



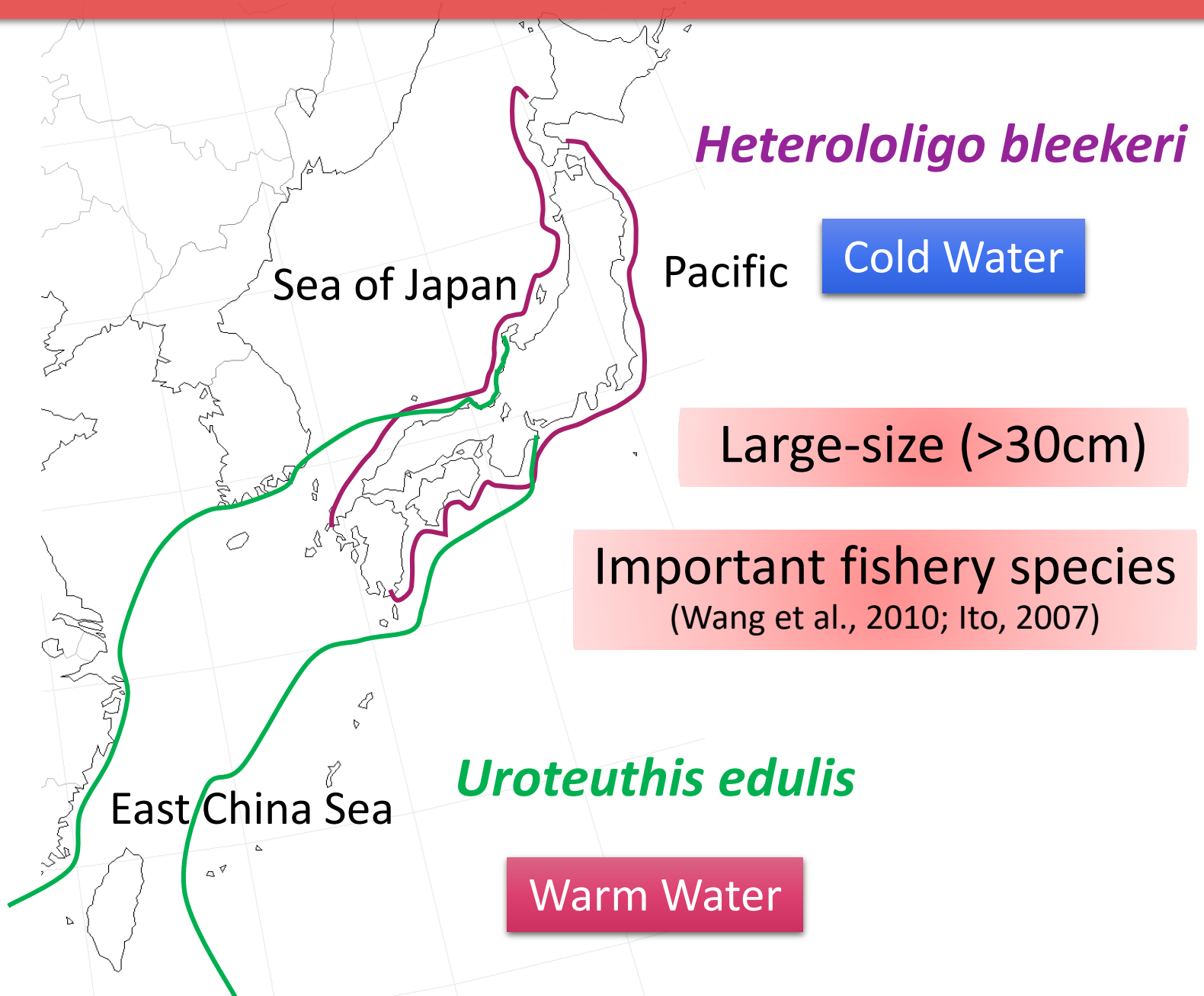
Environmental effects on reproductive traits in cold/warm-water squids: implications on catch fluctuation

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Introduction Squids around Japan Sea



Introduction Spawning season & Ecology

Heterololigo bleekeri

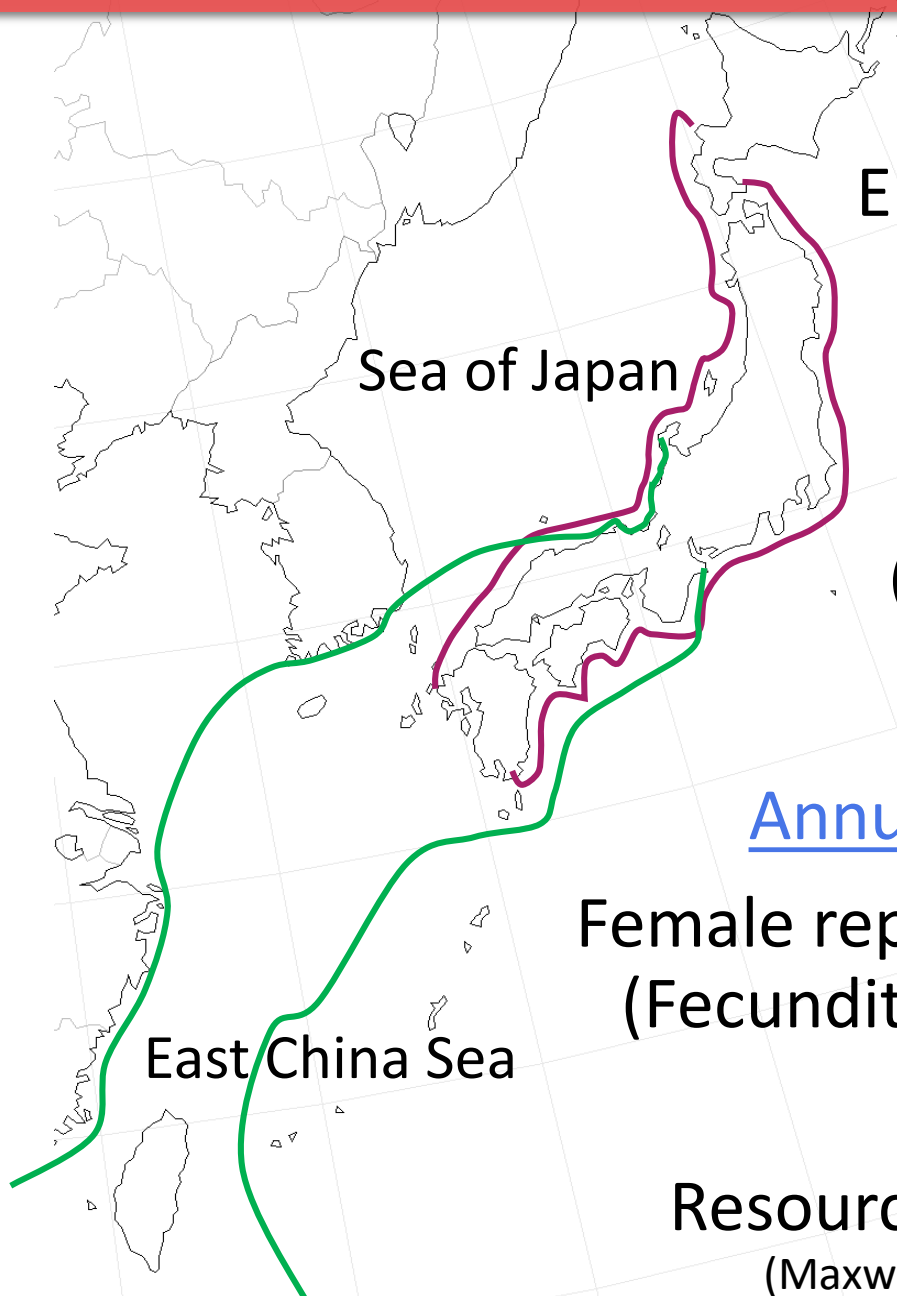
Winter

January – April
(Kawano, 2005; Ito, 2007)

Uroteuthis edulis

All year around

Spawning peaks
West Japan Sea: Summer
East China Sea:
Spring & Autumn
(Wang et al., 2008)



Environmental changes
(WT, food condition)



Life history traits
(growth, maturation and reproduction)
(Pecl & Jackson, 2008)

