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

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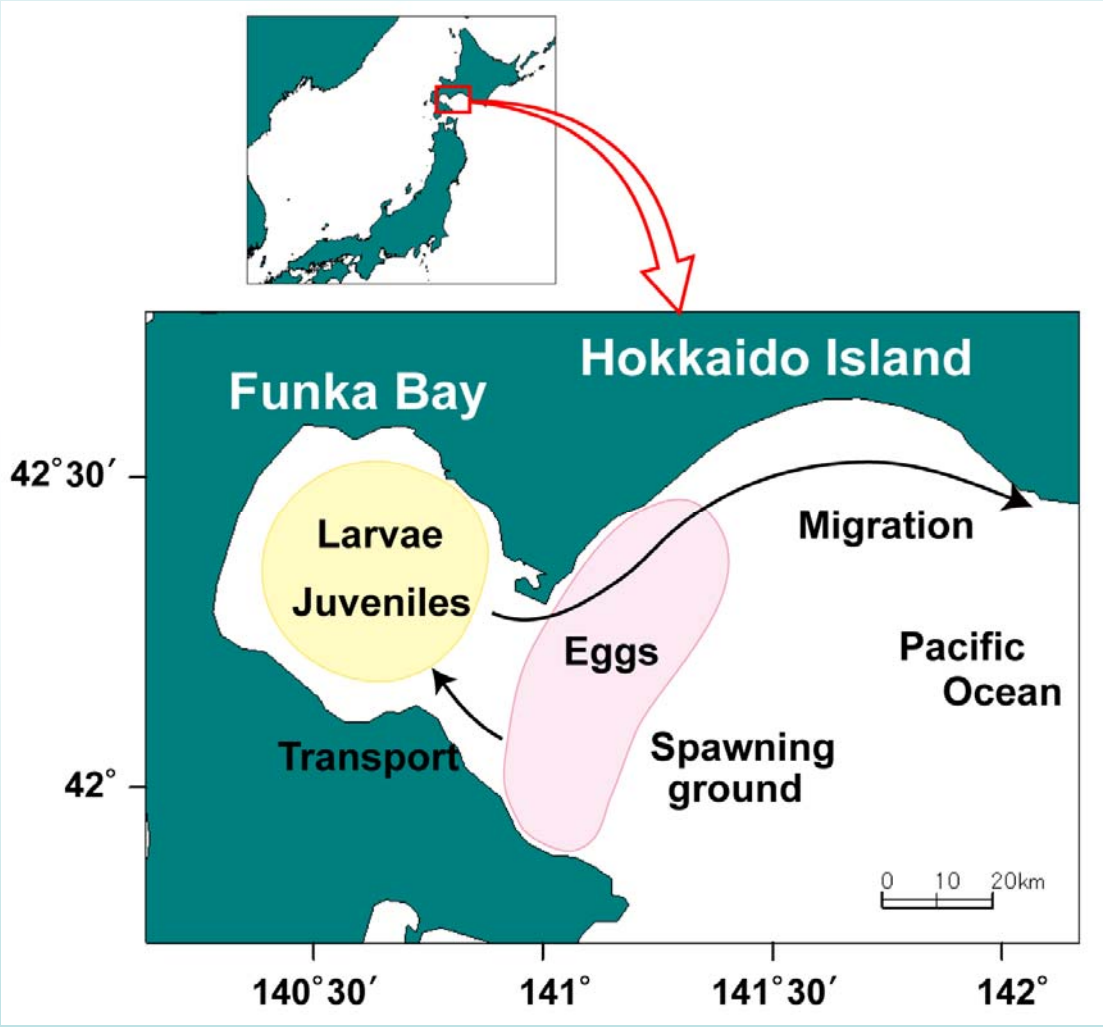
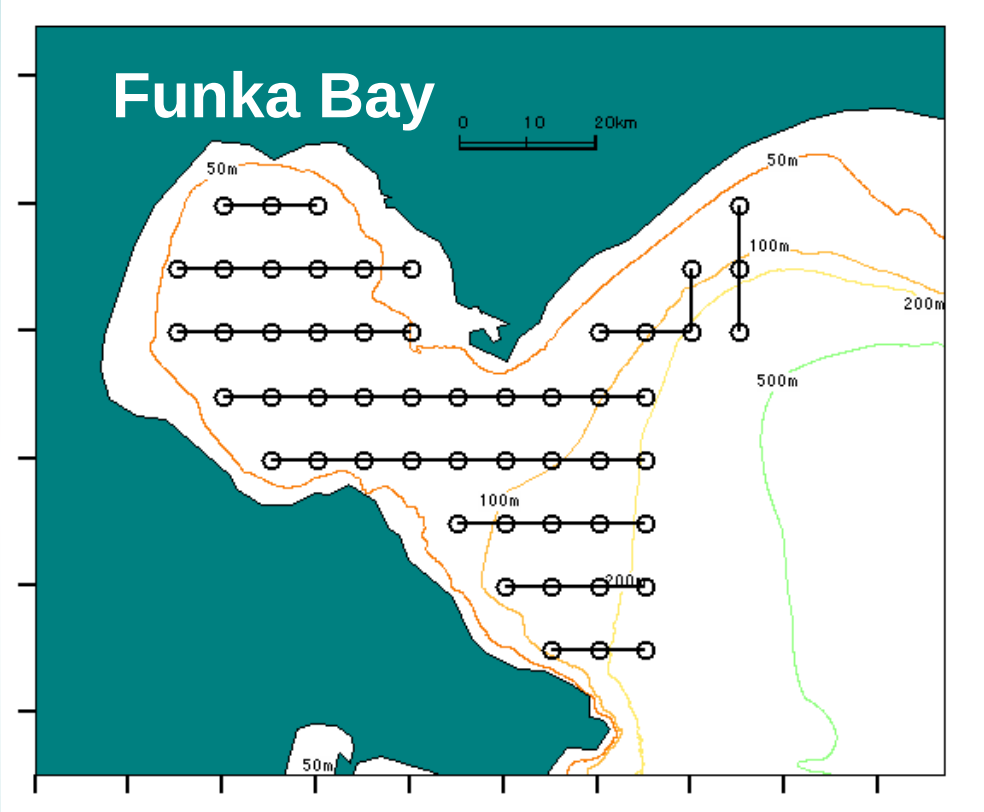
Target stock

