

Configuration of migratory history from stable isotope and trace elements in otoliths of the North Pacific chum salmon

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Otolith (earstone)

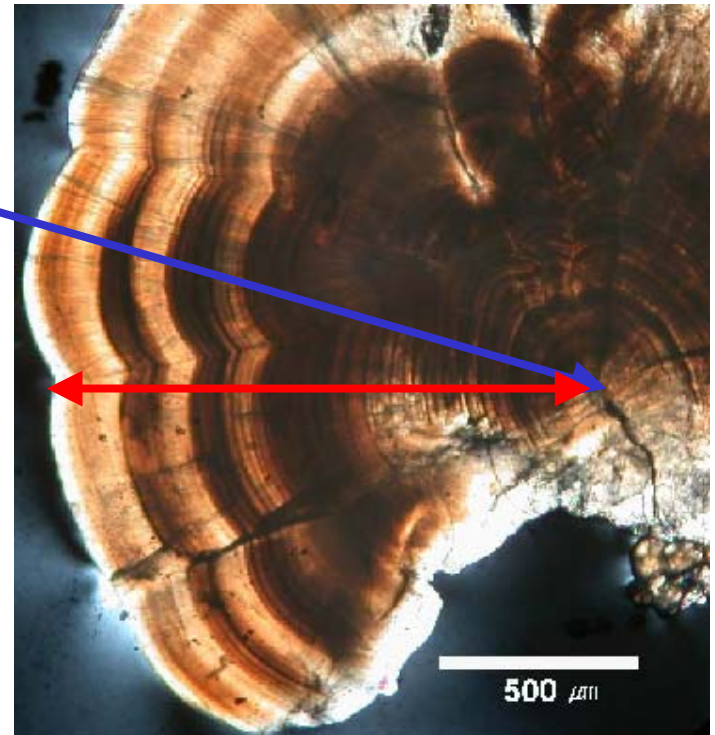
- Otolith is a calcified structure for balancing and hearing sense of fish.
- As fish grow, otolith also grows until they die.
- Otolith is a metabolically inert timekeeper.
- Therefore, the chemical composition of otolith indicates environmental characteristics of habitat during the specific life stage.



Otolith chemistry research:

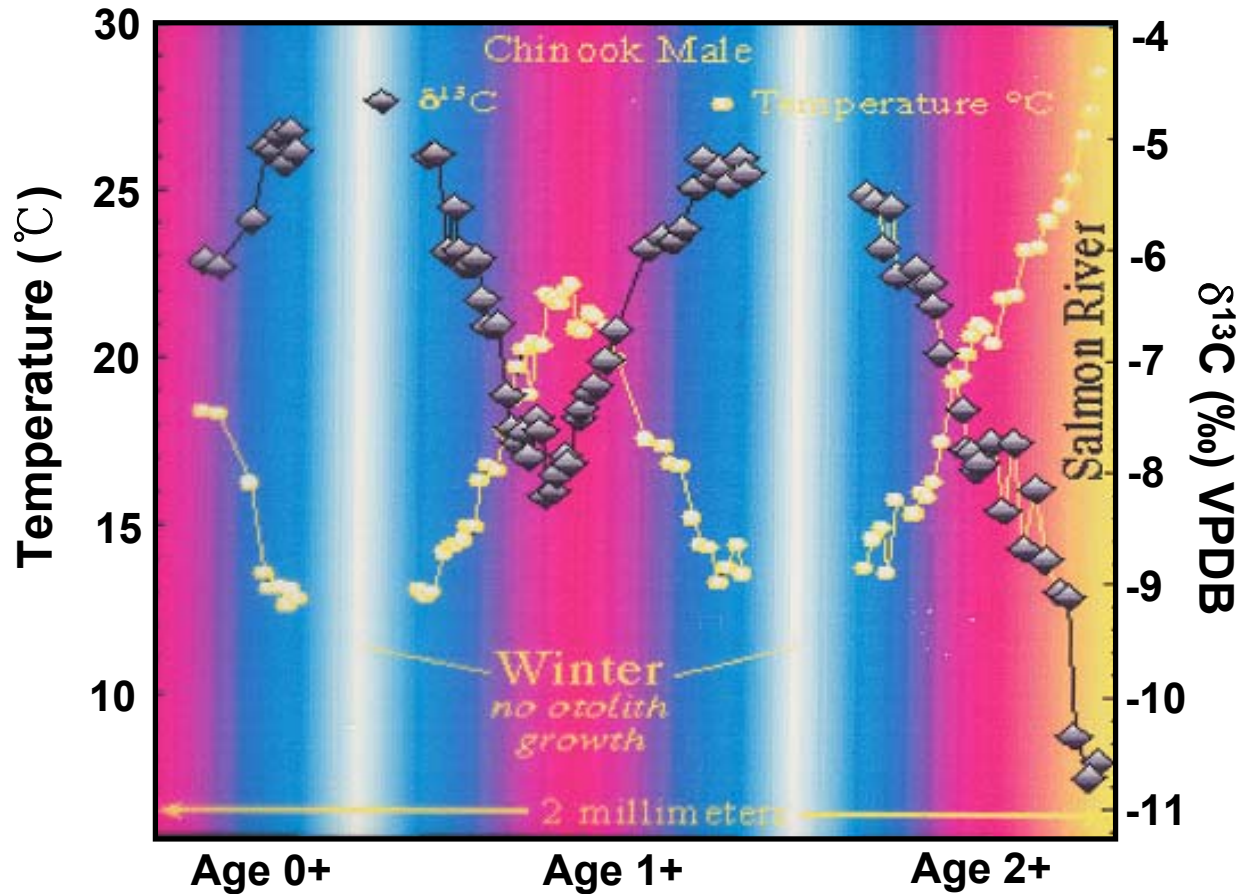
isotope analysis vs trace element analysis

