SPF-S2_Lee

Observed pattern of diel vertical migration of Pacific mackerel larvae and its implication for spatial distribution off the Korean Peninsula

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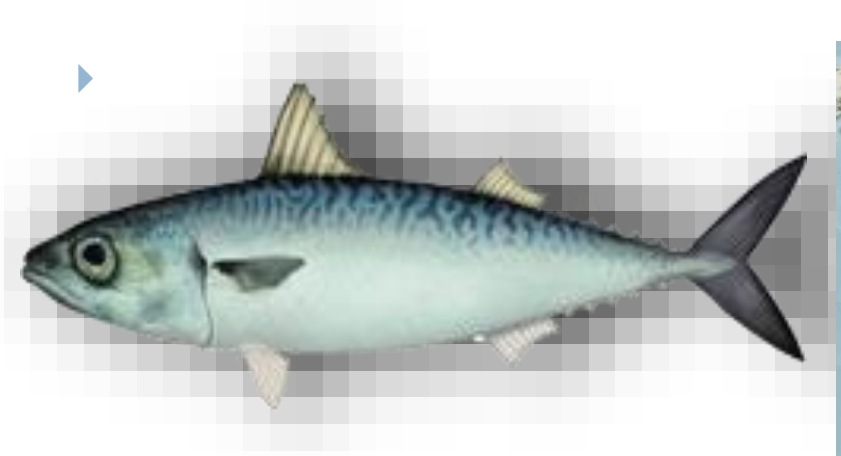
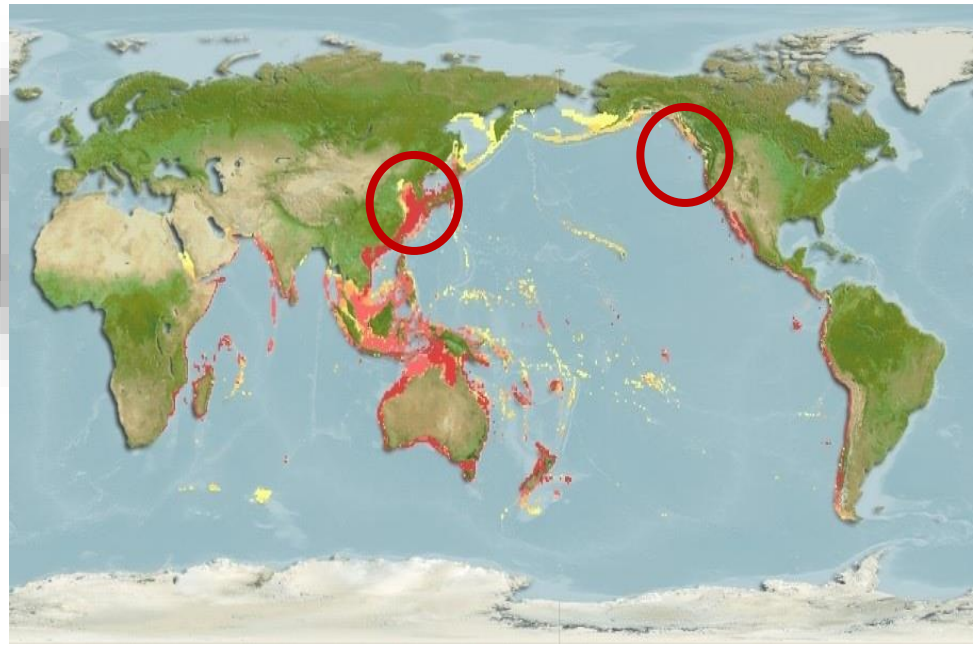
Pacific mackerel, *Scomber japonicus*

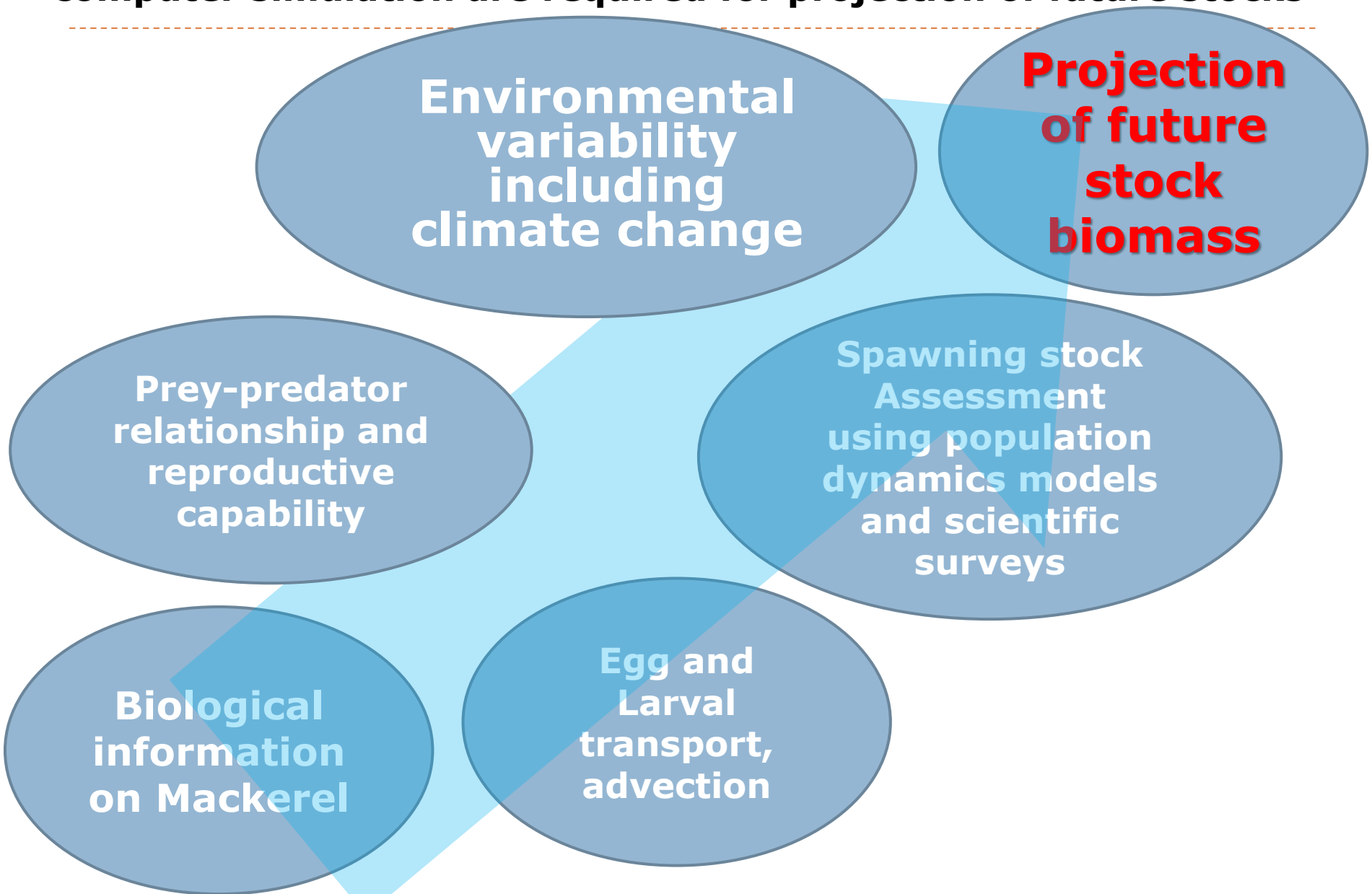
- **Mackerel is one of the most dominant commercial species in the northwestern Pacific Ocean.**
- **However, little is known about early life history characteristics such as transport process and recruitment variability in Korean waters.**