- *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**

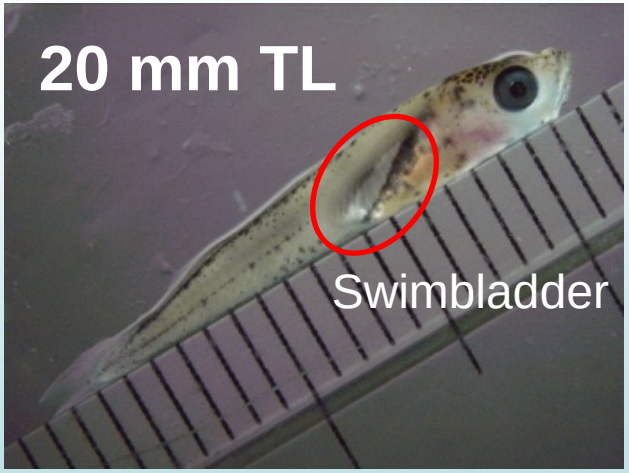
Summary of survey



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

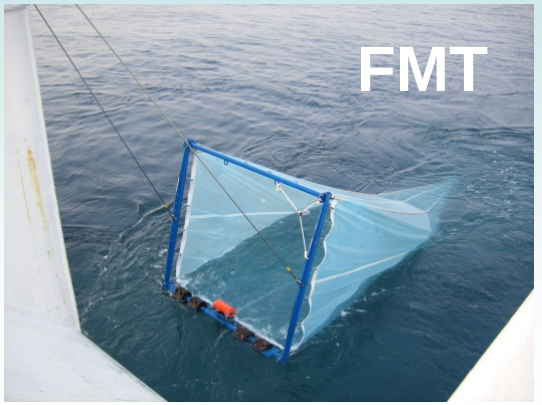
Why acoustic survey ?