- growth
- stock identification
- reconstruction of temperature and salinity history
- determination of migration pathway
- detection of anadromy
- use as a natural tag
- chemical mass marking



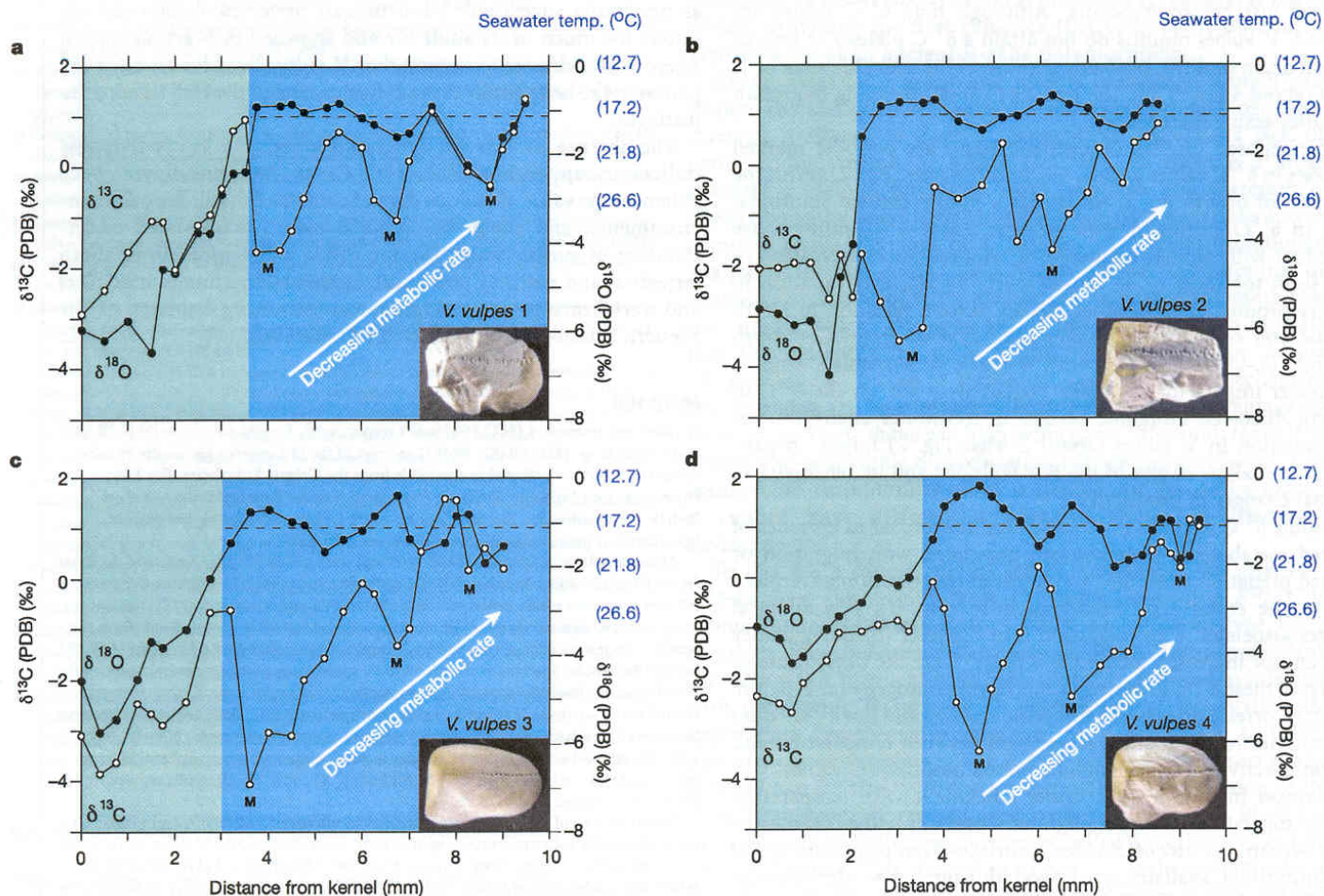
Stable isotope analysis

Chinook male



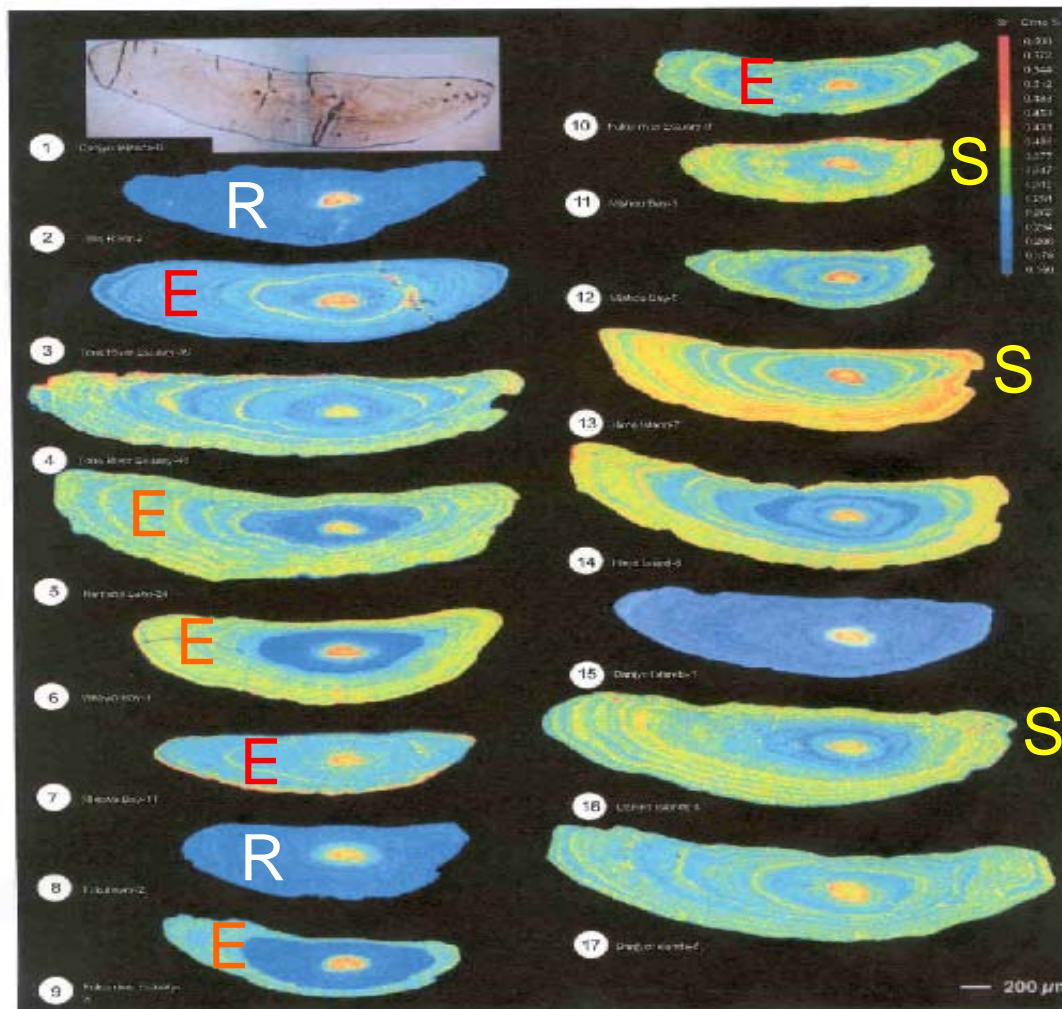
(W.P. Patperson, U. of Saskatchewan)