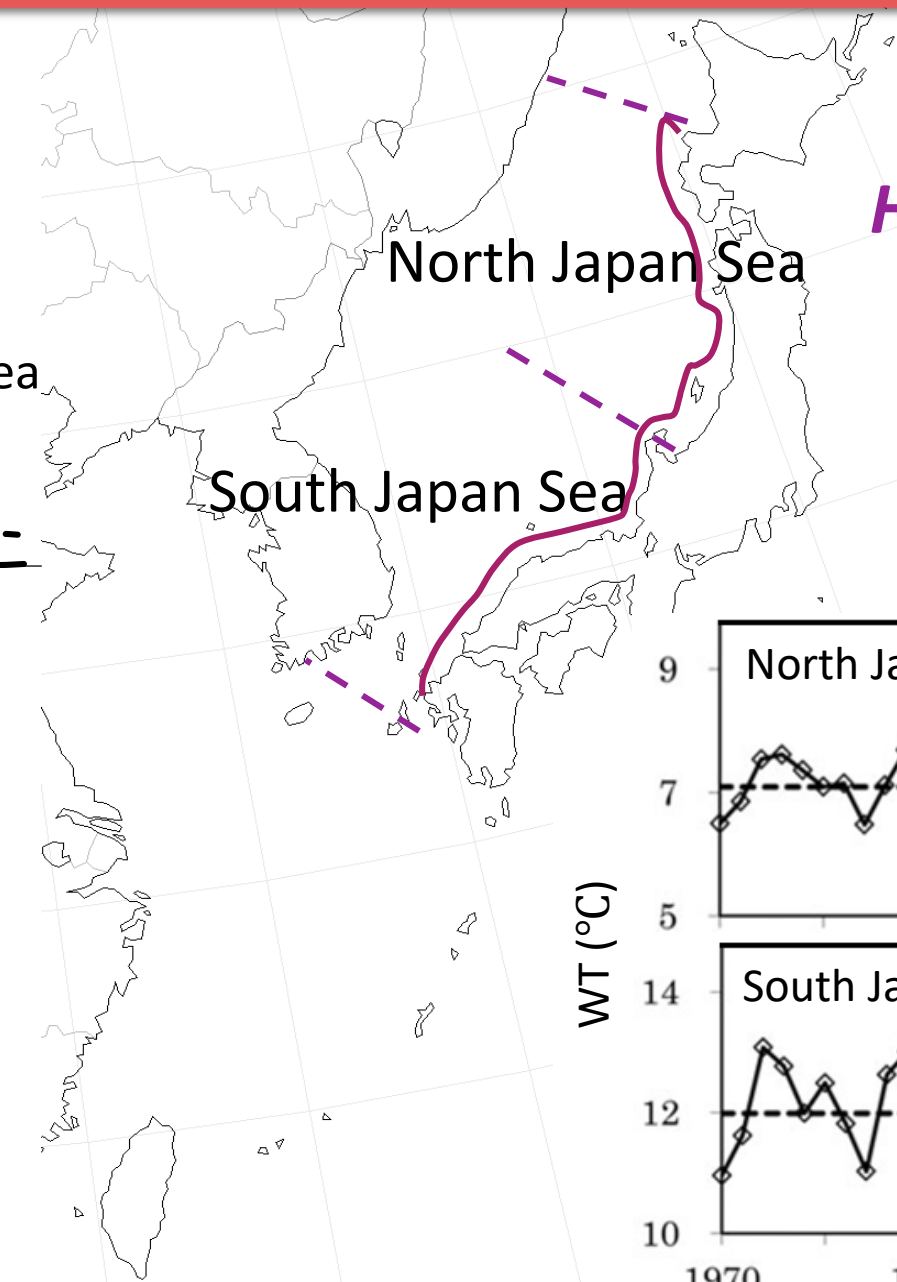
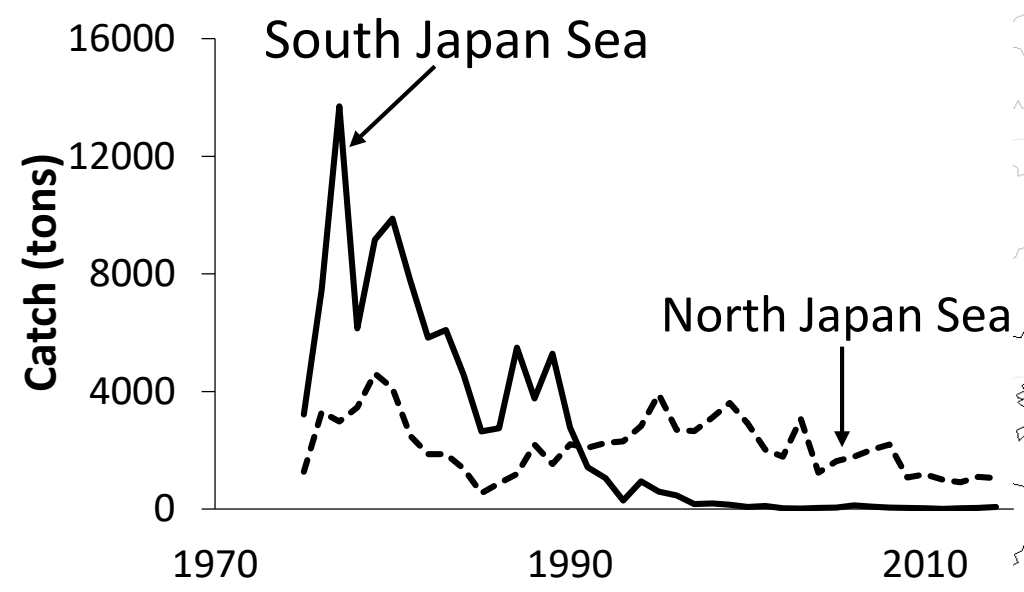
Annual species

Female reproductive traits
(Fecundity & Egg traits)

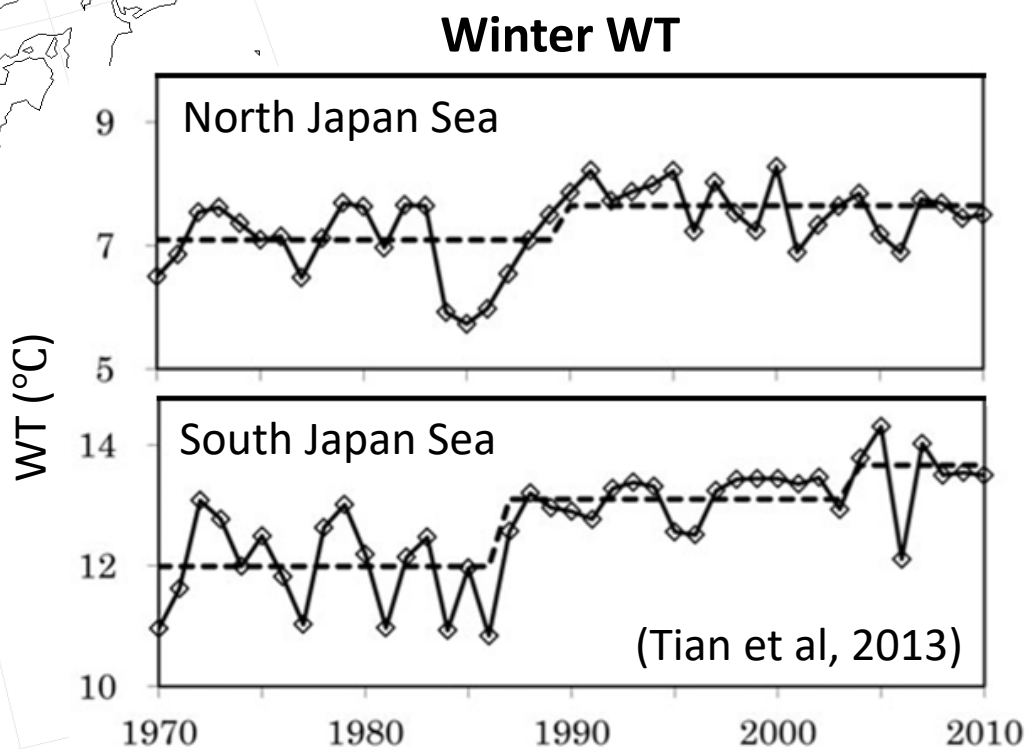
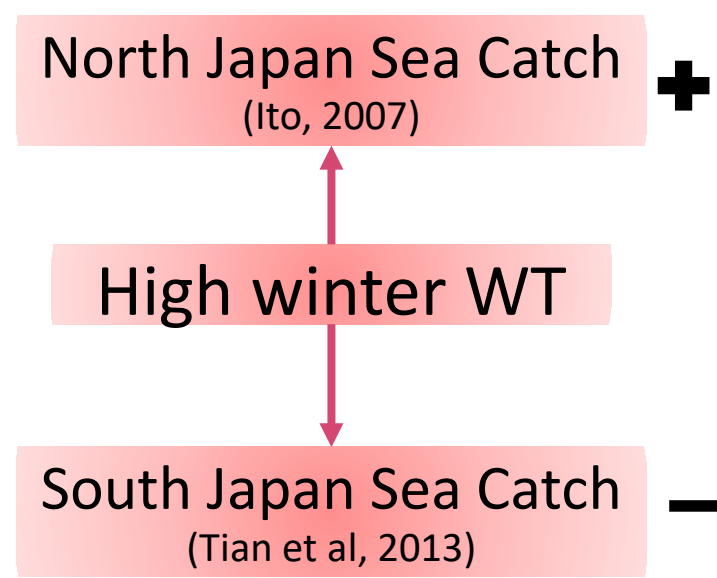