- **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**

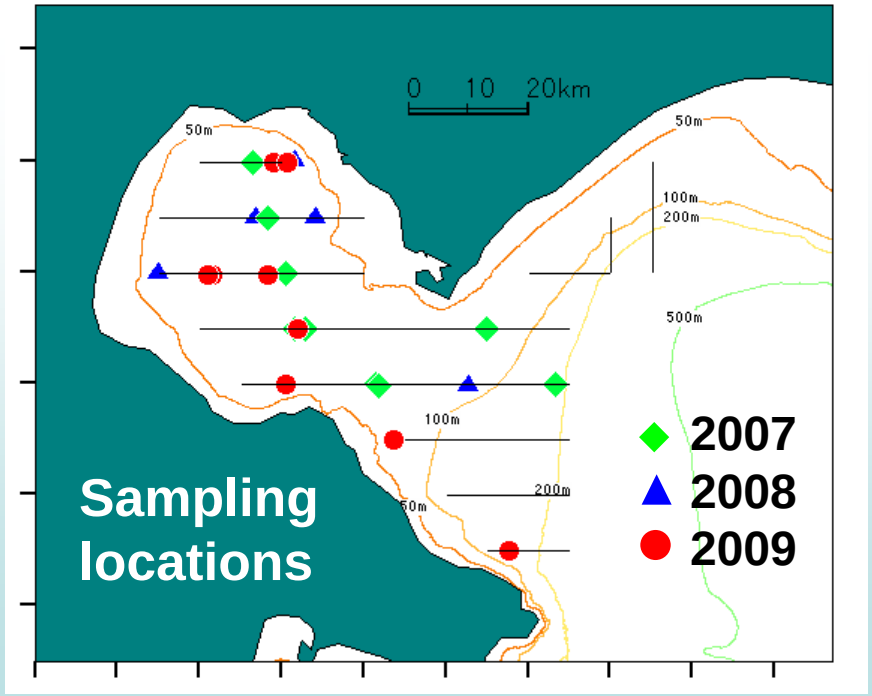


Net sampling

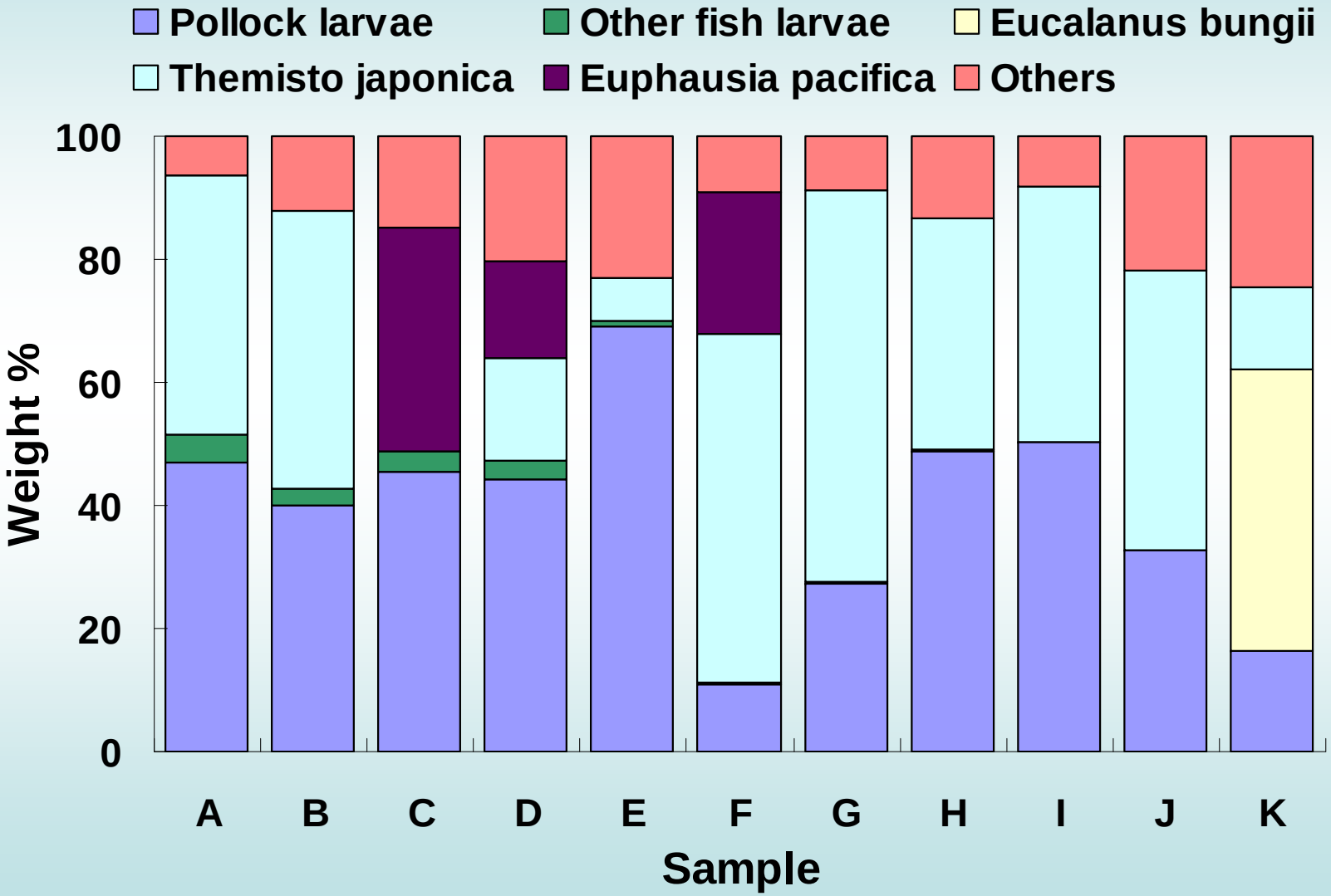
- **Gear : Frame trawl (FMT)**
  Mouth : 2 x 2 m
  Mesh size : 1.5 mm
  (cod end : 0.333 μ m)



- **Number of tows :**
  9 tows in 2007
  5 tows in 2008
  11 tows in 2009



Weight composition of FMT (2009)



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

- ***Pollock larvae*** **> Sadayasu (2005)**

  $\mathbf{TS = 26.57 \times \log_{10}FL - 74.03}$

- ***Eucalanus bungi*** **and** ***Themisto japonica***

  > Stanton and Chu (2000)