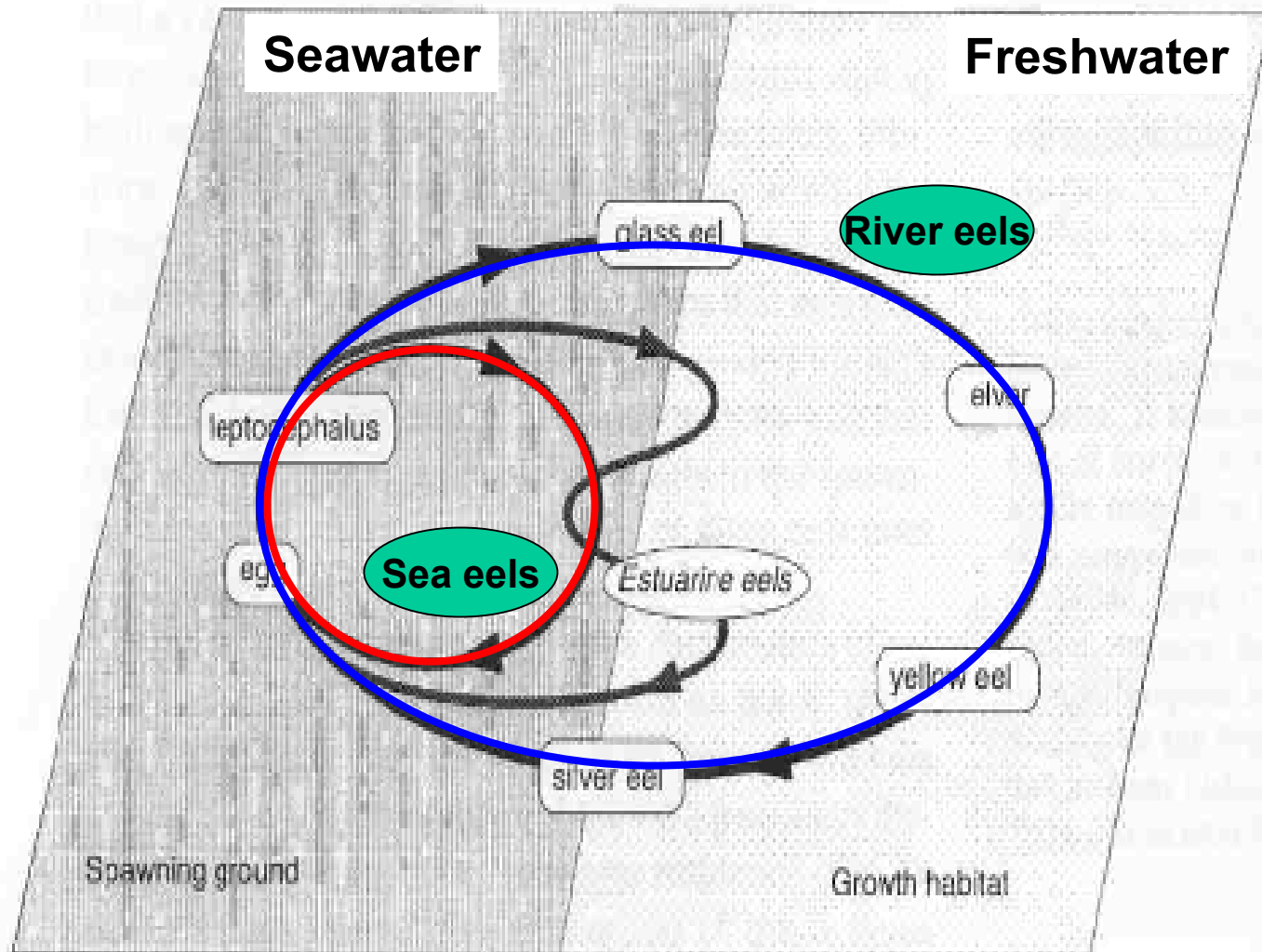
- $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values of *Vorhisia vulpes* otolith specimens preserved in late Cretaceous sediments (Carpenter et al., 2003)
- demonstrate fish behavior under the rapidly changing environment