Pacific mackerel
= Chub mackerel



Observation by ocean survey, parameter estimation by lab experiment, understanding ecological processing and proper computer simulation are required for projection of future stocks



The purposes of this study

- To find the changing pattern of specific gravity of eggs and larvae during their development,
- To consider how we use such information for the recruitment variability
- To provide the basis for proper projection on future Pacific mackerel stock in Korean waters.

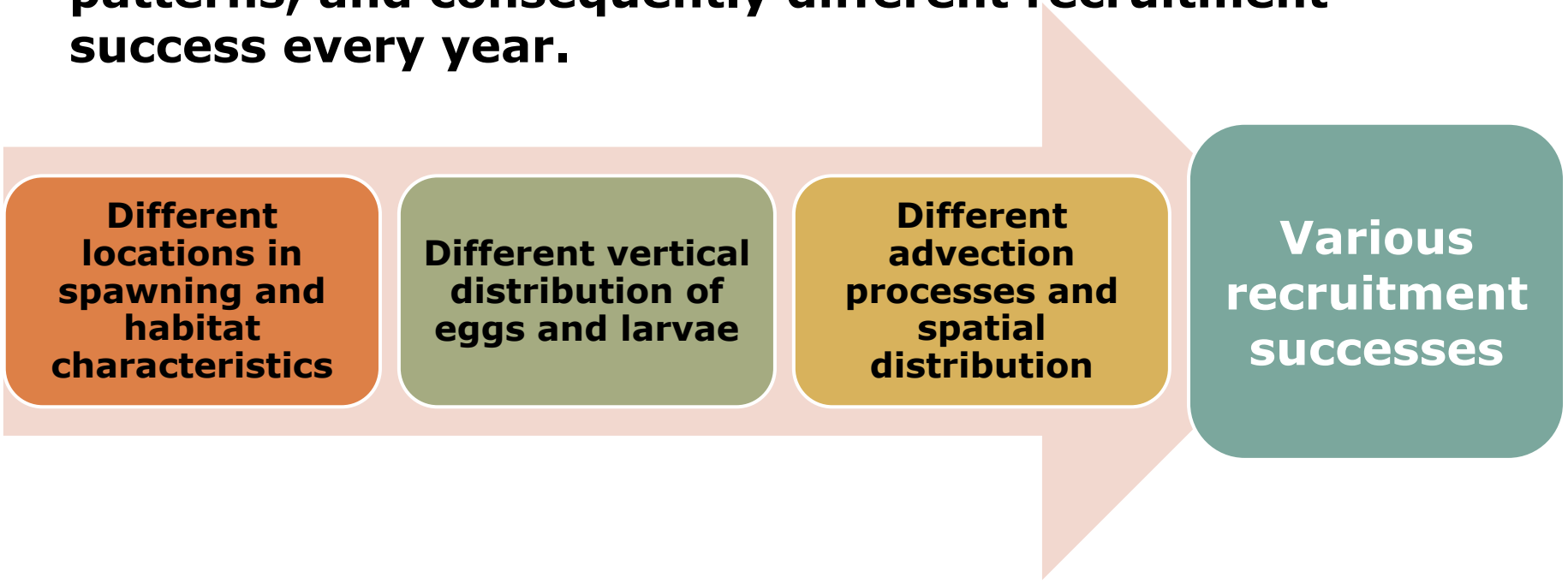
Outline of presentation

1. **Lab Experiment Results**
   - **Eggs and larval Specific gravity changes**
     - **Vertical distribution of eggs and larvae in the Ocean**
2. **Ocean Survey Results**
   - **Egg and larval distribution in the Korean Waters.**
     - **This information for spawning biomass estimation**
     - **How we explain recruitment variability**

Why do we measure specific gravity?

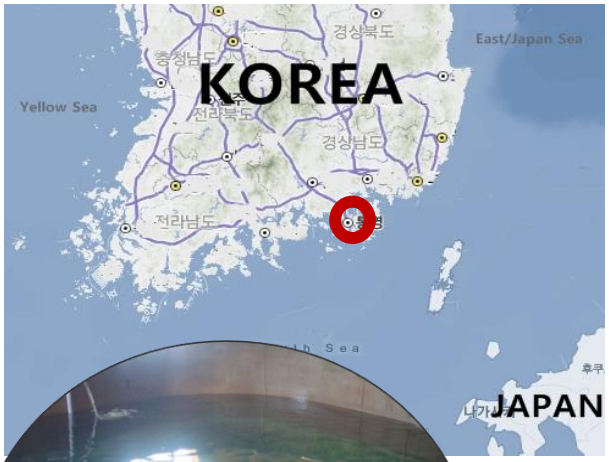
- **It is an essential information for the vertical distribution of eggs and larvae in the ocean.**