  Distorted Wave Born Approximation model

- ***Euphausia pacifica*** **> Miyashita et al. (1996)**

  $\mathbf{TS = 54.77 \times \log_{10}TL - 169.7}$

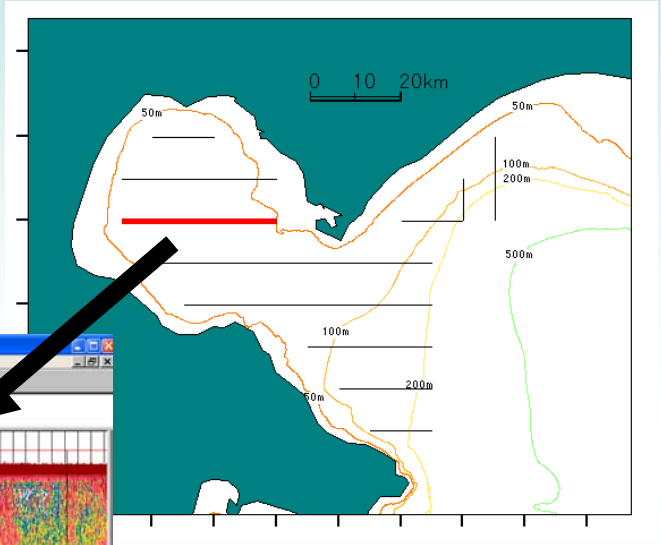
TS of pollock larvae and planktons

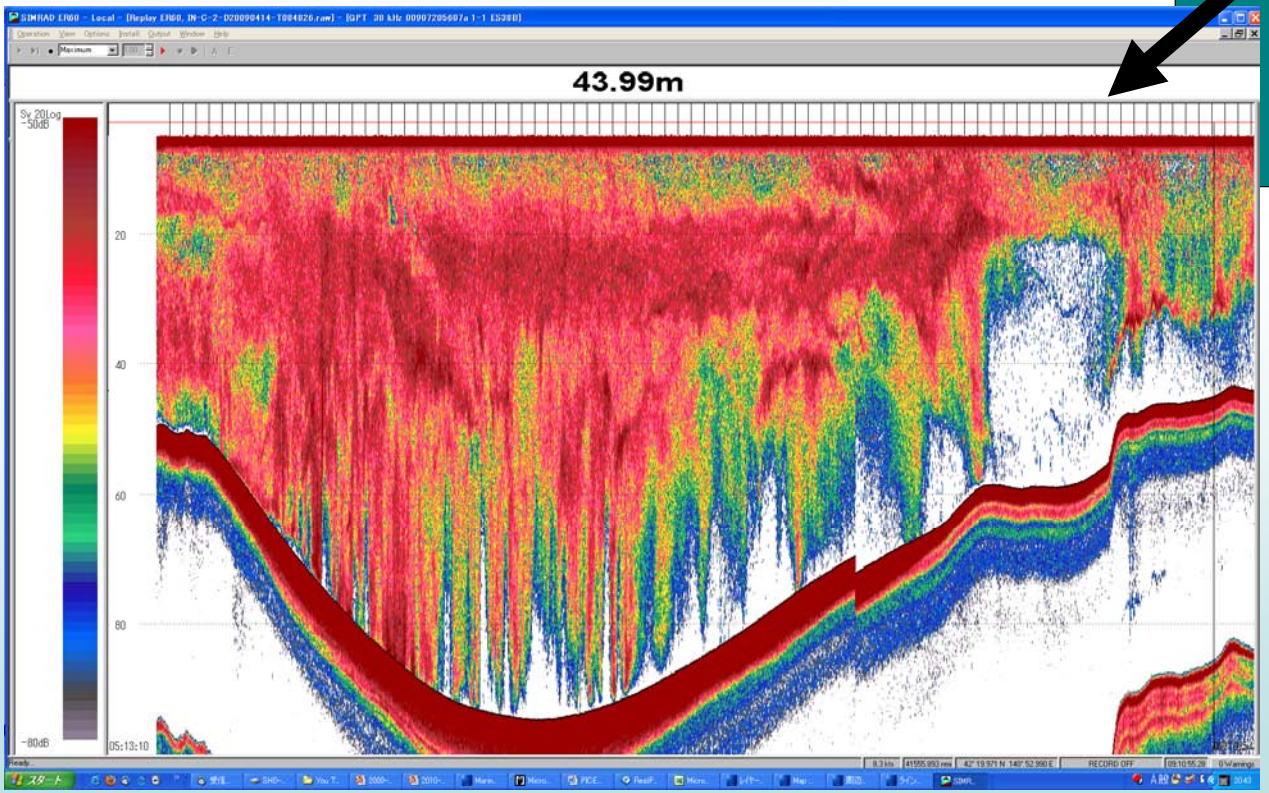
- ***Pollock larvae*** **: -67.5 ~ -70.9 dB (13.1 ~ 17.7 mm TL)**
- ***Eucalanus bungi*** **: -110 dB**
- ***Themisto japonica*** **: -102.3 ~ -110.4 dB**
- ***Euphausia pacifica*** **: -108.9 ~ -112.5 dB**

- **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)

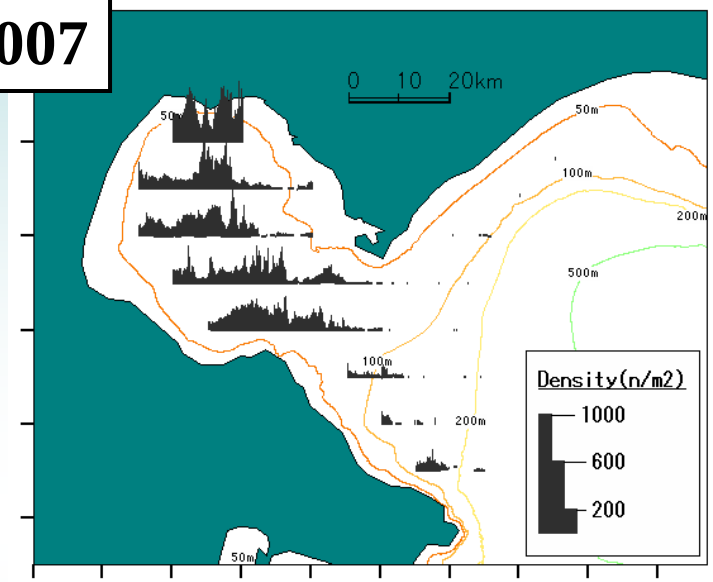
- **Frequency : 38 kHz**
- **Vertical range : 0 ~ 100 m**
- **Color scale : -50 ~ -80 dB**



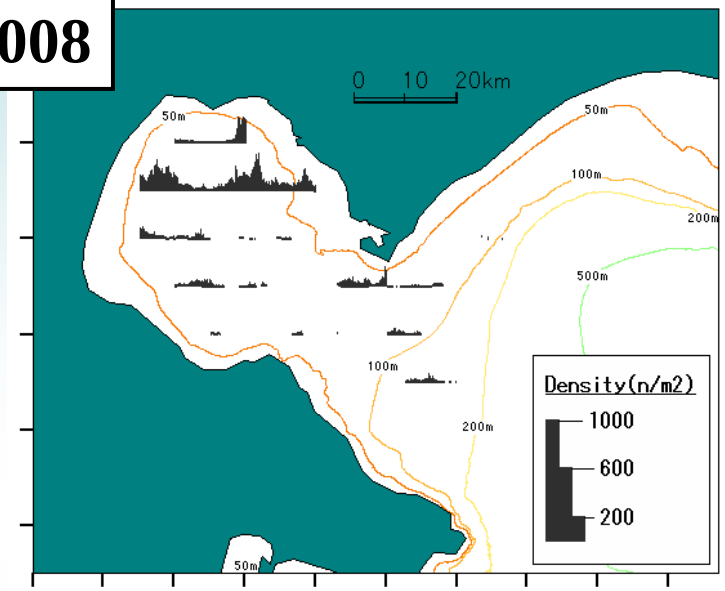


Pollock horizontal distribution (density)