Resource fluctuation
(Maxwell et al., 2005)

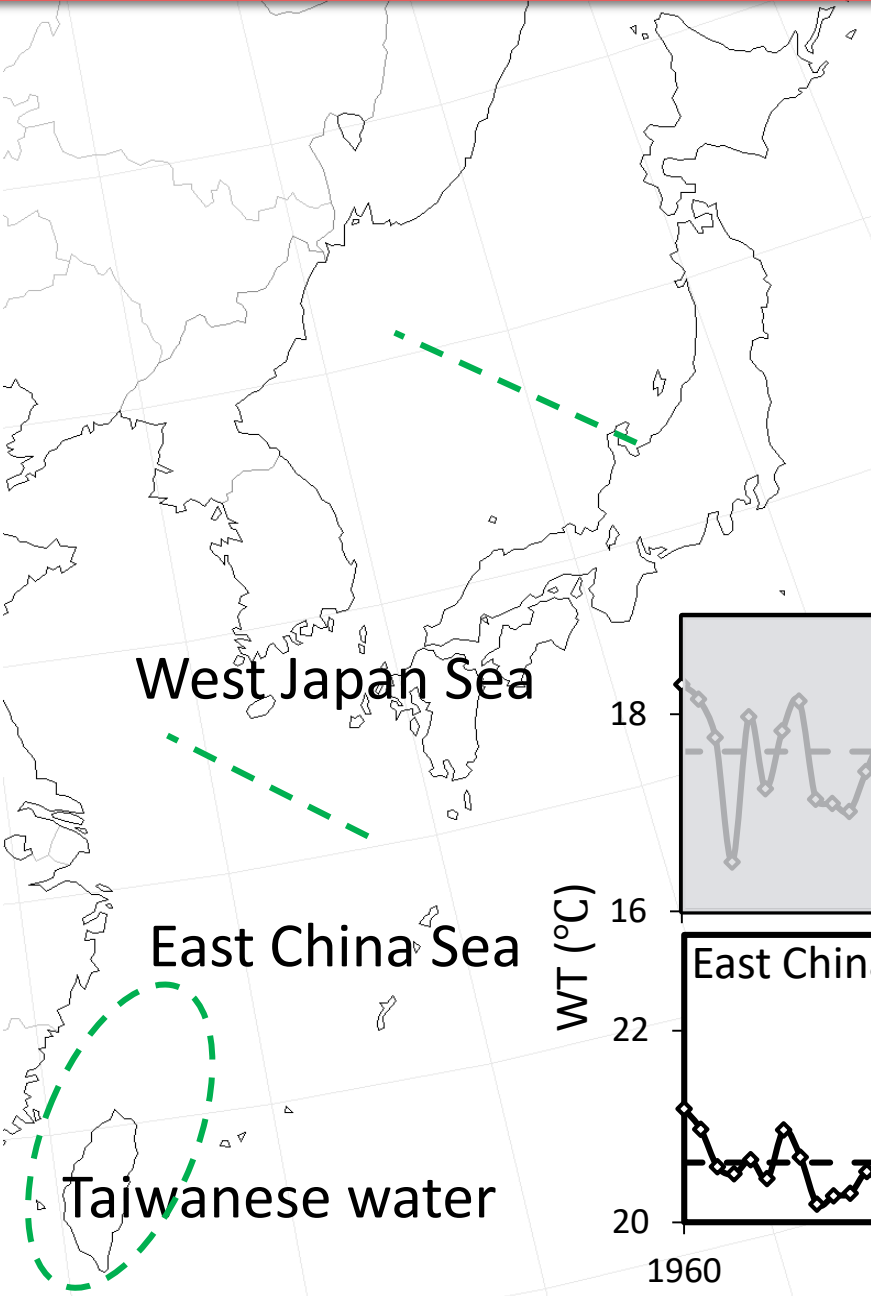
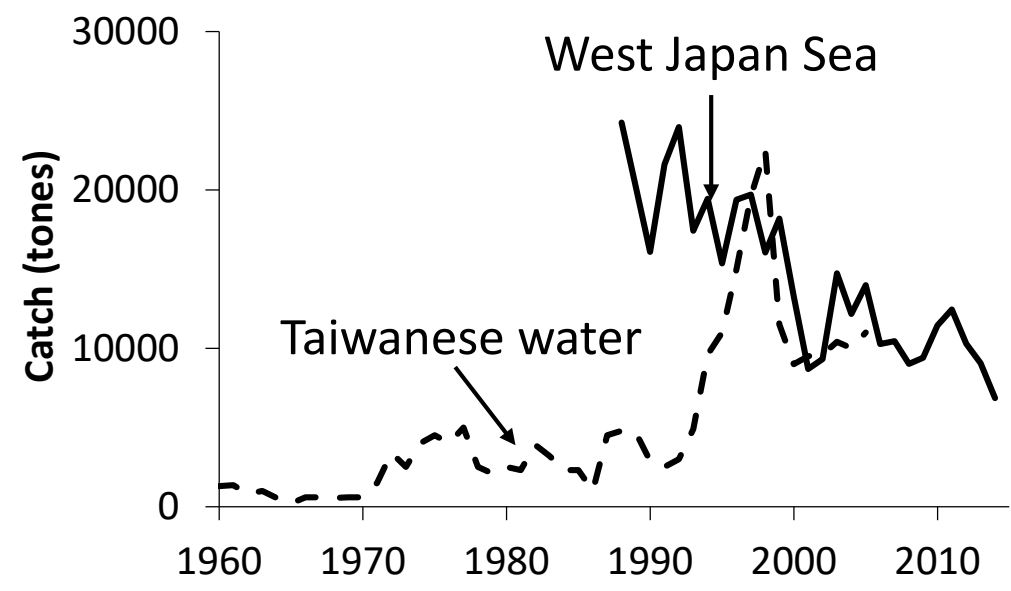
Introduction Catch fluctuation and its connection with WT