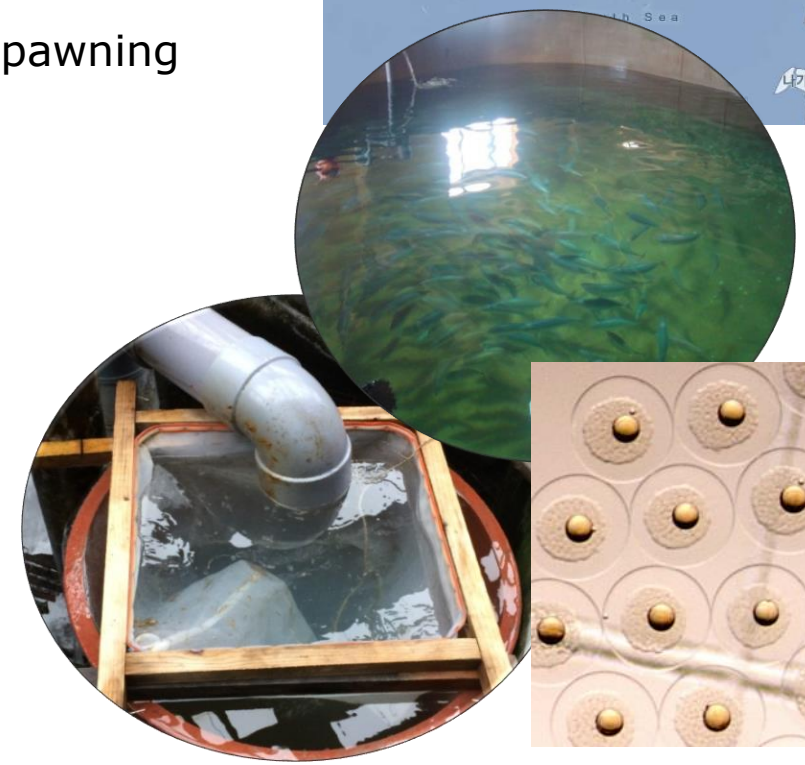
- **Ocean current moves the eggs and larvae in different vertical depths, results in various spatial patterns, and consequently different recruitment success every year.**



Specific gravity experiment

- At the Gyeongsangnam-do Fisheries Institute
  - Around 300 adults were reared in a large tank
- Rearing conditions of tank
  - Maintained by 17-18℃ // Salinity 34-35
- Pacific mackerel eggs
  - Released by hormone injection for spawning
  - Fertilized after spawning in tank
- Spawning and egg collection
  - May 27, 2014 // June 12, 2015
- Experimental duration
  - About 15 days after spawning
- Embryonic period
  - 48 hours at 20℃, 33.5
  - **50 hours at 18℃, 33.5**

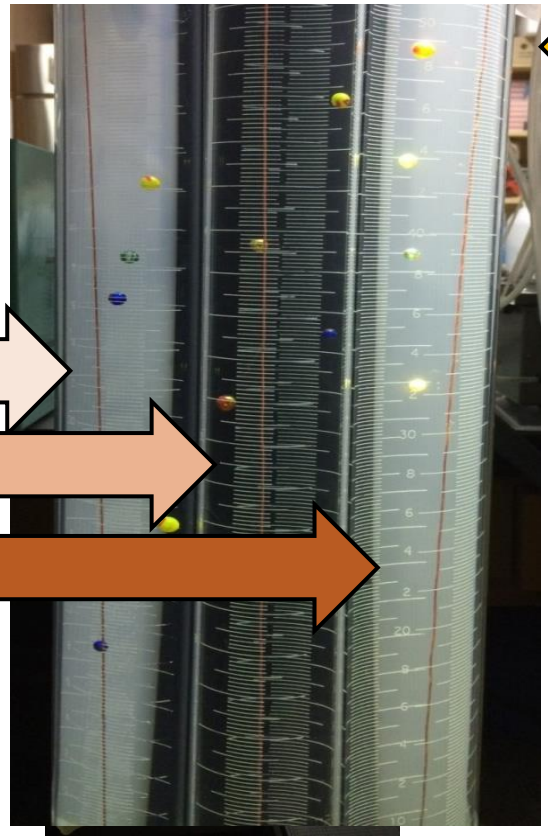




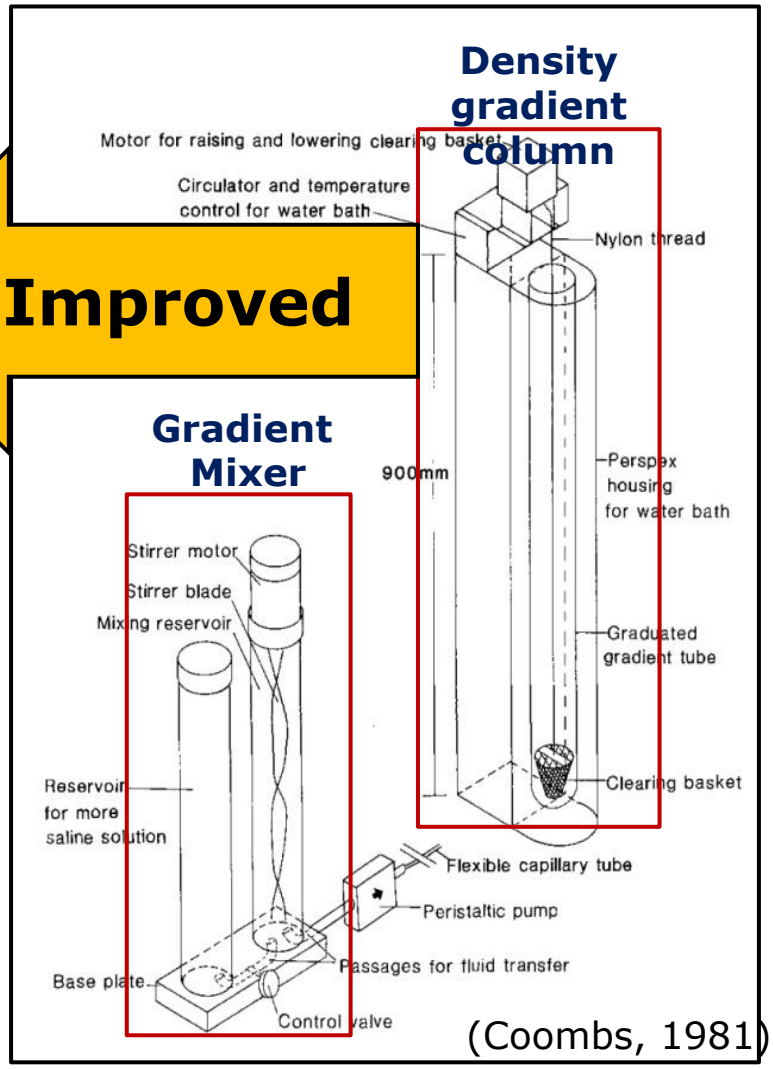
Device for specific gravity measurement

- **A Density-gradient column for determining the specific gravity of fish eggs.**