Trace element analysis

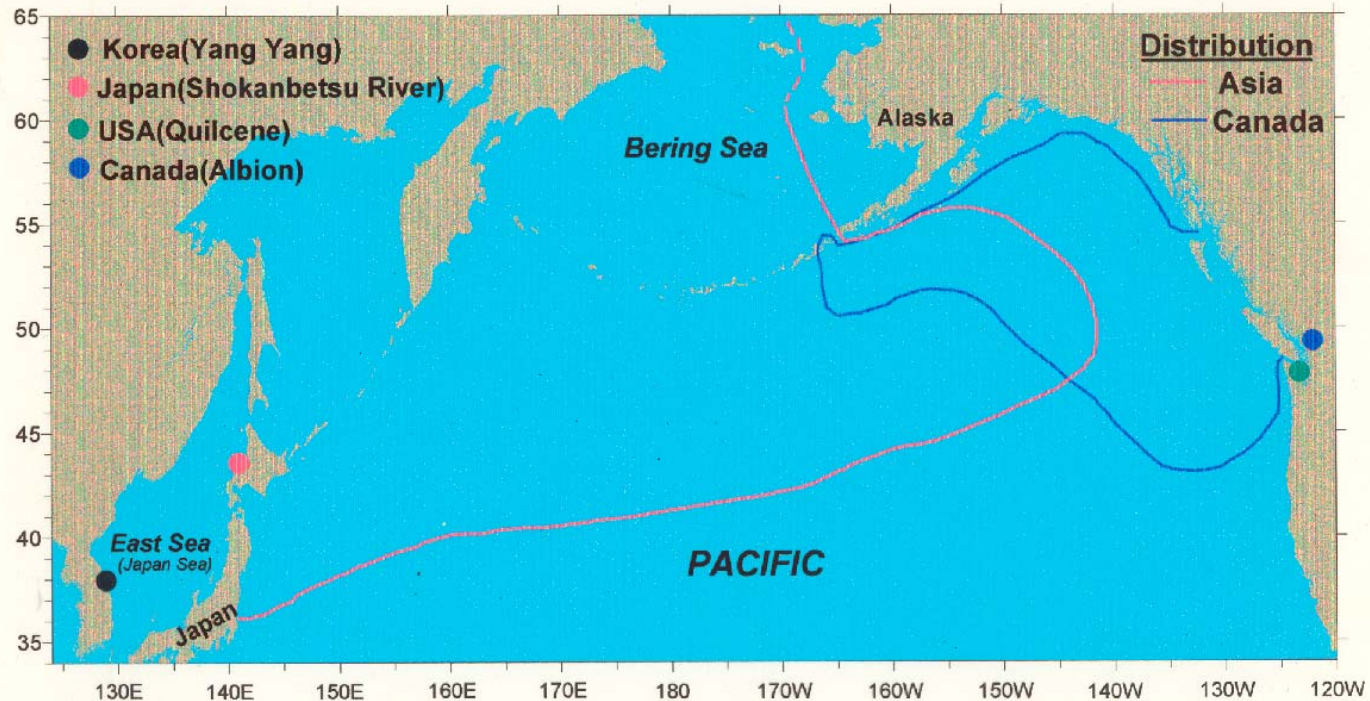


- R: river eels
- E: estuarine eels
- S: sea eels

- Three types eels based on migratory history
- Facultative catadromy of the eel between freshwater and seawater habitats (Tsukamoto and Arai, 2001)



Flexible pattern of migration



Known migration route of chum salmon in the North Pacific Ocean

Purpose

- To understand the migratory history of chum salmon (*Oncorhynchus keta*) in the North Pacific Ocean through the investigation on stable isotopes and trace elements in otolith



