Distribution of walleye pollock (Theragra chalcogramma) larvae around Funka Bay, Japan: Relationships with environmental factors

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Target stock

- **Japanese Pacific stock of walleye pollock**

- Spawning ground: outside of Funka Bay
- Spawning season: December ~ March
- Eggs: transported into Funka Bay
- Larvae and Juveniles: remain in Funka Bay until approximately June
Summary of survey

- Year: 2007 ~ 2009
- Month: April
- Area: around Funka Bay
- Vessel: Hokko maru
- Echosounder: Simrad EK500
- Frequency: 38 kHz
- Environments: temperature and salinity (XCTD)
Why acoustic survey?

- Acoustic survey provides a more detailed (contiguous) horizontal and vertical distribution compared with net sampling survey.
- Pollock larvae (approximately 10~30 mm TL) have a well-developed swimbladder.
- There are few other fish larvae around Funka Bay.
Net sampling

- Gear: Frame trawl (FMT)
  - Mouth: 2 x 2 m
  - Mesh size: 1.5 mm
  - (cod end: 0.333 μm)

- Number of tows:
  - 9 tows in 2007
  - 5 tows in 2008
  - 11 tows in 2009
Weight composition of FMT (2009)

Pollock larvae
Other fish larvae
Eucalanus bungii
Themisto japonica
Euphausia pacifica
Others

Sample
A
B
C
D
E
F
G
H
I
J
K

Weight %
Target strength (TS) equation and model (38kHz)

• *Pollock larvae* > Sadayasu (2005)
  \[
  TS = 26.57 \times \log_{10} FL - 74.03
  \]

• *Eucalanus bungi* and *Themisto japonica*
  > Stanton and Chu (2000)
  Distorted Wave Born Approximation model

• *Euphausia pacifica* > Miyashita et al. (1996)
  \[
  TS = 54.77 \times \log_{10} TL - 169.7
  \]
TS of pollock larvae and planktons

- **Pollock larvae**: -67.5 ~ -70.9 dB  
  (13.1 ~ 17.7 mm TL)
- **Eucalanus bungi**: -110 dB
- **Themisto japonica**: -102.3 ~ -110.4 dB
- **Euphausia pacifica**: -108.9 ~ -112.5 dB

- Total contribution of each plankton to acoustic backscattering estimated from TS values and numbers was < 0.1% in all samples
- All acoustic backscattering at 38 kHz were attributed to pollock larvae in all years
Example of echogram (2009)

- Frequency: 38 kHz
- Vertical range: 0 ~ 100 m
- Color scale: -50 ~ -80 dB
Pollock horizontal distribution (density)

- There were few pollock out of the bay in all years
- In 2007 and 2009, pollock were widely distributed in the bay
- In 2008, pollock aggregated in the northern part of the bay
• Biomass were high around 20 m depth across all years
• We examined the relationships between environments at 20 m depth and pollock density (n/m² : vertically accumulated)
Pollock density vs 20m temperature

- The density of pollock larvae was low in cool water in 2008 and 2009.
Pollock density vs 20m salinity

- Pollock larvae were scarce in low-salinity waters especially in 2007 and 2009
Threshold temperature and salinity

- Water temperature has a relatively abrupt threshold
- High pollock density is observed above approximately 3.5 °C
- Obvious threshold is not identified for salinity
The lowest larval biomass of 60 billions was obtained in 2008 when age-1 recruitment was highest.

Survival rate from larvae to age-1 ranged 0.1~2.5%.
Conclusions

• Distribution of pollock larvae was under the control of small-scale environmental variability
• Pollock larvae were abundant in warm and high-salinity waters
• Few pollock larvae were found in waters < 3.5 °C
• Lower threshold is not clear for salinity
• Estimated total number of pollock larvae ranged from 60 ~ 950 billions
• The lowest larval biomass was observed in 2008 when age-1 recruitment was highest
Future subjects

• Refinement to TS equation of pollock larvae
• Relationships of pollock density with chlorophyll concentration and prey density
• Examination of link between environments and pollock distribution using GAM
• Establishment of life table for Japanese Pacific stock of walleye pollock