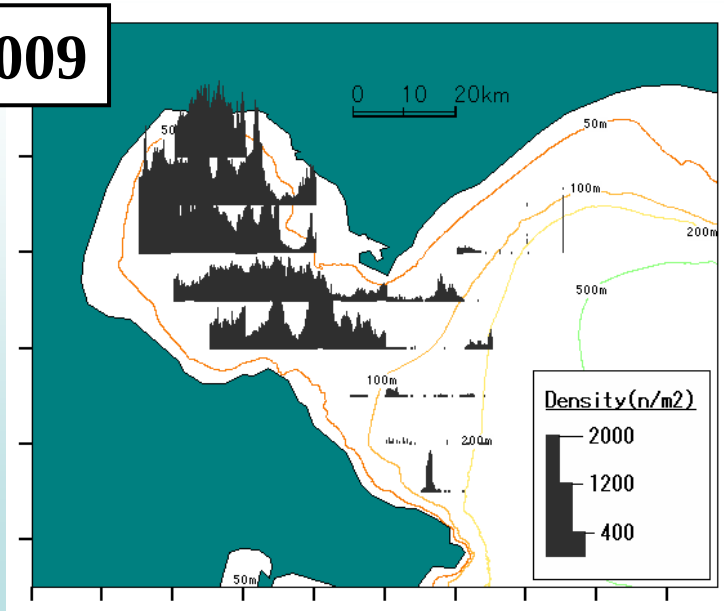
2007



2008

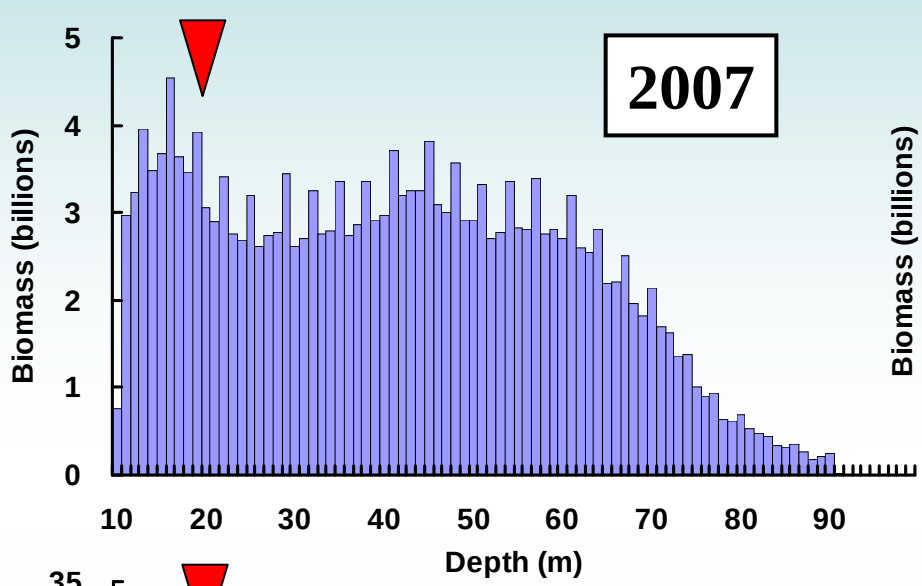


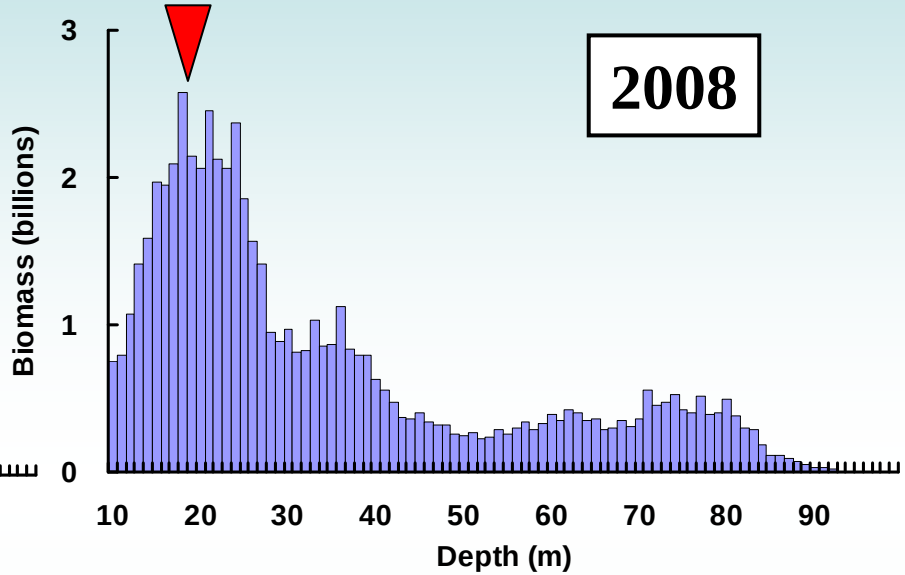
2009

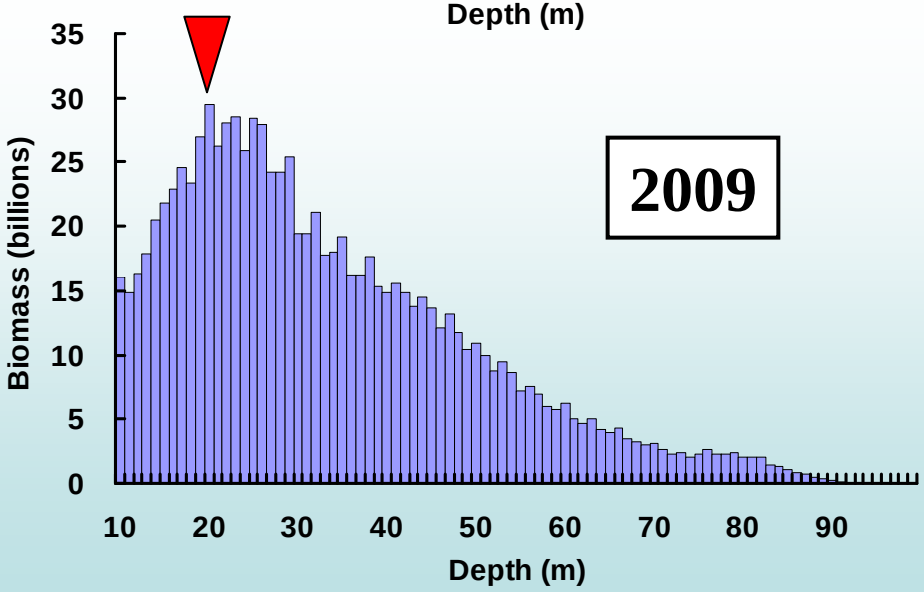


- **There were few pollock out of the bay in all years**
- **In 2007 and 2009, pollock were widely distributed in the bay**
- **In 2008, pollock aggregated in the northern part of the bay**