3 columns



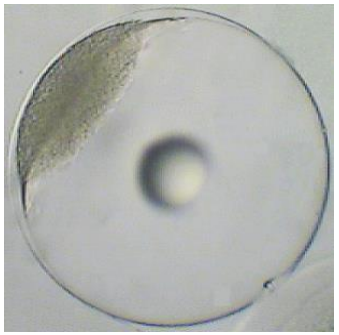
Improved



(Coombs, 1981)

Two types of measurements

1. Continuous measurement from fertilization to hatching

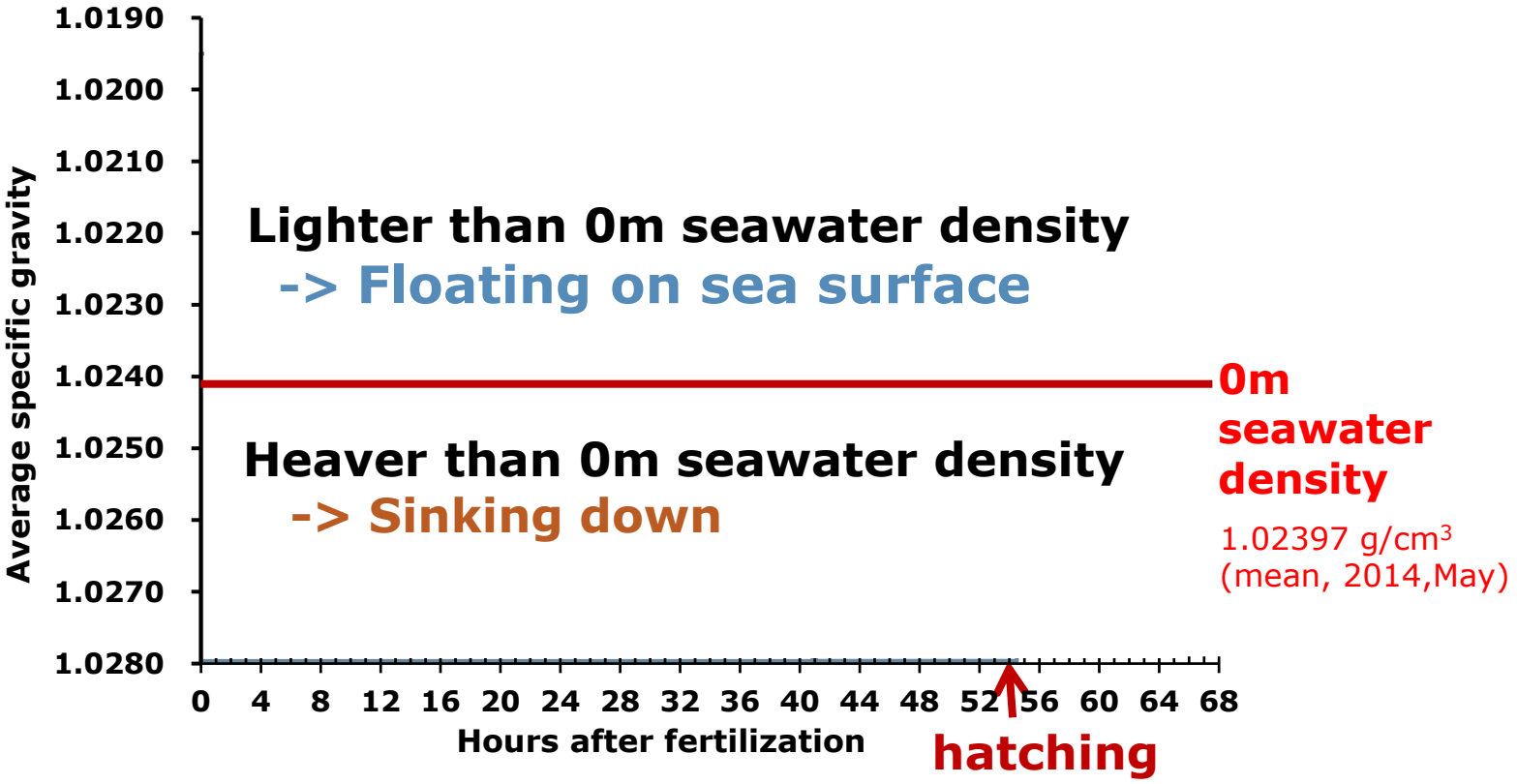


- Temperature: 20 ºC
- Salinity rage of water column: 20-50 PSU
- Observation : every 2 hours

2. Instant point measurement at larval stage

- Rearing tank for larvae: 18-19 ºC, 33.0-33.5 PSU
- Anesthesia: 20 min in 0.005% MS222
- Feed: Rotifer & Artemia, 1 hour before anesthesia
- Observation: 3 times a day - 3, 10, 18 hr. (2014)
  4 times a day - 0, 6, 12, 18 hr. (2015)
- 15 – 20 individuals were used at each observation