Materials and Methods

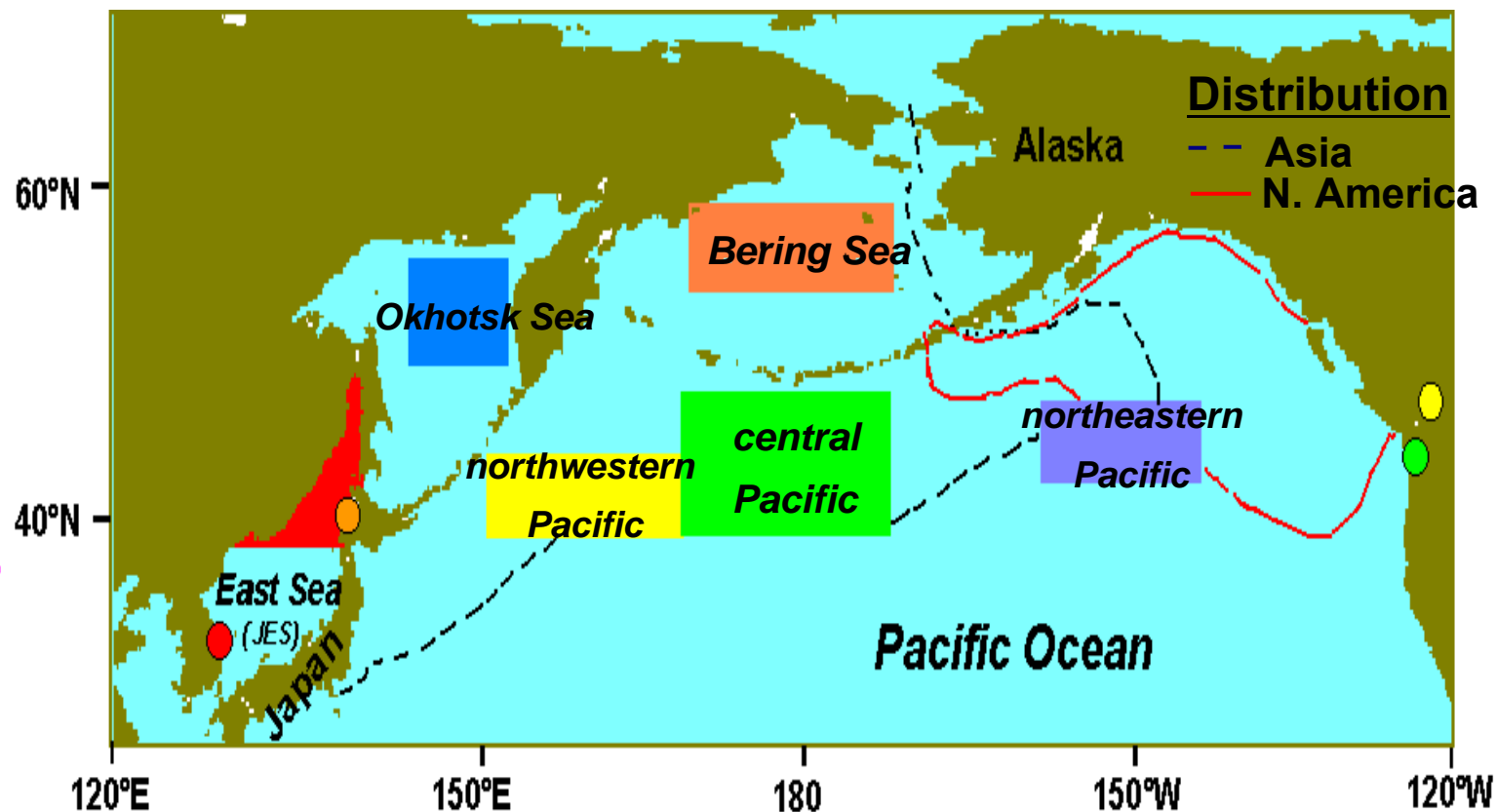
● Salmon sampling

- * **adult chum** - 1997 ~ 1999 spawning seasons
 - Four locations in the North Pacific eastern (Canada and USA) western (Japan and Korea)
- * **juvenile sockeye, chinook**
 - off Auke Bay (Alaska, USA) in 2002

● Seawater temperature analysis

- NODC, JODC, KODC, CREAMS
- 20~50m depth, May-Oct.
- 1994-1998





Locations of sampling area of chum salmon in the North Pacific Ocean. Squares indicate subareas for seawater temperature.

Materials and Methods

● Stable isotope analysis

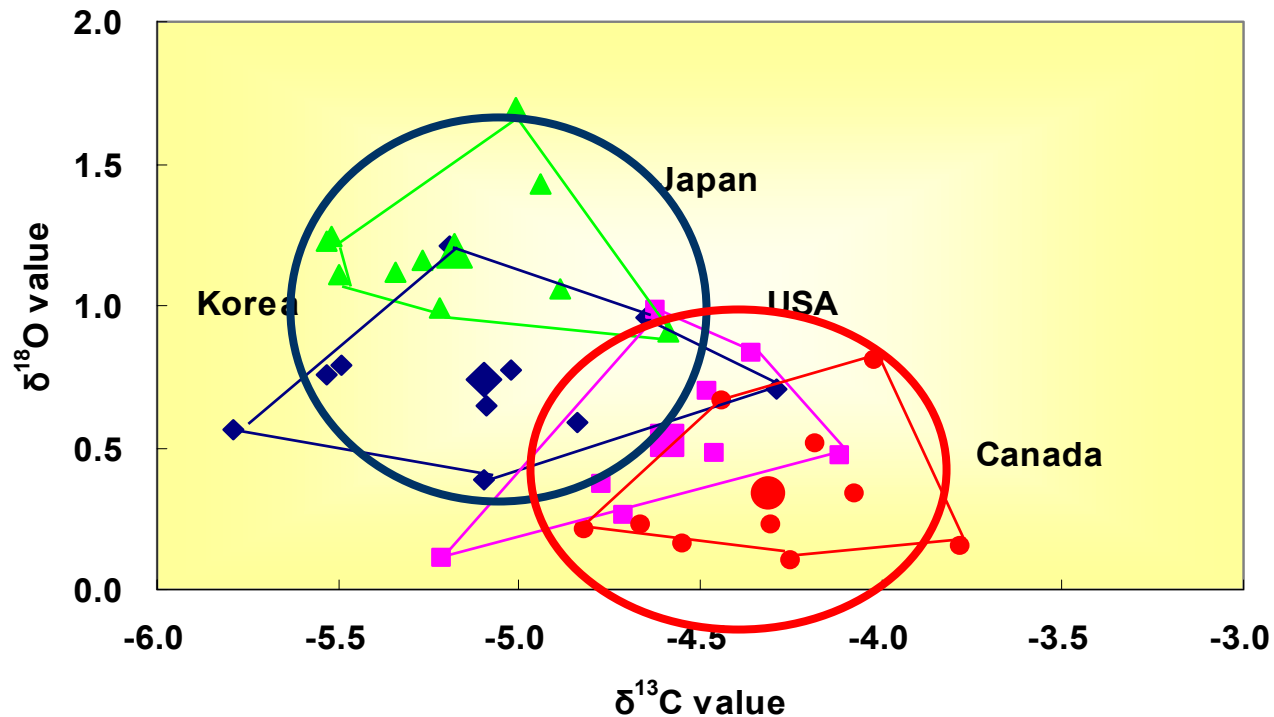
- $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$
- Whole otolith was ground
- age-0 (smolt) band from adult otolith