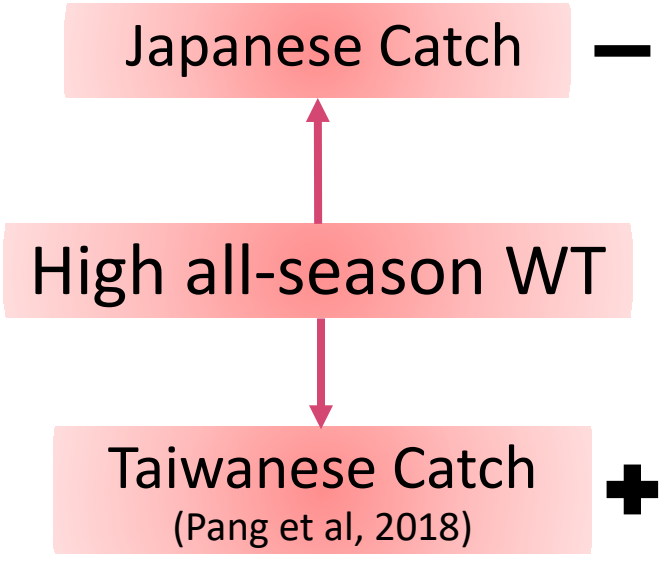
Heterololigo bleekeri
Winter Spawning



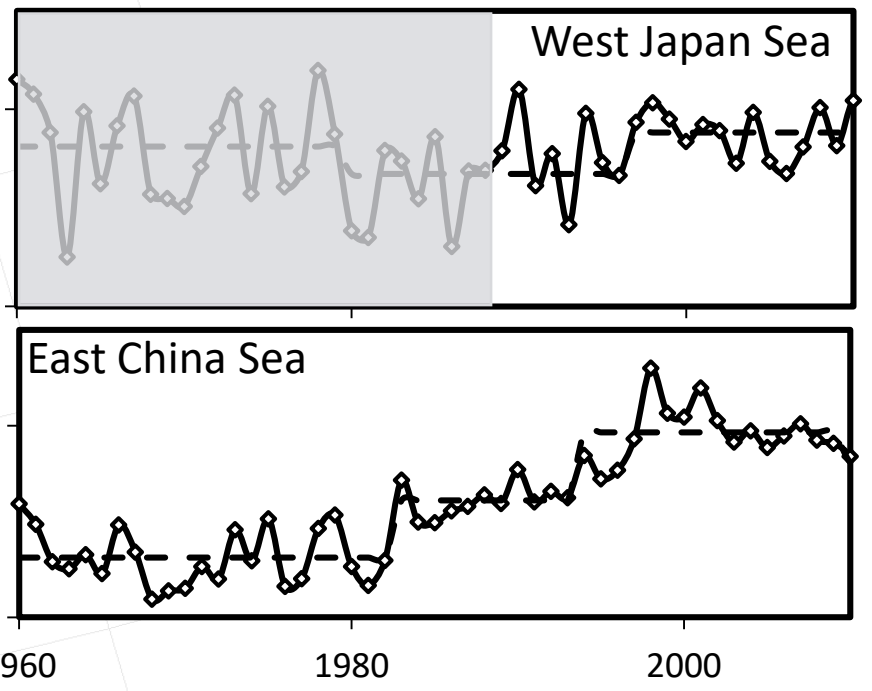
Introduction Catch fluctuation and its connection with WT



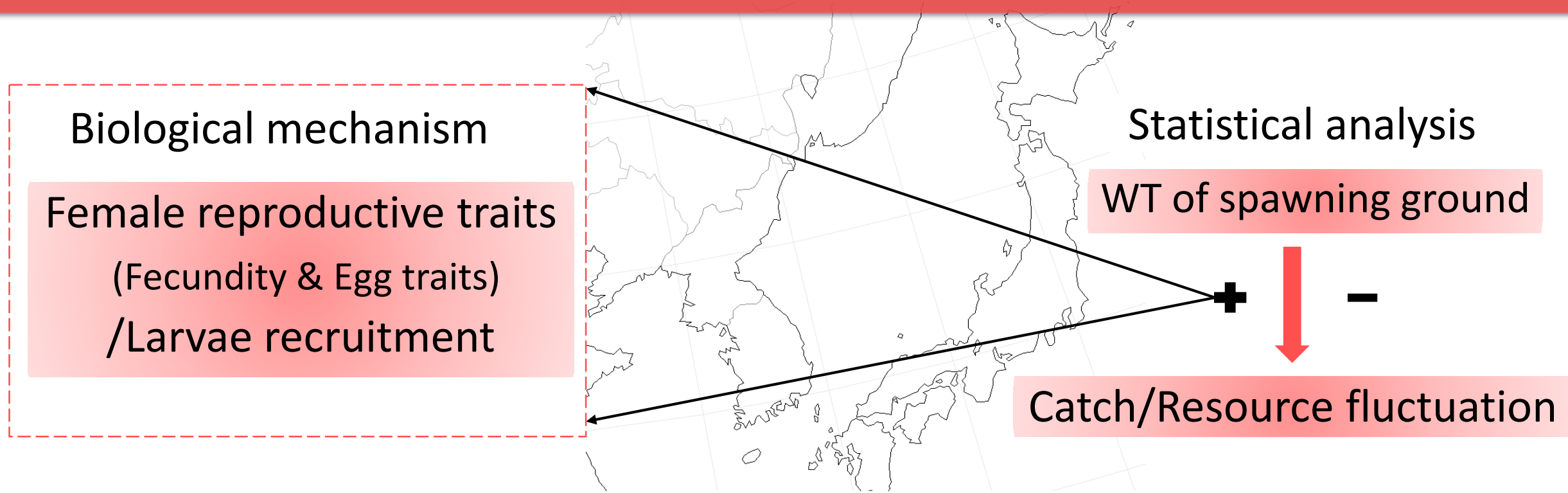
Uroteuthis edulis
All year around
Spawning



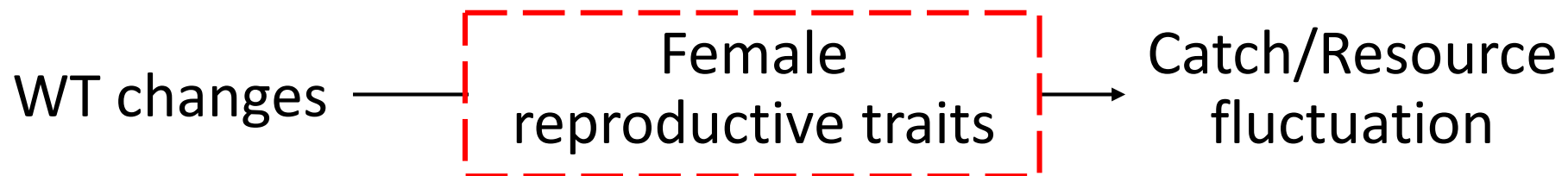
Average yearly WT



Study Purpose



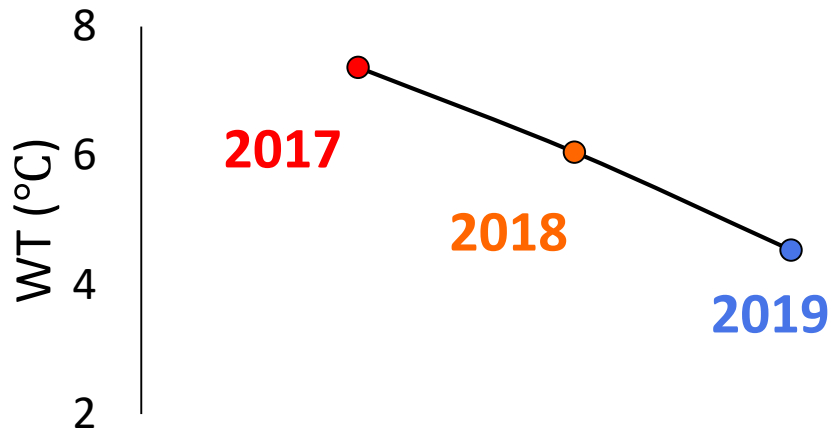
Through comparing different geographical populations of
cold water Heterololigo bleekeri & *warm water Uroteuthis edulis*



Sampling sites, period and WT profile (*H.bleekeri*)

