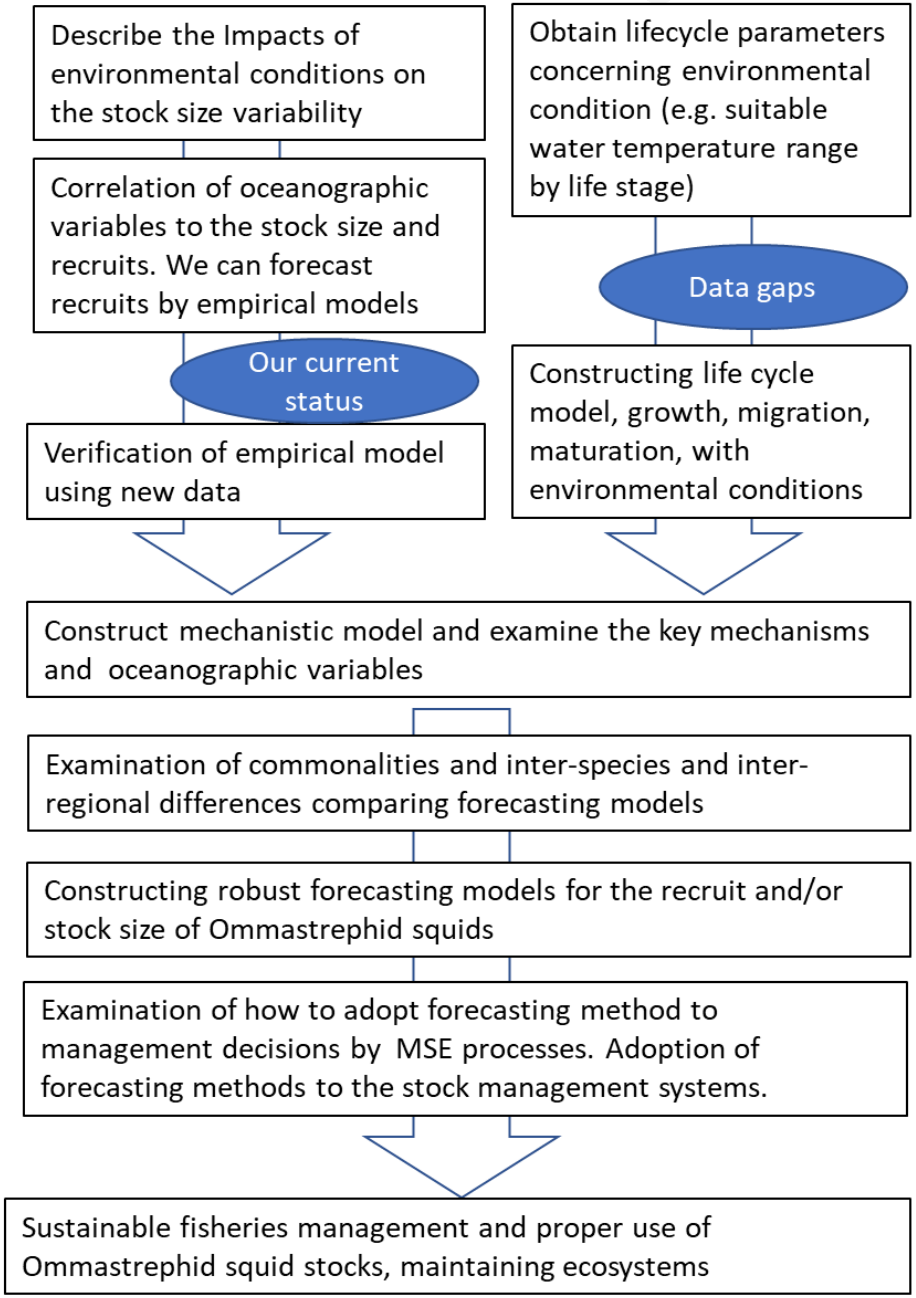


(Kidokoro et al., 2013; Yamashita and Kaga, 2013)

BRPs based on S/R relationship

Low/high stock size is dependent on cold/warm temperature regimes, so S/R BRPs are regime-specific

Schematic road map, toward predictive models for squid fisheries management



Conclusions

- Cephalopods populations are very sensitive to env. variability
- Species show wide fluctuations in abundance, and that this is most evident for the ommastrephid nerito-oceanic squid.
- The large exploited stocks of ommastrephids are mostly associated with large-scale oceanographic processes such as high velocity western boundary current systems of the Atlantic and Pacific Oceans and eastern boundary current ecosystem of the Pacific.
- Urgent need for further research and development of tools to support squid fisheries management.
- Ecological fishery forecasting squid distribution and abundance has emerged as a potential tool that could help decision-makers and managers and stakeholders plan for the future

Thank you

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