● Trace element analysis

- LA-ICPMS, Univ. of Victoria
- **Continuous line scanning** from core to margin of otolith (Sr/Ca ratio, Zn/Ca ratio, n=110)

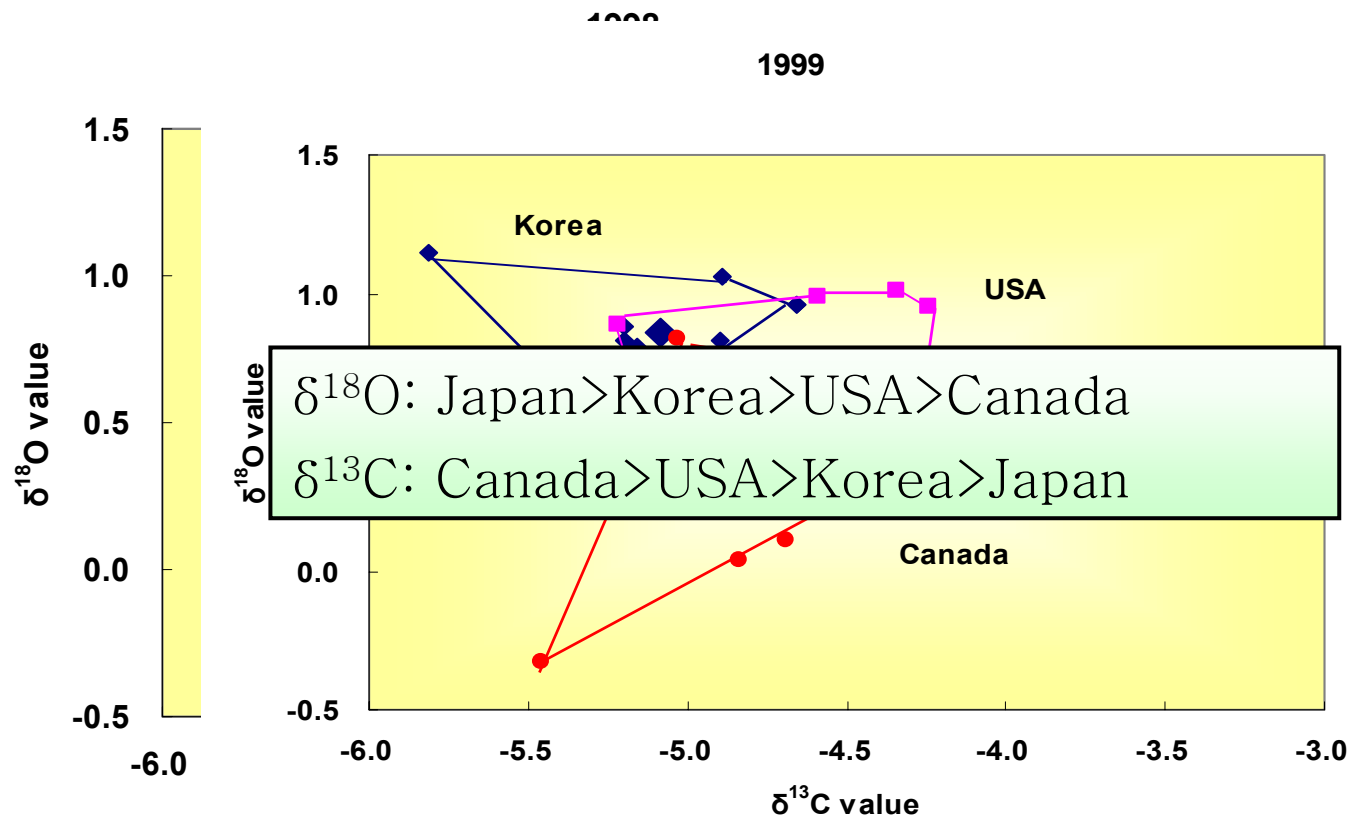