Heterololigo bleekeri

Average (Jan-Apr) WT in sampling site



2017 > 2018 > 2019

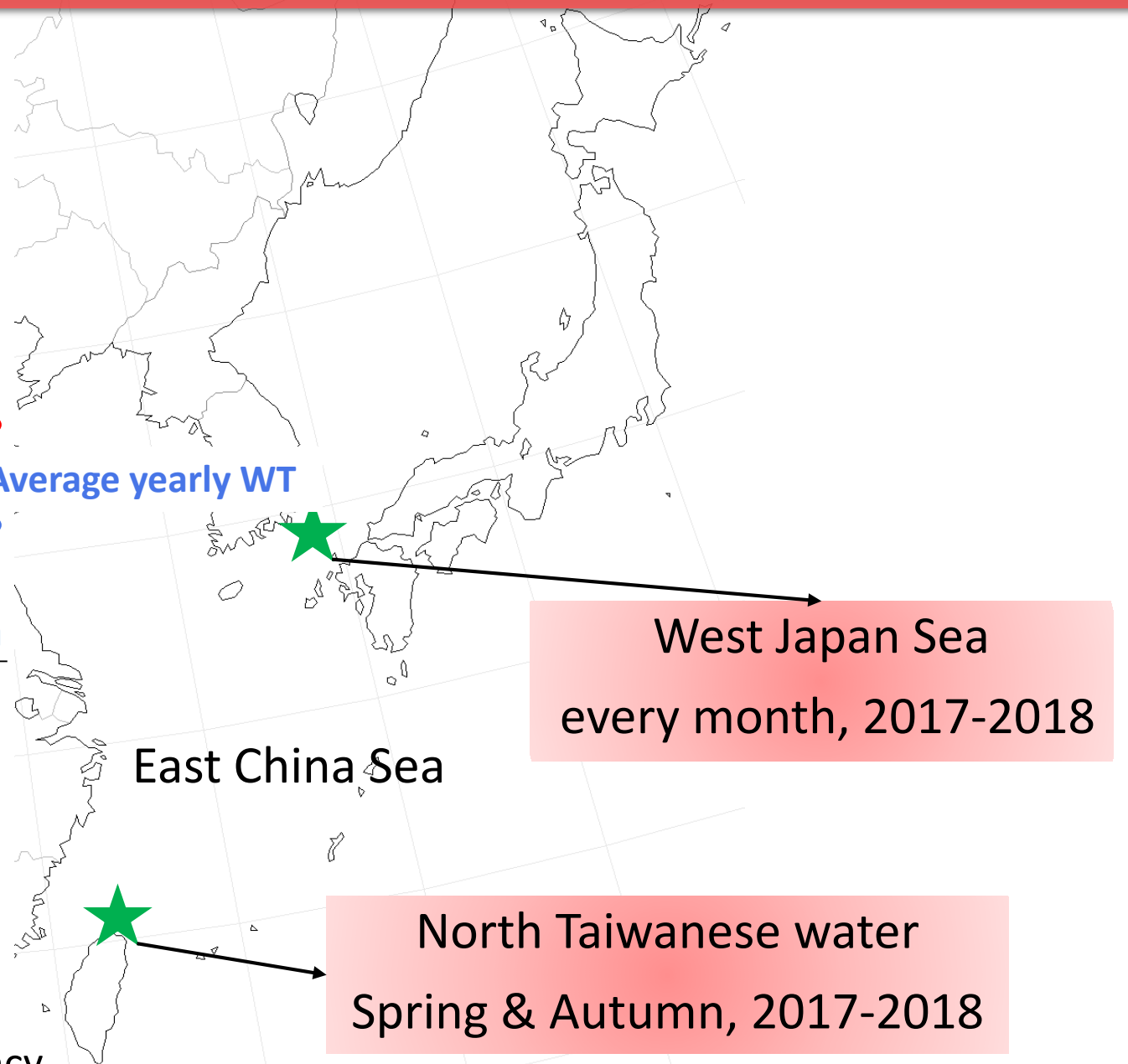
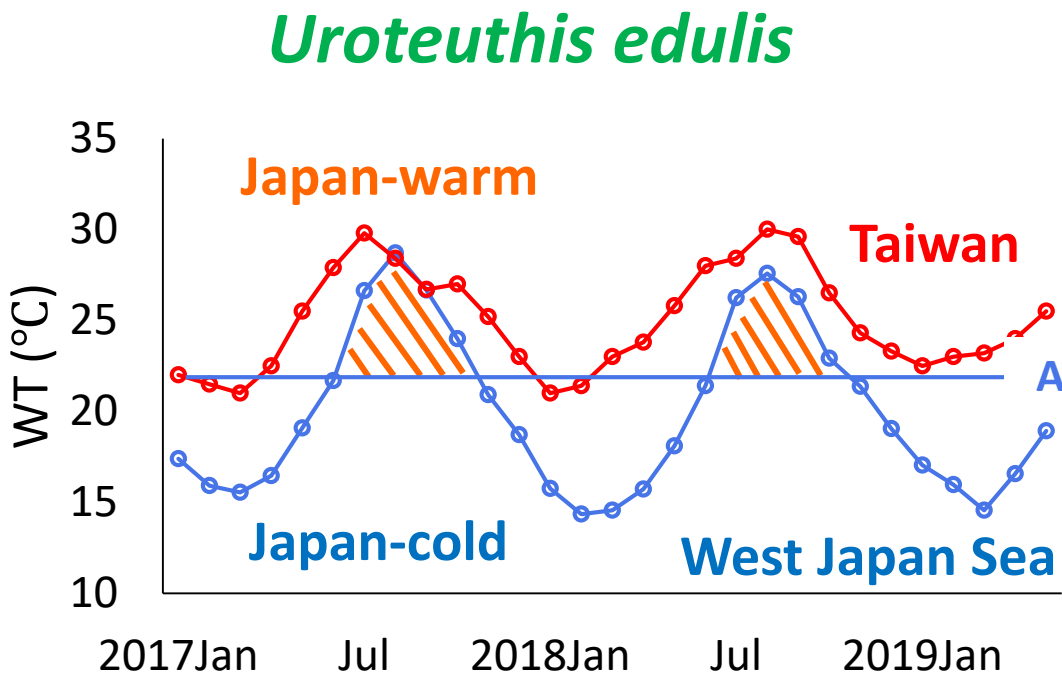
Japan Meteorological Agency



North Japan Sea
January–April
2017-2019

South Japan Sea
No Samples

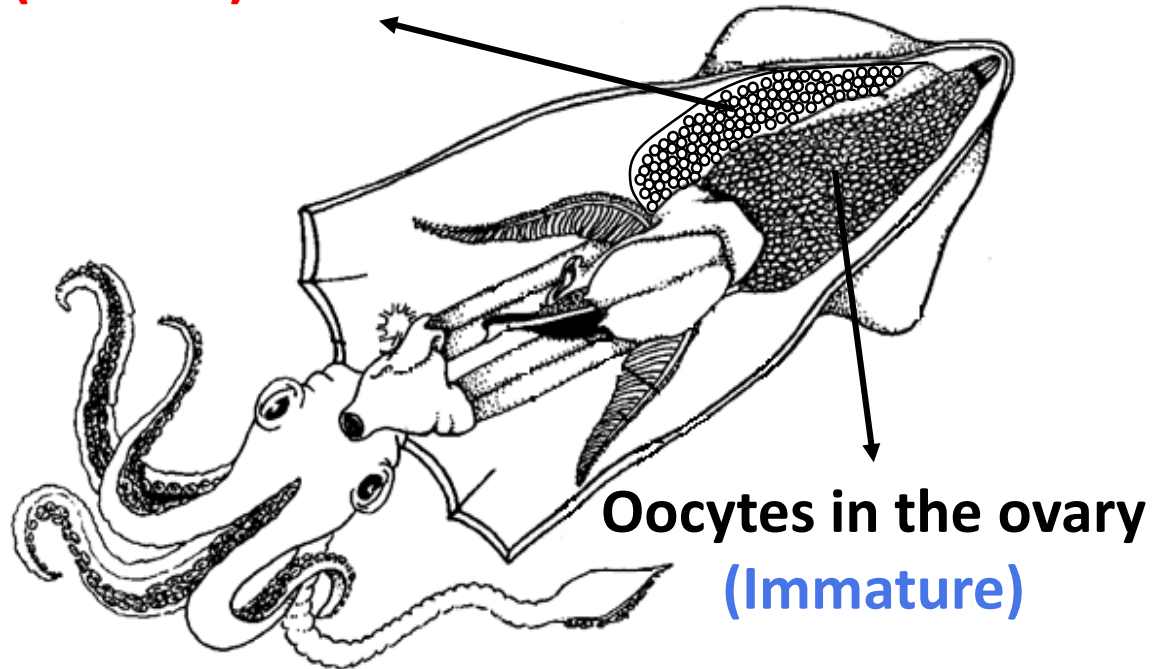
Sampling sites, period and WT profile (*U.edulis*)