Pollock vertical distribution (biomass)

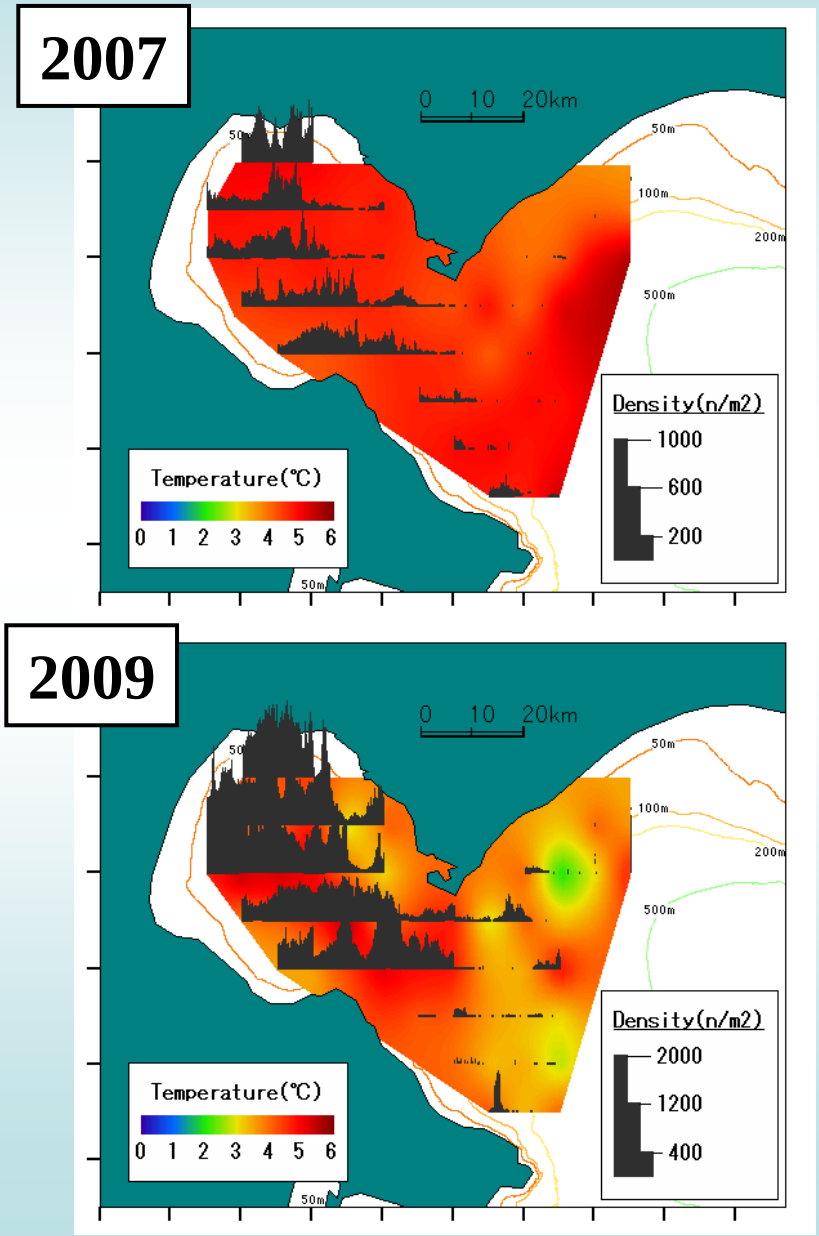






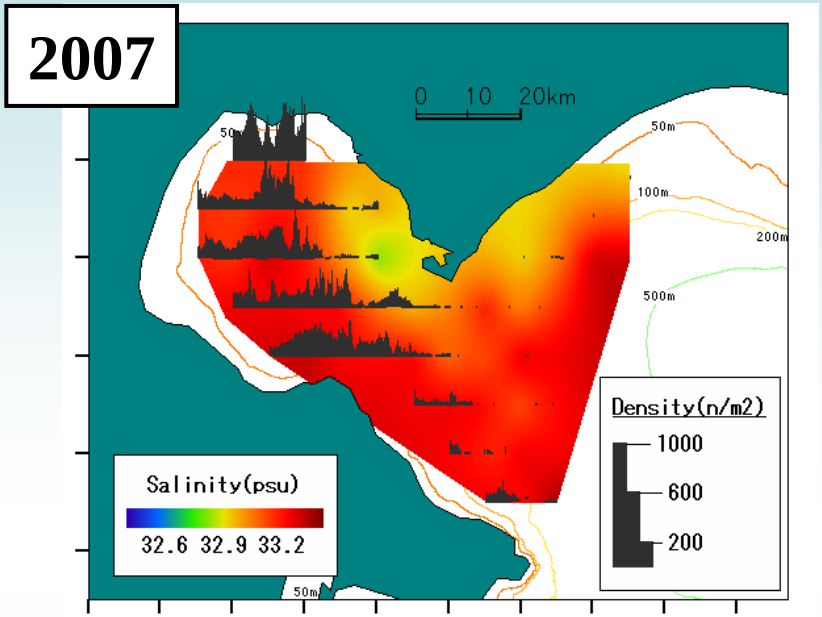
- **Biomass were high around 20 m depth across all years**
- **We examined the relationships between environments at 20 m depth and pollock density (n/m^2 : vertically accumulated)**

