Differences in biological characteristics of walleye pollock (*Gadus chalcogrammus*) off the eastern Korean Peninsula during 1960s–2000s

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Background & Introduction

Biomass fluctuation of fisheries resources

Overfishing

Ecological process within foodweb

Changes in Oceanographic conditions
Walleye pollock?

Spawning season

Habitat depth
- **Juvenile:** Shallow water
- **Adult:** 200~350m (NFRDI, 2010)

Habitat temperature
- **Juvenile:** 2~7℃ (Nakatani and Maeda, 1984)
- **Adult:** 2~10℃ (most preferable 3~5℃) (NFRDI, 2010)

Prey
- **Juvenile:** copepod, euphausiid (Yamamura et al. 2002)
- **Adult:** euphausiid, shrimp, cephalopod, fish (NFRDI, 2010)

Map: Wonsan Bay, Korea, East Sea, Japan
To reveal the change in growth and maturity of pollock during 1960s–2000s off the eastern Korea, and

To investigate the relationship between environmental change and its impacts on fisheries resources.
Data & Methods

◆ Biological/Fisheries data

- National Institute of Fisheries Science (NIFS) scientists subsampled biological parameters (length, weight, maturity, etc.) from Danish seine and Drift gill net fisheries since the late 1950s, and we extracted data from winter season (Nov.-Feb) only.

Three stages of fisheries

1) Period 1:
   - Initial period (1958–1968)

2) Period 2:
   - Active period (1973–1985)

3) Period 3:
**Environmental Data**

- NIFS serial oceanographic observation data
- Oceanic environmental data
  - seawater temperature at depth and zooplankton abundance etc.

**Statistical Analysis**

- Cross-correlation function (CCF) analysis
  - to see the time-lag effect in correlation between the environment variables and the pollock catch
- Sequential Regime Shift Detector (SRSD)
  - to detect changing phase of seawater temperature
Estimate of Biological Parameter

① von Bertalanffy growth curve

\[ L_t = L_\infty \left(1 - e^{-K(t-t_0)}\right) \]

- \( L_t \) = length at age \( t \)
- \( L_\infty \) = theoretical maximum length (asymptotic)
- \( K \) = growth coefficient, proportional to rate at which \( L \) is reached
- \( t_0 \) = theoretical age at \( L = 0 \) (often negative, or zero)

② Length at 50% maturity

\[ P_i = \frac{1}{1 + e^{-K \times (X_i - L_{50})}} \]

- \( P_i \) = proportion of the mature fish at length \( X_i \)
- \( K \) = instantaneous rate of fish maturation

③ Fulton Condition factor

\[ CF = \frac{BW}{FL^3} \times 10^4 \]

- \( BW \) = Body Weight (gram)
- \( FL \) = Fork Length (cm)
Estimate of Biological Parameter

4 Relative Length Frequency

Bonar (2002) developed a simple method to assess the size structure of a fish population quickly by comparing its sampled length frequency with an average developed for the particular geographic region.

For comparing particular periods caught in the same geographic region

5 PSD (Proportional size distribution)

: to differentiate size distribution of fish and to determine the level of recruitment

\[
PSD = \frac{\text{Number of fish} \geq \text{minimum quality length}}{\text{Number of fish} \geq \text{minimum stock length}} \times 100
\]

Stock Length: mean length of first maturity 25cm (Kang et al, 2013)

Quality Length: length at 50% maturity 37cm
Results & Discussion

von Bertalanffy growth curve

\[ L_t = 56.3(1 - e^{-0.34(t+0.06)}) \]

\[ L_t = 51.5(1 - e^{-0.42(t+0.11)}) \]
Length at 50% maturity

Period 2 (1973–1985)
Condition factor & Euphausiid density

$r=0.648, p<0.05$
3 period

① Initial period
   : 1958–1968

② Active period
   : 1973–1985

③ Weak period
   : 1991–2002
Proportional Size Distribution (PSD)

- Period 1 (1958–1968)
- Period 2 (1973–1985)
During the 1975–1996

Seawater temperature in the coastal area in December – juvenile catch

1. 10m: $r = -0.515$, $p < 0.05$
2. 20m: $r = 0.507$, $p < 0.05$
3. 75m: $r = -0.659$, $p < 0.05$
4. 100m: $r = 0.592$, $p < 0.05$
Biological characteristics of Korean pollock examined by the progression of fisheries

Period 1: initial stage from 1958 to 1968
Period 2: active stage from 1973 to 1985
Period 3: weakening stage from 1991 to 2002

1) In the beginning stage of fisheries (Period 1), there were relatively more ‘large fishes’, and fish size decreased as fisheries became active.

2) The length of 50% maturity was 33cm in the active stage of fisheries (Period 2), but it increased to 37cm in the weak period (Period 3)
3) In active stage of fisheries, the length range became narrow, and the numbers in large- and small-size classes were reduced later period.

4) A density-dependent growth mechanism seemed to be acted for Korean pollock. Condition factor and mean length of pollock were larger in weak stage of fisheries than in active period.

5) Relative length frequency showed more ‘small-size fish’ in initial period. Proportional Size Distribution (PSD) reflected that recruitment was relatively higher in the initial stage than in later period.

6) Statistical analysis revealed that there were significant positive correlations between juvenile pollock catch and seawater temperatures in surface layer with time-lags.
Future study

- We need to construct the number of pollock at age using some population dynamic models to explain the recruitment variability of pollock,

- We need to demonstrate the relationship between the biological characteristics and environmental conditions on recruitment variability.