Taiwan > Japan warm > Japan cold

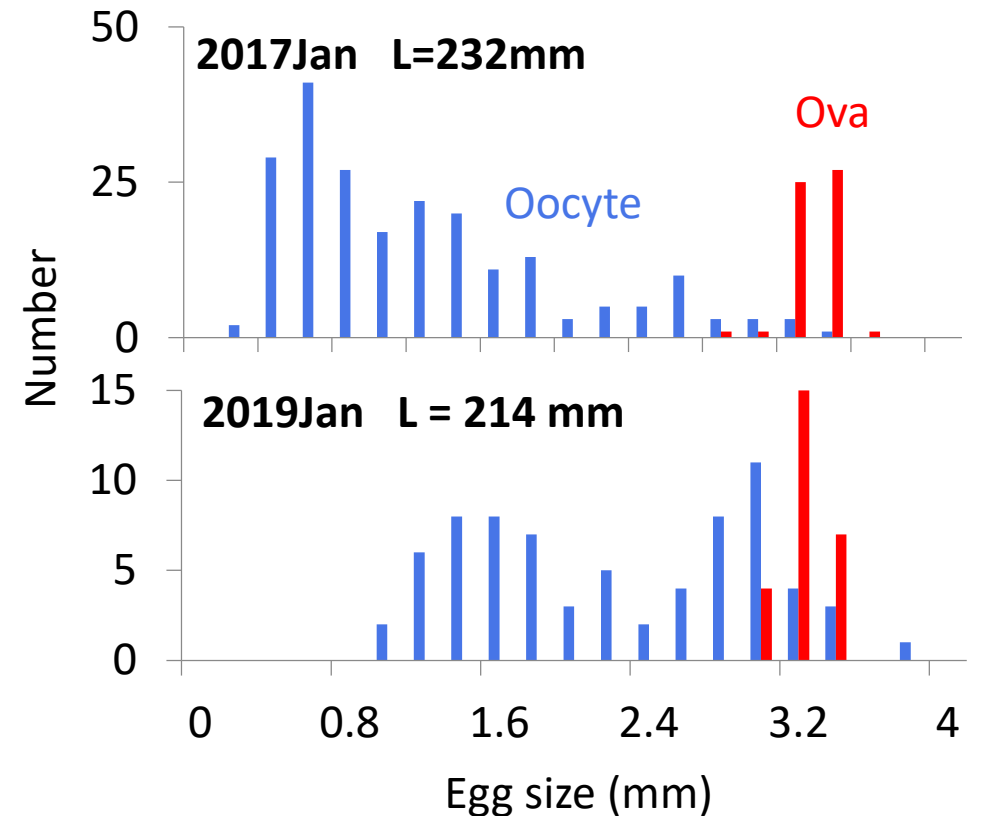
Biological data Mature female Reproductive traits

(Mature) Ova in the oviduct



- Fecundity
the number of oocytes (1g sub-sample)
- Batch fecundity
the number of ova (1g sub-sample)

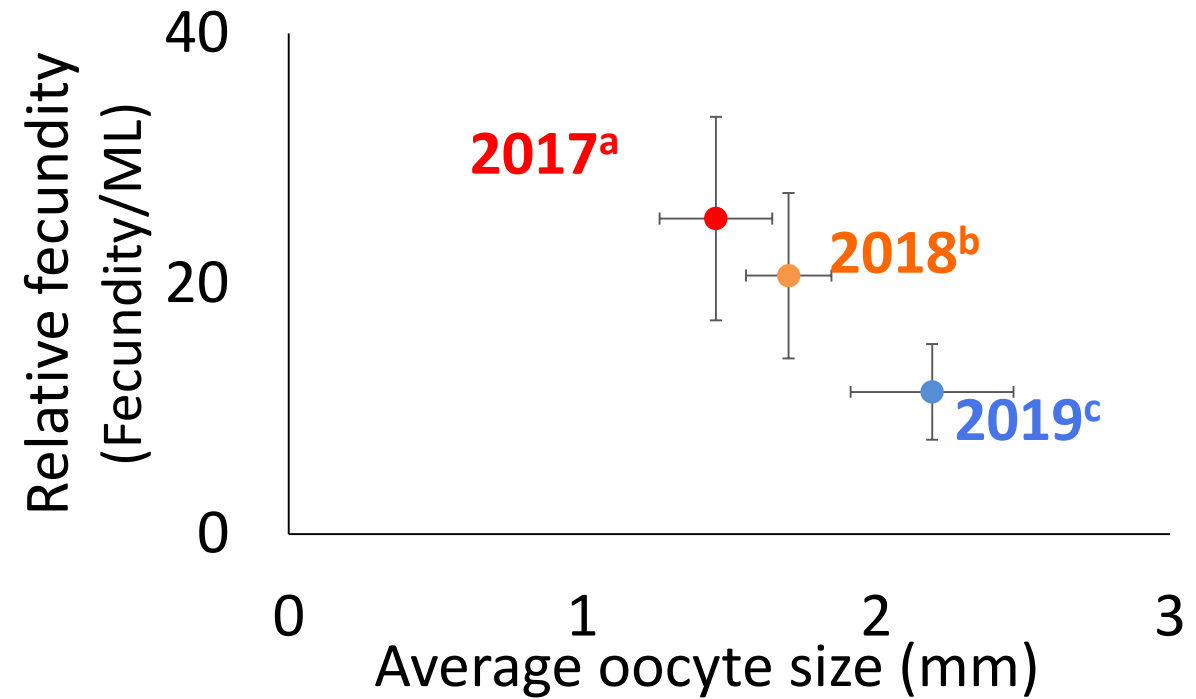
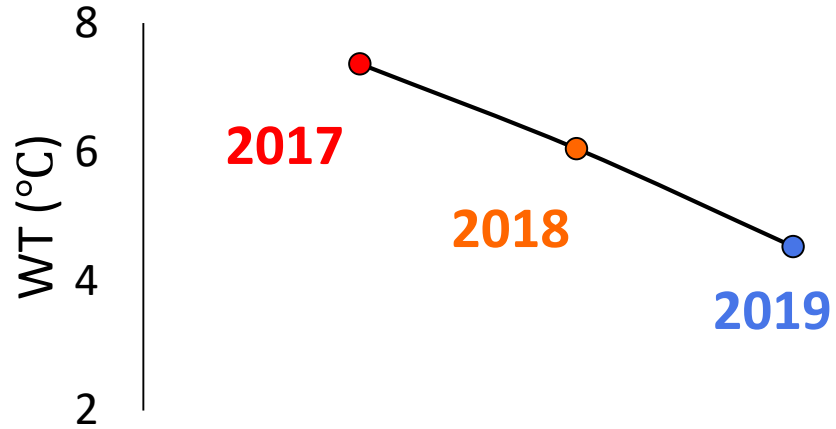
Intermittent terminal spawning



- Average oocyte size (>100 eggs)
- Average ova size (>50 eggs)

Result *Heterololigo bleekeri* – Fecundity & Oocyte size

Heterololigo bleekeri



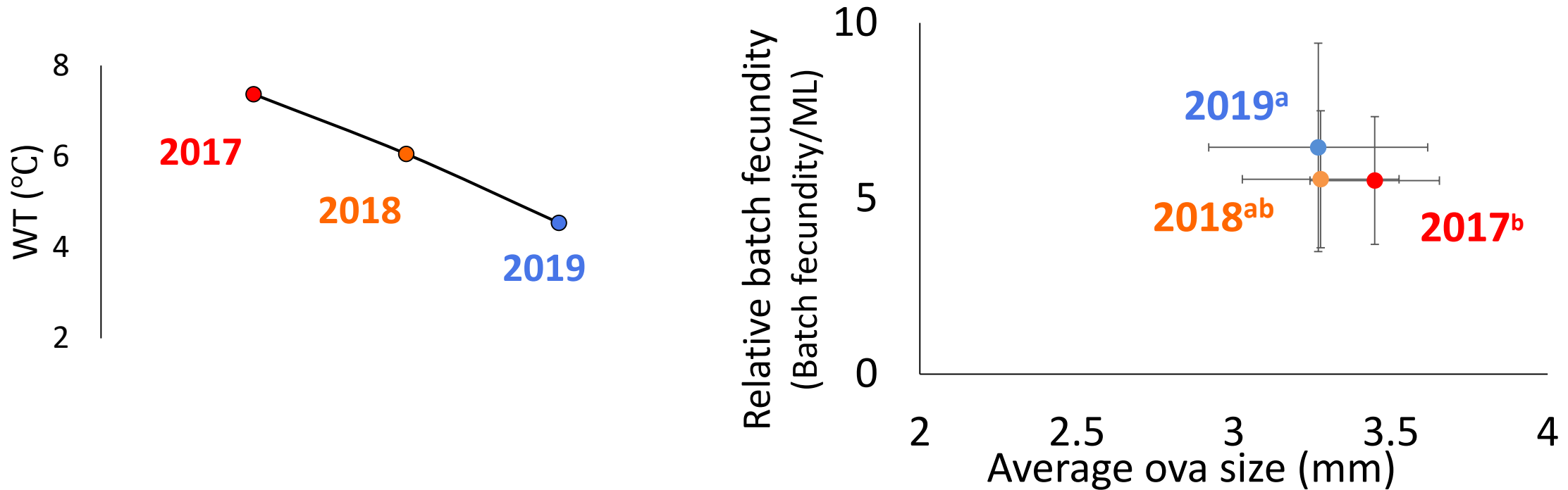
To a cold environment (2017 → 2019)