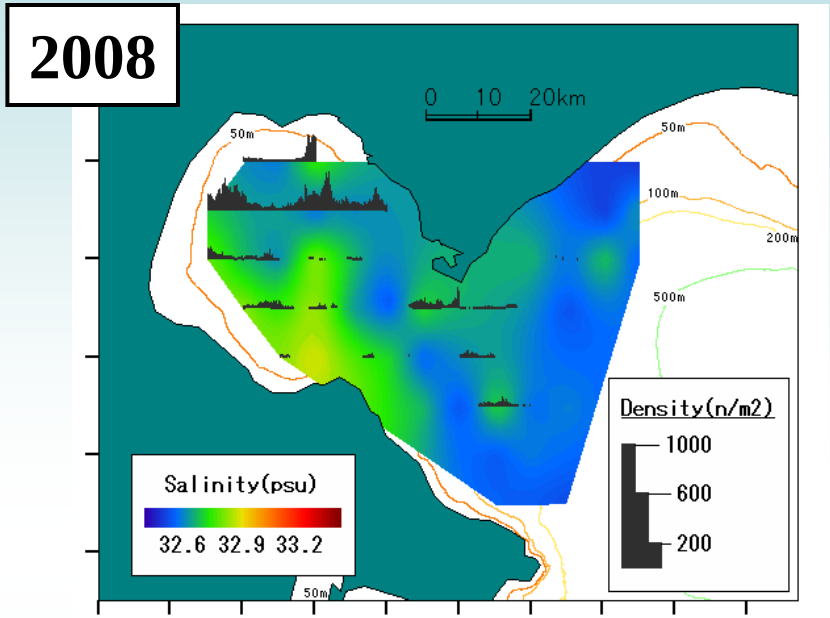
Pollock density vs 20m temperature

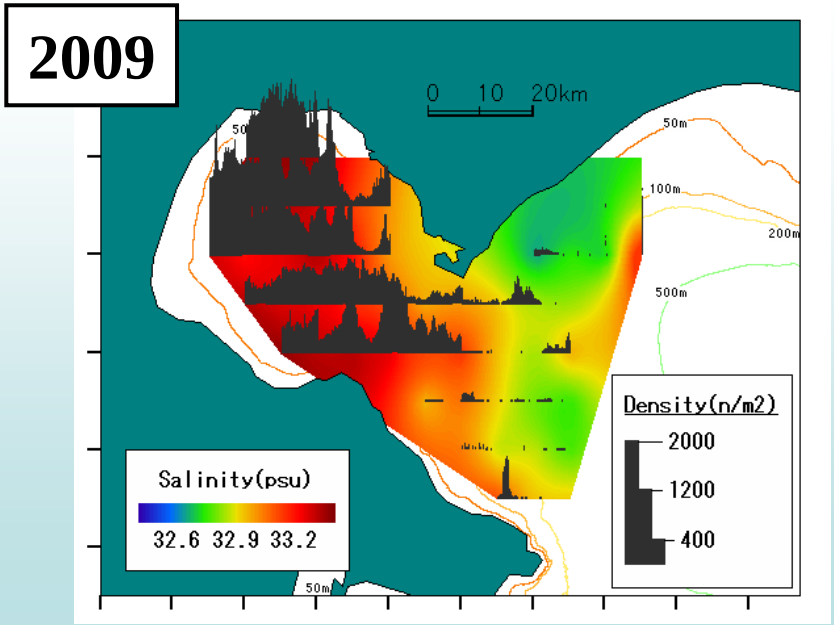


- **The density of pollock larvae was low in cool water in 2008 and 2009**

Pollock density vs 20m salinity

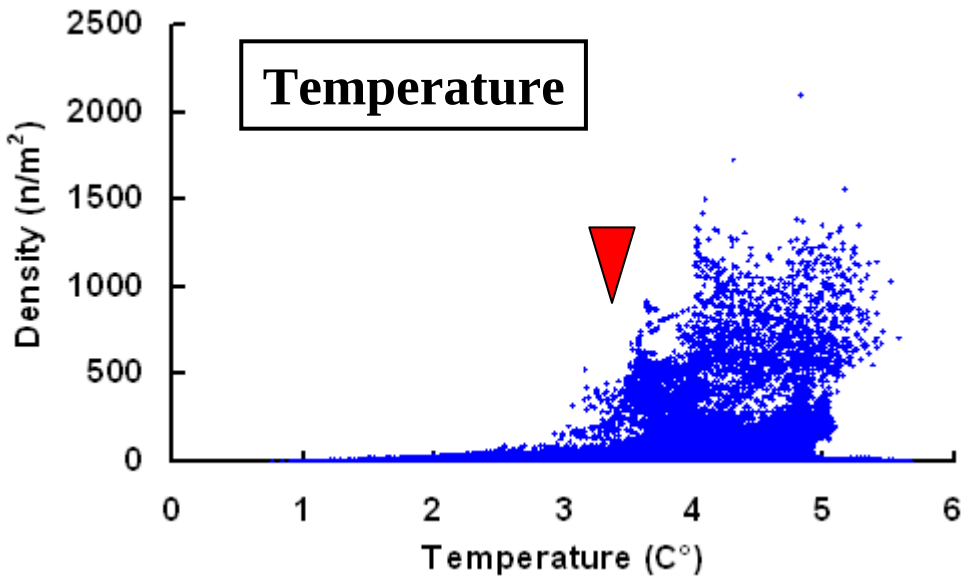


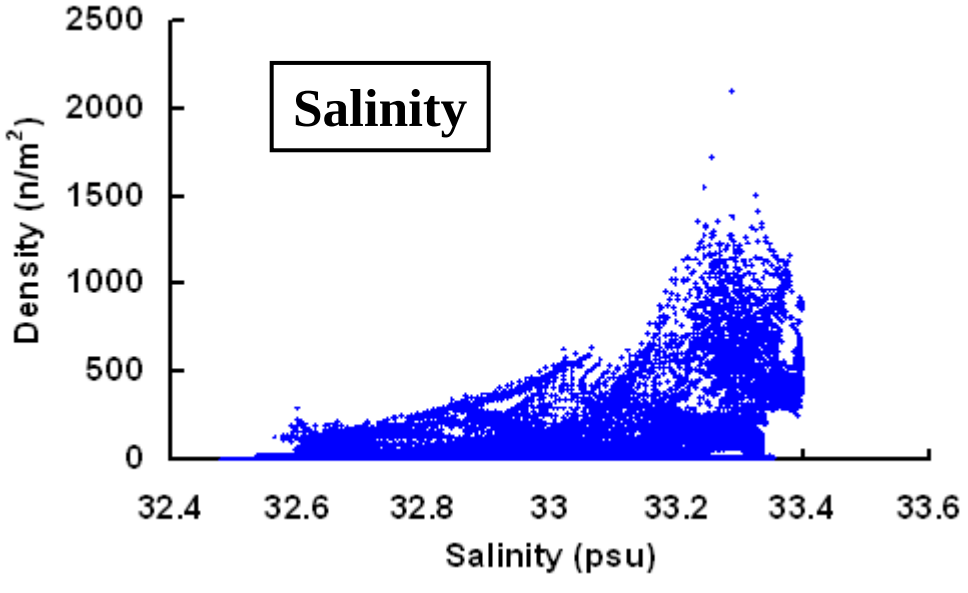




- **Pollock larvae were scarce in low-salinity waters especially in 2007 and 2009**