Results 1.
Changes in specific gravity of mackerel eggs



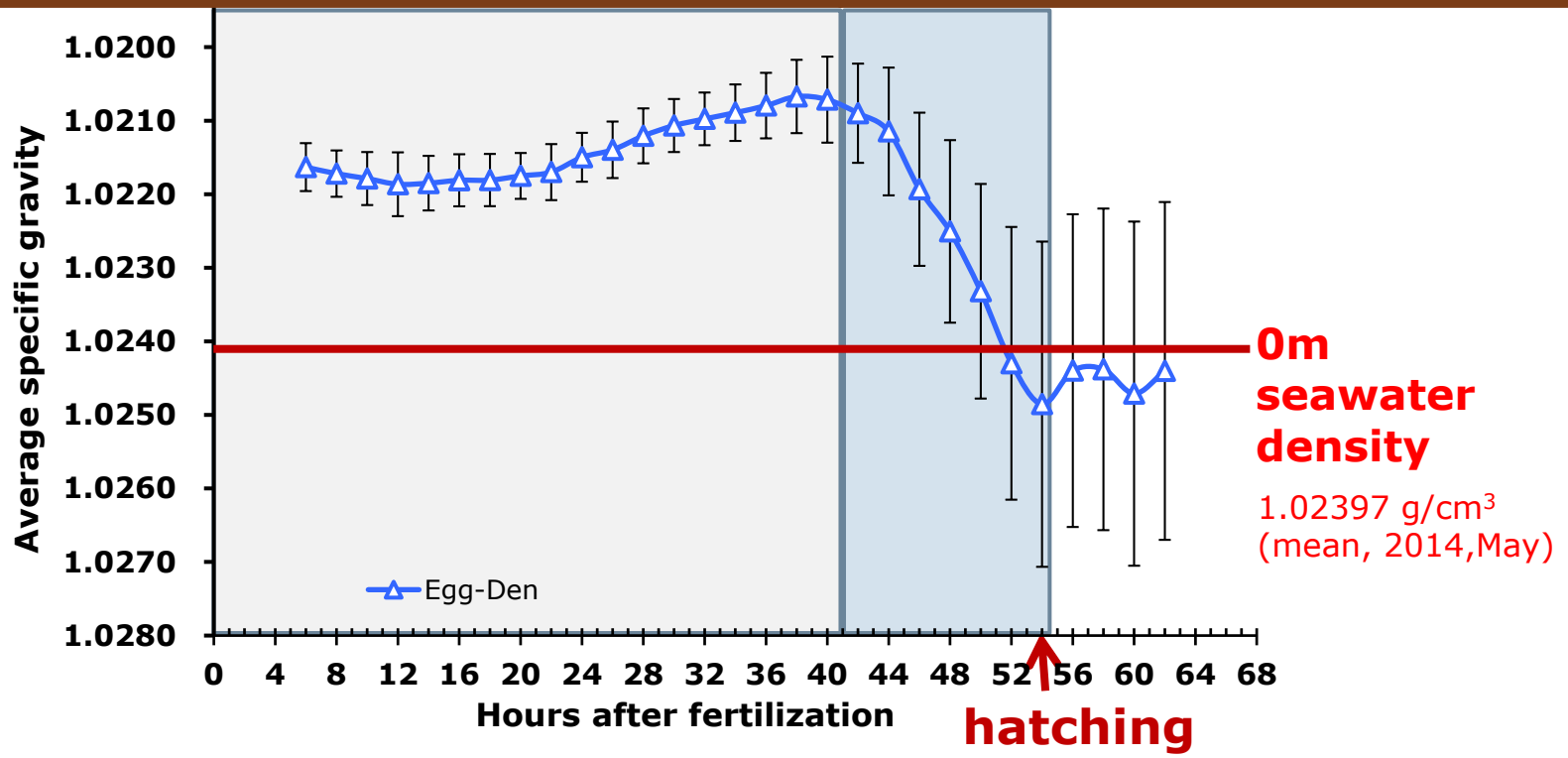
Results 1.
Changes in specific gravity of mackerel eggs

Early - Middle stages

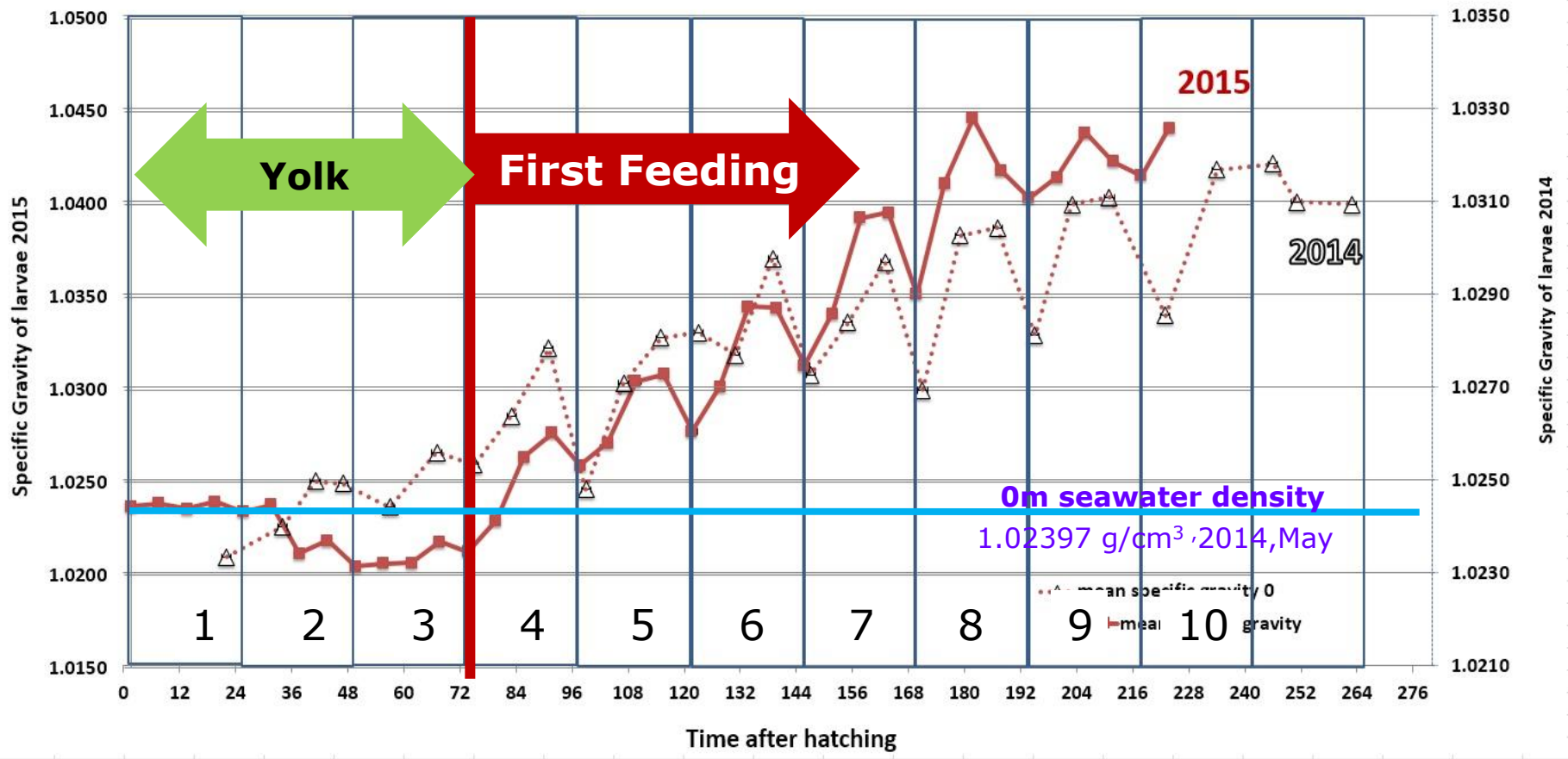
- Lighter than seawater density
- Stay in the surface layer

Late stage

- Specific gravity increases,
- Heavier than seawater
- Sink toward the deeper water