Fecundity level ↓ & Oocyte size ↑

(ANCOVA, Fecundity : $p < 0.0001$, oocyte size: $p < 0.0001$)

Result *Heterololigo bleekeri* – Batch fecundity & Ova size

Heterololigo bleekeri



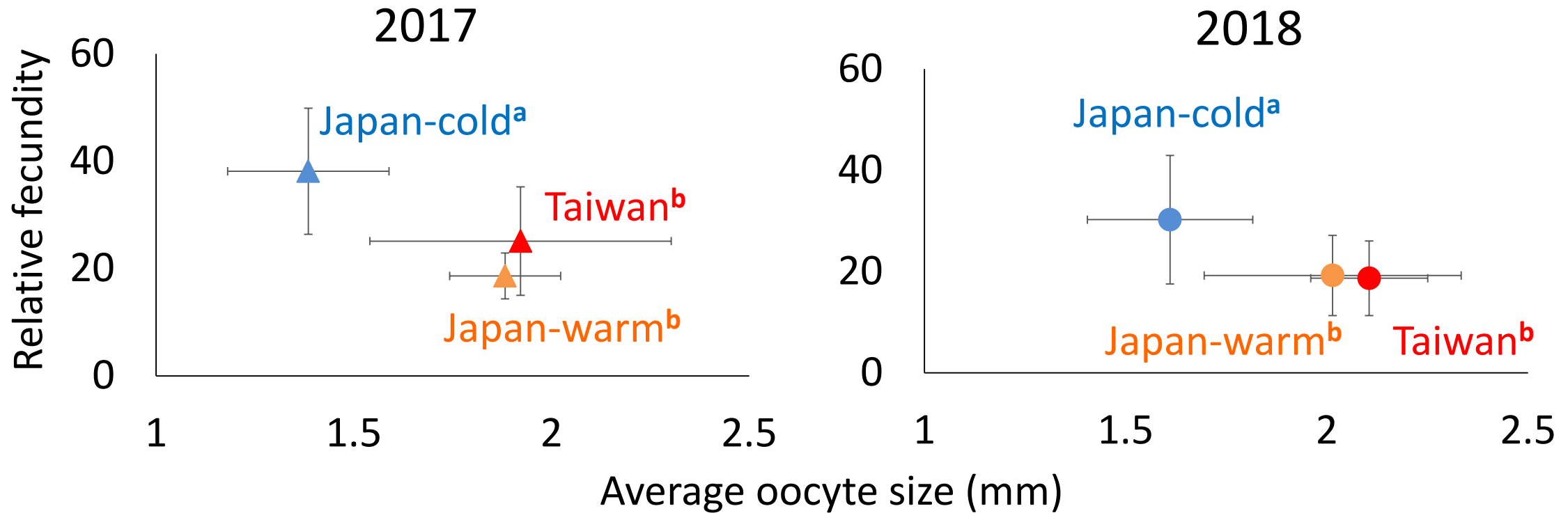
To a cold environment (2017 → 2019)

Batch fecundity ↑ & Ova size ↓

(ANCOVA, batch fecundity: $p < 0.001$; ova size: $p < 0.05$)

Result *Uroteuthis edulis* – Fecundity & Oocyte size

Uroteuthis edulis



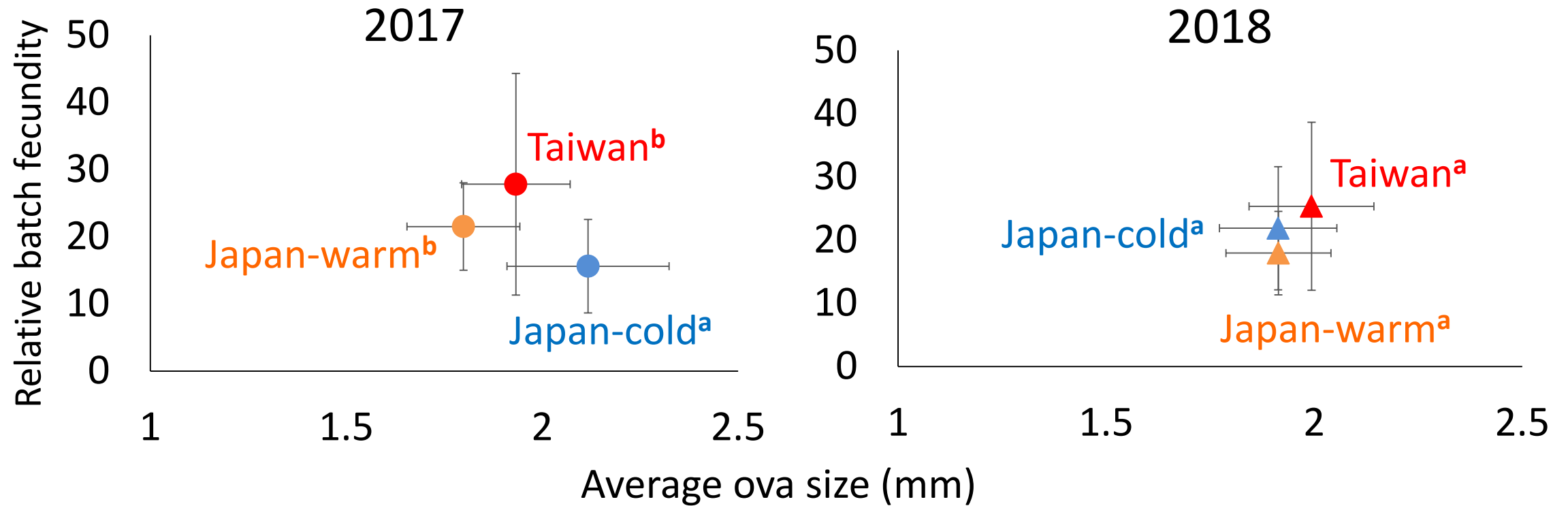
In a warm environment (Japan-cold → Taiwan)

Fecundity level ↓ & Oocyte size ↑

(ANCOVA, Fecundity : $p < 0.0001$, oocyte size: $p < 0.0001$)

Result *Uroteuthis edulis* – Batch fecundity & Ova size

Uroteuthis edulis



In a warm environment (Japan-cold → Taiwan)

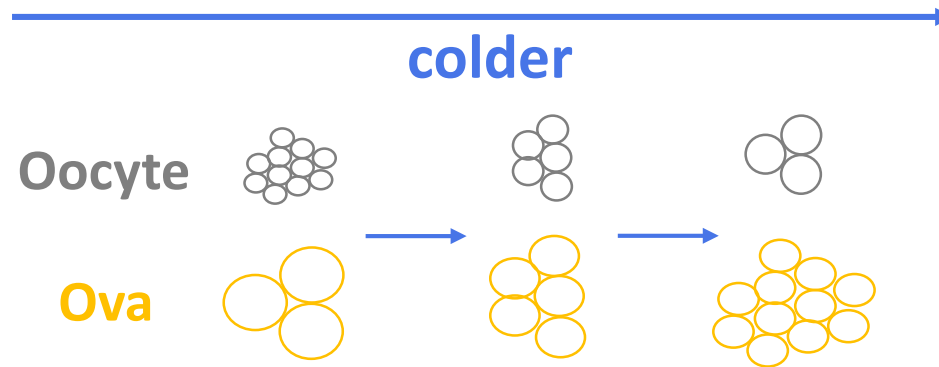
Batch fecundity ↑ & Ova size ↓

(ANCOVA, batch fecundity: $p < 0.001$; ova size: $p < 0.01$)

Summary

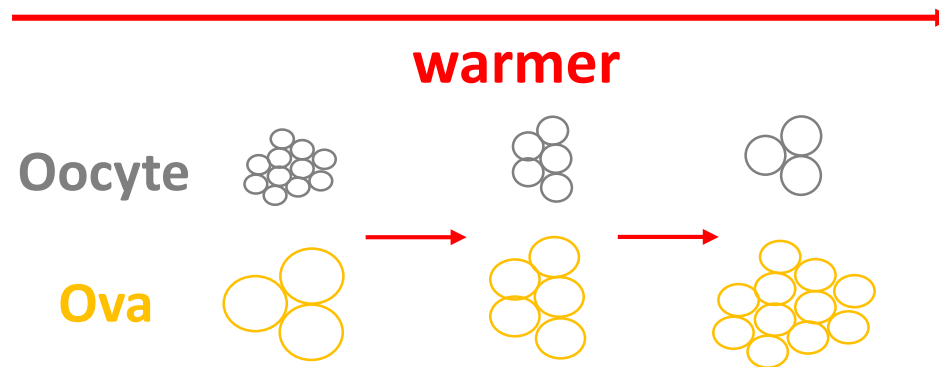
When WT of spawning ground changes,

Cold water
Heterololigo bleekeri



Reproductive traits (fecundity, egg traits) are changed in the similar pattern.