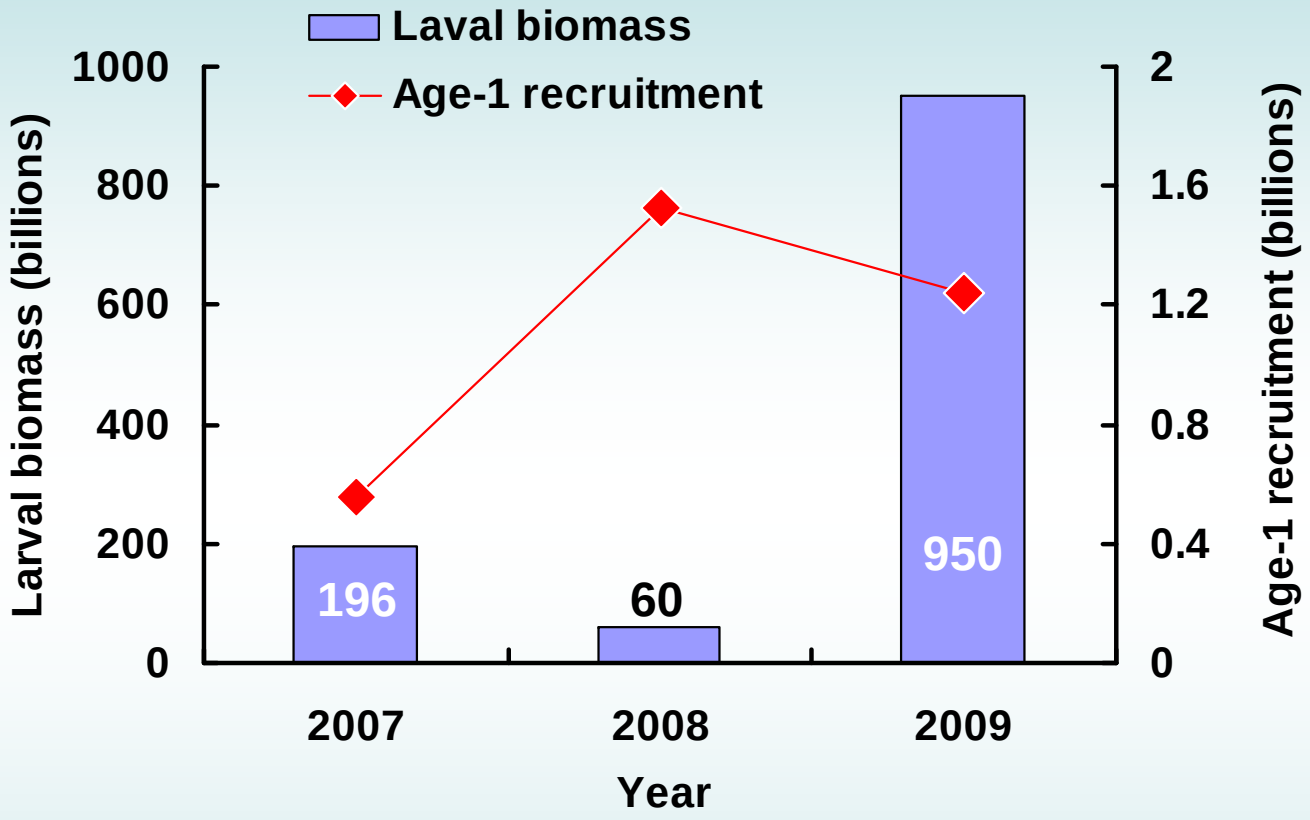
Threshold temperature and salinity





- **Water temperature has a relatively abrupt threshold**
- **High pollock density is observed above approximately 3.5 ºC**
- **Obvious threshold is not identified for salinity**

Laval biomass vs recruitment



- **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 ºC**
- **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**