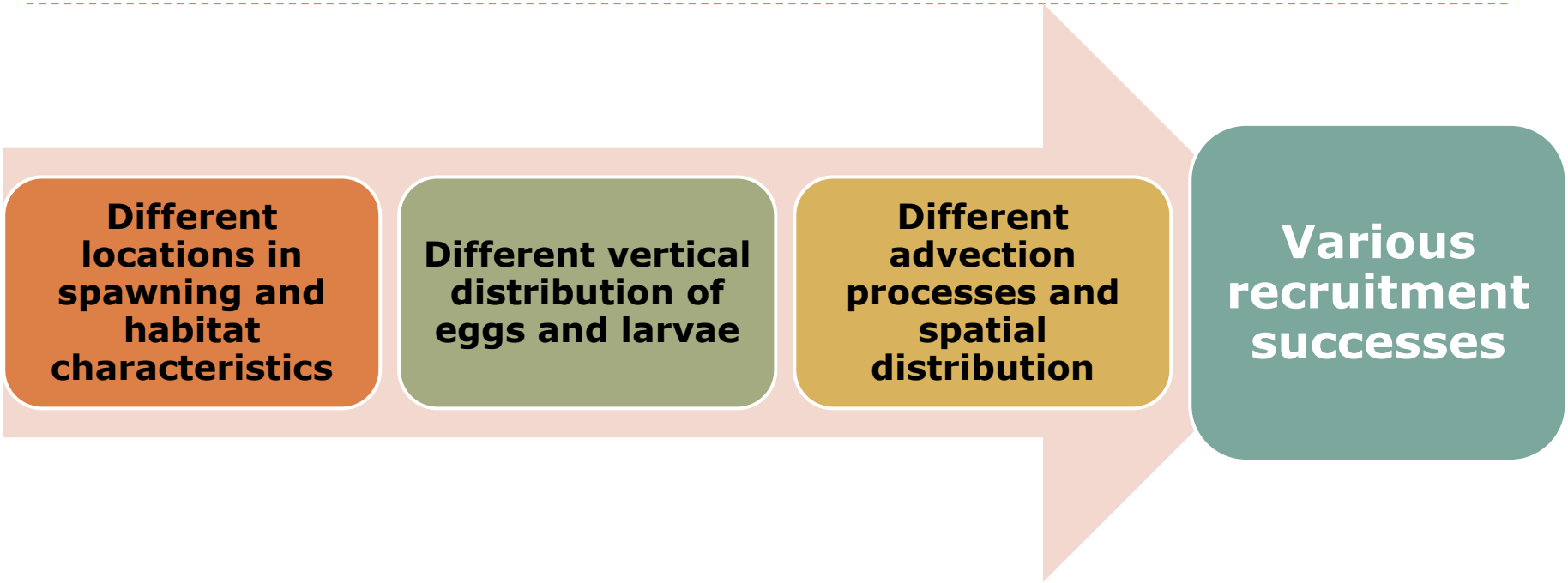


Results 2.
Changes in Specific gravity of mackerel larvae



- Fluctuation start: 4th Day after hatching
  - **Lowest within a day: midnight** (02:00, 00:00)
  - **Highest within a day: daytime** (18:00, 12:00)

Ichthyoplankton survey

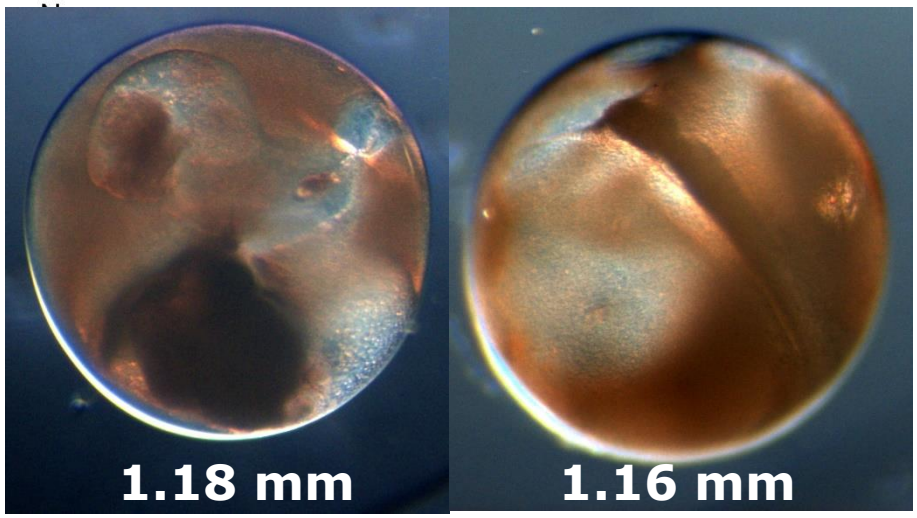


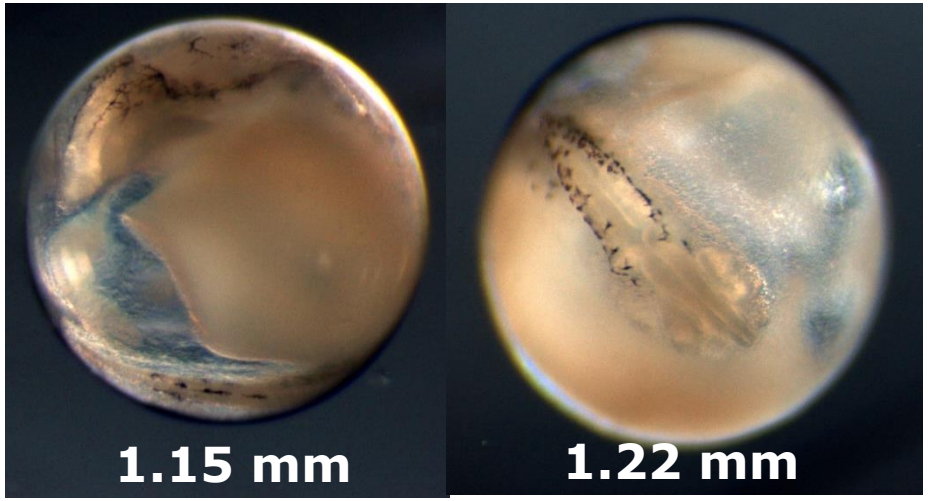
- Where and When does spawning occur in Korean Waters?
  - Different seawater properties, advection processes, and feeding conditions may result in different recruitment success interannually.