Warm water
Uroteuthis edulis



Opposite biological response in cold- and warm-water species

Discussion

Potential biological mechanism

Heterololigo bleekeri

High spawning ground WT

High fecundity

North Japan Sea Catch



Uroteuthis edulis

High spawning ground WT

Low fecundity

Japanese Catch



Statistical analysis

Heterololigo bleekeri

North Japan Sea Catch
(Ito, 2007)

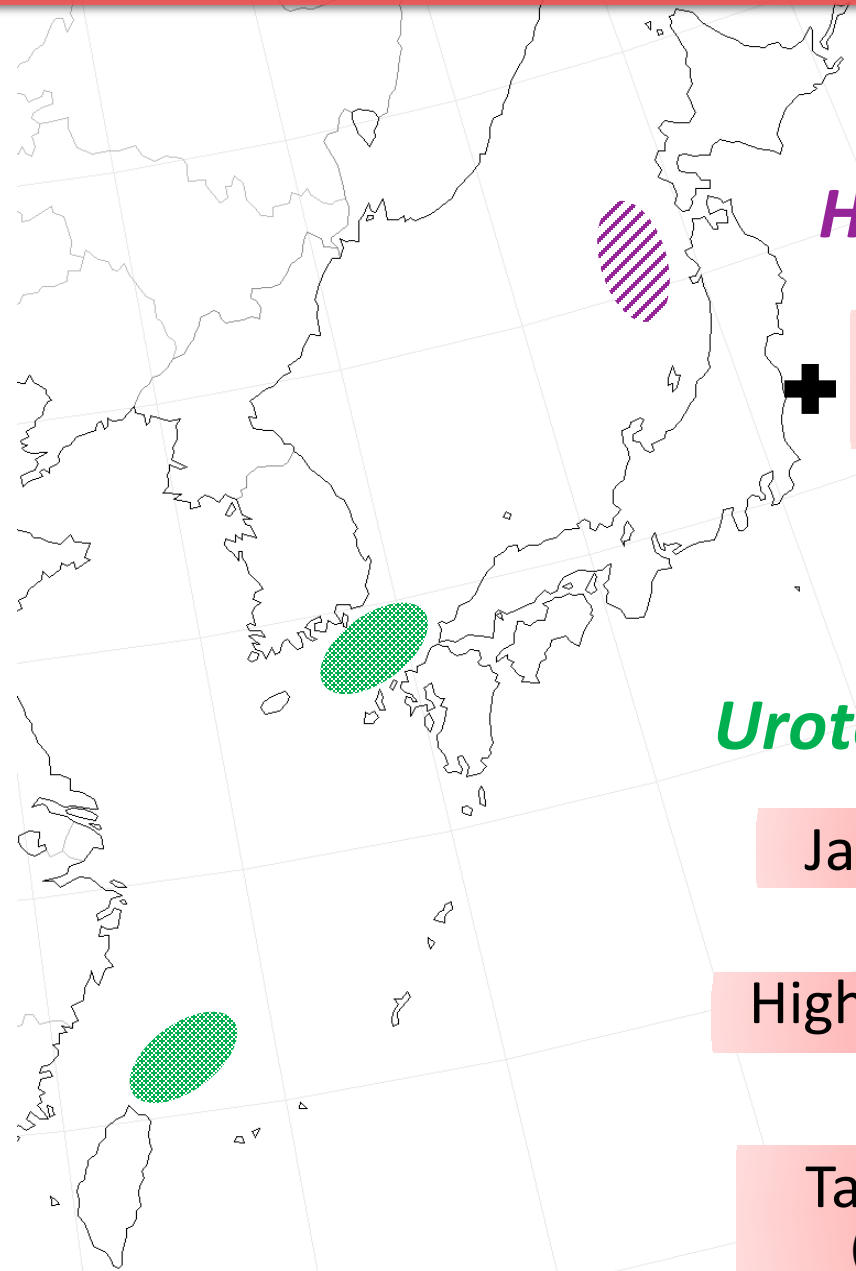
High winter WT

Uroteuthis edulis

Japanese Catch

High all-season WT

Taiwanese Catch
(Pang et al, 2018)



Discussion

WT of spawning ground could affect squid resource/catch through the impact on fecundity.

However, food condition is also an important factor.

Example: Japan spawning group

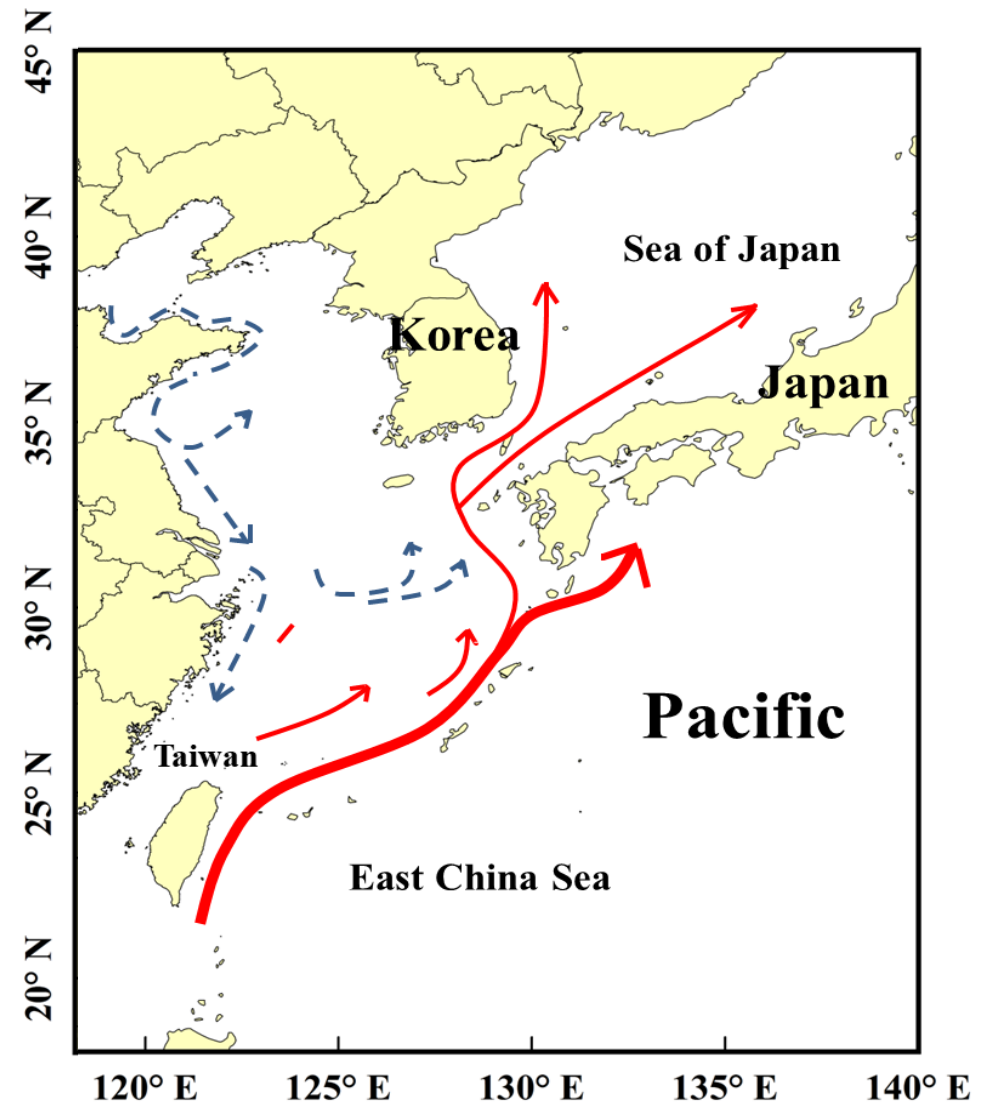
Fecundity level:

Cold period > Warm period

Better food condition in summer/autumn ?

Future

Life trajectories of different cohorts & species-specific fishery management



Acknowledgement

To Lab of Biology of Fisheries Science,
Atmosphere and Ocean Research Institution,
The University of Tokyo

