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

Yumeng Pang¹, Chin-Shin Chen², Tomohiko Kawamura¹, Yoko Iwata¹

¹Atmosphere and Ocean Research Institute, University of Tokyo, Japan
²Institute of Marine Affairs and Resource Management, National Taiwan Ocean University, Taiwan
E-mail: yumeng.pang@aori.u-tokyo.ac.jp
Introduction    Squids around Japan Sea

Heterololigo bleekeri

Uroteuthis edulis

Large-size (>30cm)

Cold Water

Important fishery species
(Wang et al., 2010; Ito, 2007)

Sea of Japan

Pacific

Large-size (>30cm)

East China Sea

Warm Water

Important fishery species
(Wang et al., 2010; Ito, 2007)
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

High winter WT

North Japan Sea Catch
(Ito, 2007)

South Japan Sea Catch
(Tian et al, 2013)
**Introduction**

Catch fluctuation and its connection with WT

**Uroteuthis edulis**

All year around Spawning

Japanese Catch

High all-season WT

Taiwanese Catch (Pang et al, 2018)

Catch (tones)

- West Japan Sea
- East China Sea

Average yearly WT

- West Japan Sea
- East China Sea

Taiwanese water

(Pang et al, 2018)
Study Purpose

Biological mechanism
Female reproductive traits
(Fecundity & Egg traits)
/Larvae recruitment

Statistical analysis
WT of spawning ground
Catch/Resource fluctuation

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

WT changes

Female reproductive traits

Catch/Resource fluctuation
Sampling sites, period and WT profile (*H. bleekeri*)

**Heterololigo bleekeri**

Average (Jan-Apr) WT in sampling site

- **North Japan Sea**
  - January–April 2017-2019

- **South Japan Sea**
  - No Samples

Japan Meteorological Agency

2017 > 2018 > 2019
Sampling sites, period and WT profile (*U. edulis*)

*Uroteuthis edulis*

**West Japan Sea**
- Every month, 2017-2018
- Spring & Autumn, 2017-2018

**North Taiwanese water**
- Spring & Autumn, 2017-2018

**Average yearly WT**

**Taiwan**
- Japan-cold

**Japan-warm**
- Average yearly WT

**Japan Meteorological Agency**

---

**Map**
- West Japan Sea
- East China Sea
- Japan Meteorological Agency
- North Taiwanese water

---

**Graph**
- WT (°C)
  - 10 to 35
  - 2017 Jan, Jul, 2018 Jan, Jul, 2019 Jan
- sampling locations
  - Taiwan
  - Japan-cold
  - Japan-warm

---

**Text**
- **Taiwan** > **Japan warm** > **Japan cold**
Biological data  Mature female Reproductive traits

(Mature) Ova in the oviduct

Oocytes in the ovary (Immature)

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

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

Intermittent terminal spawning

Egg size (mm)

Number

2017Jan  L=232mm
Oocyte
Ova

2019Jan  L = 214 mm

0 0.8 1.6 2.4 3.2 4

0 5 10 15 20 25 30 35 40 45 50
**Result** *Heterololigo bleekeri* – Fecundity & Oocyte size

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

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)
Cold water
*Heterololigo bleekeri*

Warm water
*Uroteuthis edulis*

When WT of spawning ground changes,

**Summary**

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

Opposite biological response in cold- and warm-water species.
**Heterololigo bleekeri**
- High spawning ground WT
- High fecundity
- North Japan Sea Catch

---

**Uroteuthis edulis**
- High spawning ground WT
- Low fecundity
- Japanese Catch

---

**Potential biological mechanism**

---

**Statistical analysis**

---

**Discussion**

---

**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)
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