Surveys in 2016

- Ichthyoplankton surveys were conducted by the National Institute of Fisheries Science.
  - Survey period
    - 12-28, May 2016. 130 stations.
    - 08-23, June 2016. 251 stations.
  - Survey area
    - Southern Part of the Korean waters
    - 37.0 – 31.5N, 124.75 – 131.0 E
  - Bongo net
    - Oblique tow, 505㎛ mesh

Distribution of Mackerel eggs





- Egg sorting from plankton samples
  - Diameter 0.85 – 1.35mm
  - Smooth egg shell
  - One Oil droplet
  - Melanophore
- We found
  - 285 eggs in May survey
  - 527 eggs in June survey
  - DNA analysis is required for confirmation.

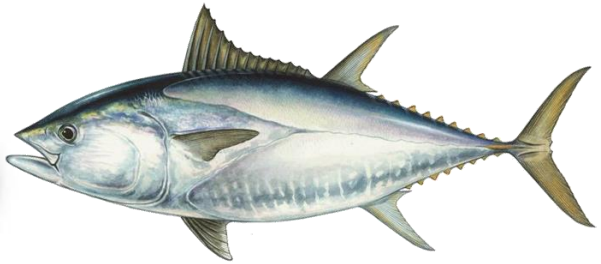
Discussion

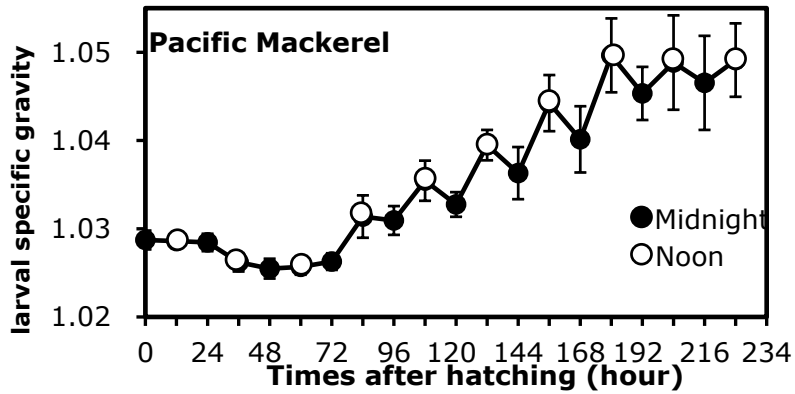
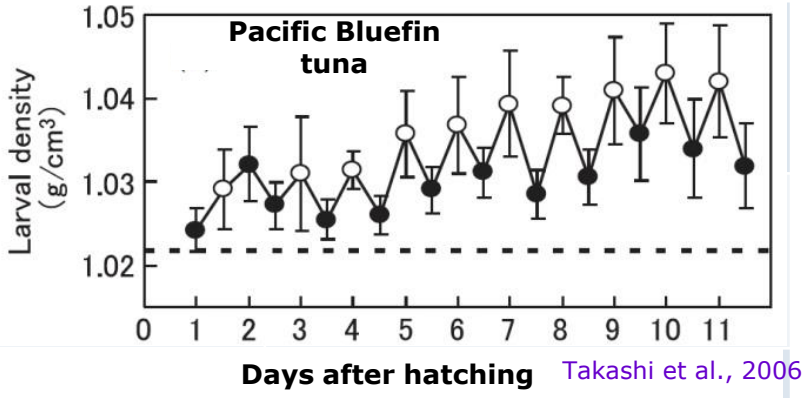
- Other similar examples in changes in larval specific gravity?

- What makes the diel pattern in specific gravity of mackerel larvae?

Discussion

- Is the diel specific gravity change popular to other fish larvae?



	Pacific mackerel *Scomber japonicus*	**Olive flounder** *Paralichthys olivaceus*	**Pacific bluefin tuna** *Thunnus orientalis*
Diel SG change pattern			
Data source	In this research	Kitajima et al., 1994	Takashi et al., 2006

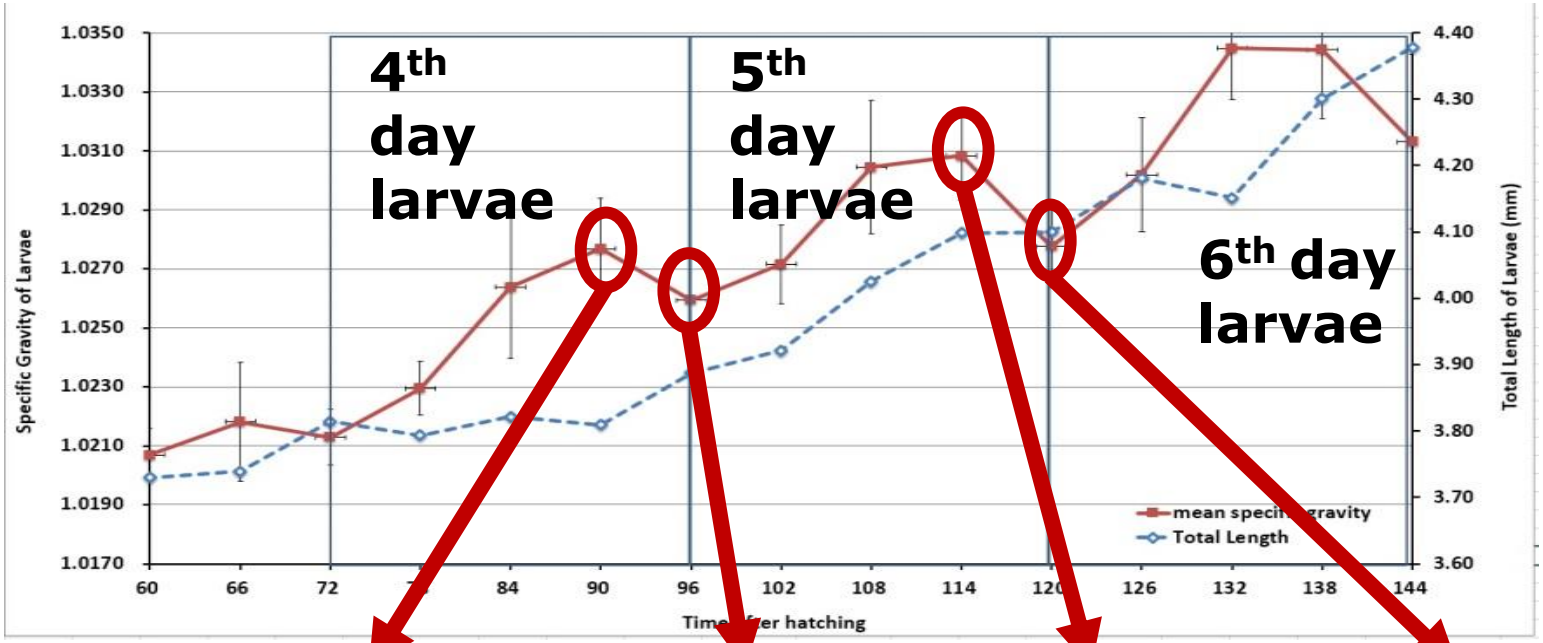
Takashi et al., 2006

We don't know

"Why and How does the larval specific gravity vary during within a day?"

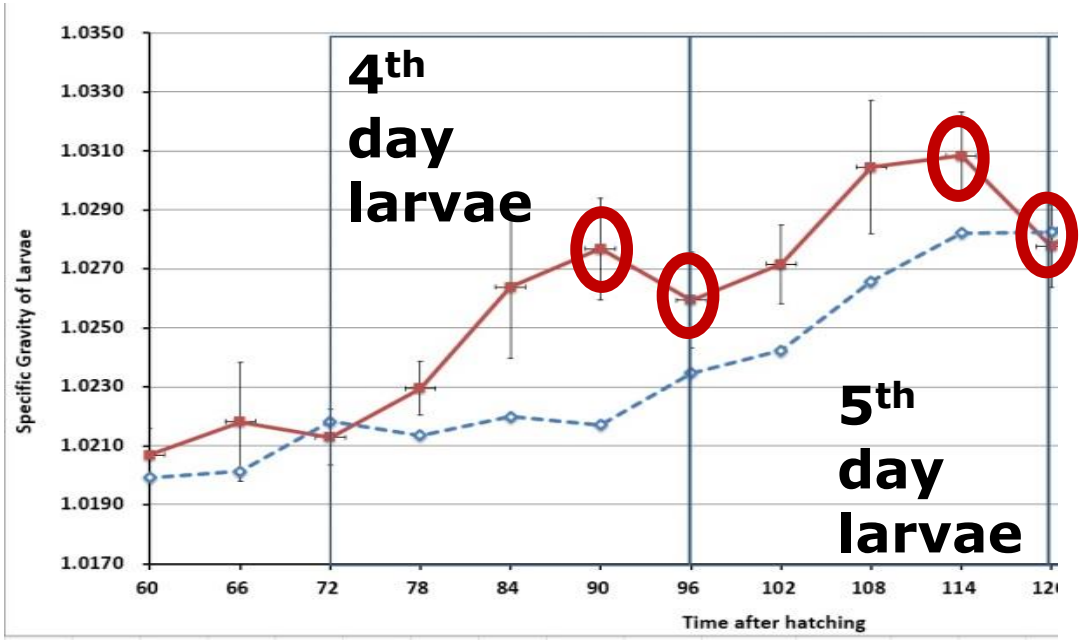
- Growing?
- Food and stomach fullness?
- Bladder formation effect?
- Other unknown metabolic process?

What cause the difference between SG of Day and Night? Length?



Day	4rd Day	5th Day	5th Day	6th Day
Observation time	**18:00**	**00:00**	**18:00**	**00:00**
Specific gravity	**1.0277** ± 0.00172	**1.0259** ± 0.00163	**1.0308** ± 0.00151	**1.0278** ± 0.00140
Total length (mm)	**3.80** ± 0.128	**3.89**± 0.123	**4.10** ± 0.191	**4.10** ± 0.206

What cause the difference between SG of Day and Night? Stomach contents?



Full

Empty

Day	4th Day	5th Day	5th Day	6th Day
Observation time	**18:00**	**00:00**	**18:00**	**00:00**
Specific gravity	**1.0277** ± 0.00172	**1.0259** ± 0.00163	**1.0308** ± 0.00151	**1.0278** ± 0.00140
Ratio of stomach fullness (#of full stomach/ total #)	**79.17%** (19/24)	**61.54%** (8/13)	**85.71%** (18/21)	**40%** (8/20)

Implication

- **Heavy in Day-time**
  - ✓ **Could move to deeper water, easily**
  - ✓ **Benefit of avoidance from predators**
- **Light in Night-time**
  - ✓ **Could move to upper water, easily**
  - ✓ **Might help finding more prey, and avoiding predators**

However, we had no information on vertical distribution of mackerel larvae in Korean waters.

Summary

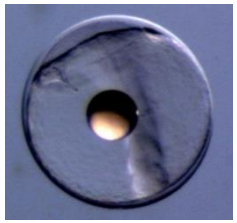
- Specific gravity of mackerel eggs and larvae were measured in 2014 and 2015 using density gradient water column.
- Egg specific gravity was compared to seawater density, and vertical movement of eggs was depicted. Egg specific gravity was lighter than seawater during early through middle stages, so that they should float on sea surface. Then, eggs sink down just before hatching due to enhanced specific gravity.
- Larval specific gravity was increased with time. At hatching, their specific gravity was lower than surface water density, so that they move toward the surface.
- After third day of hatching, however, the specific gravity became heavier than surface water density.
- We also observed the day-and-night difference in specific gravity. It showed “Low in night” and “High in day” pattern during 4 though 10 days after hatching.
- So far, we don’t know why they show such different specific gravity within a day.

Next step

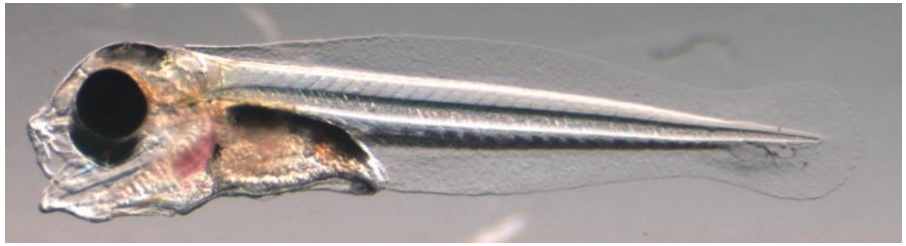
- Investigate the vertical distribution in the ocean in relation to diel-pattern of larval specific gravity.
- Use the vertical distribution of eggs and larvae for the spatial distribution using 3-dimensional current circulation models.
- Match various dispersal patterns of larvae with recruitment success of mackerel stocks interannually.

Thanks for your attention

12h AS
0.95 mm



10d AH
5.64 mm TL



5th November 2016, San Diego
Less than 25cm TL