1997



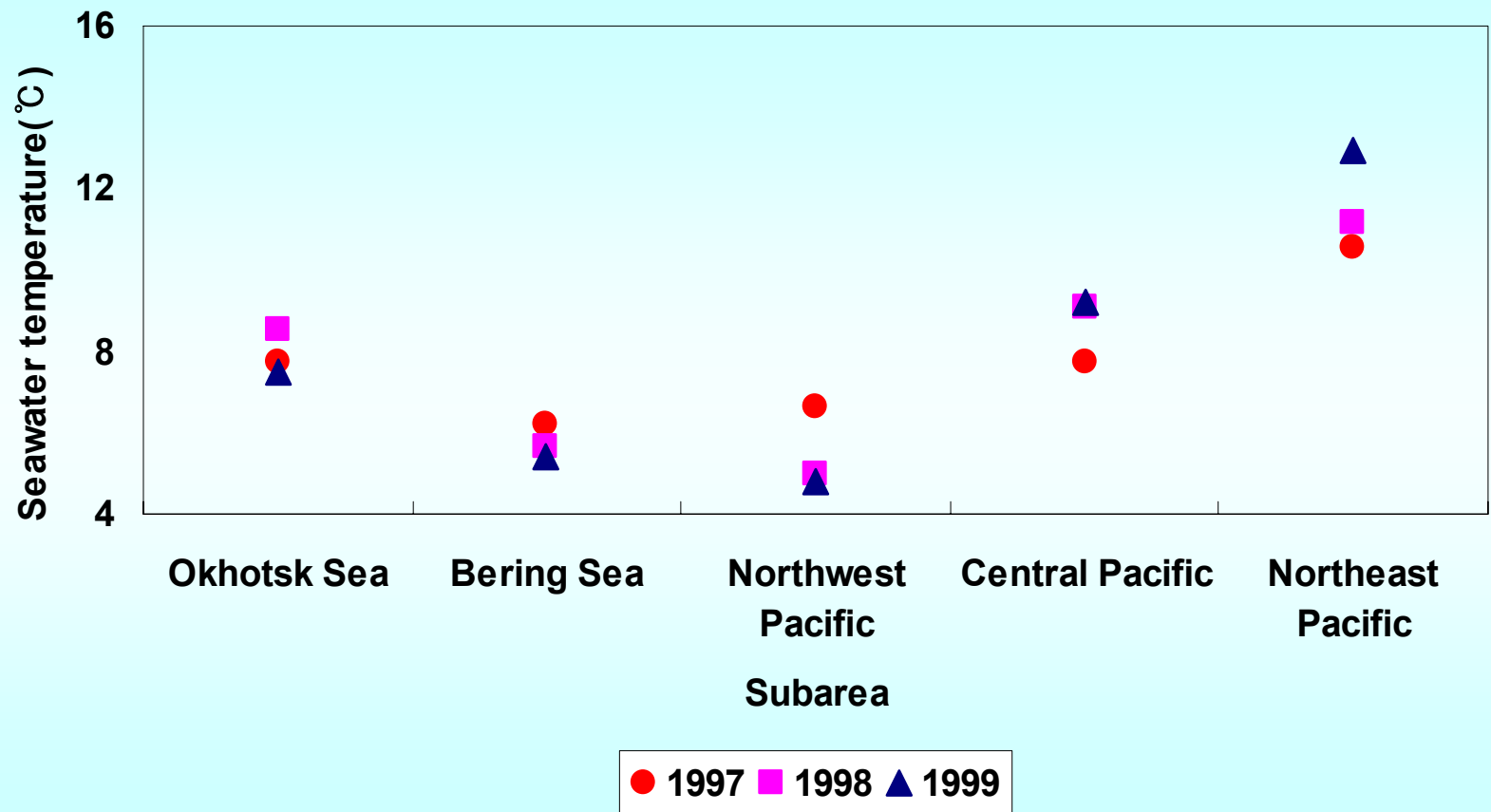
The scatter plots of $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ in otoliths of adult chum salmon, which were collected in 1997





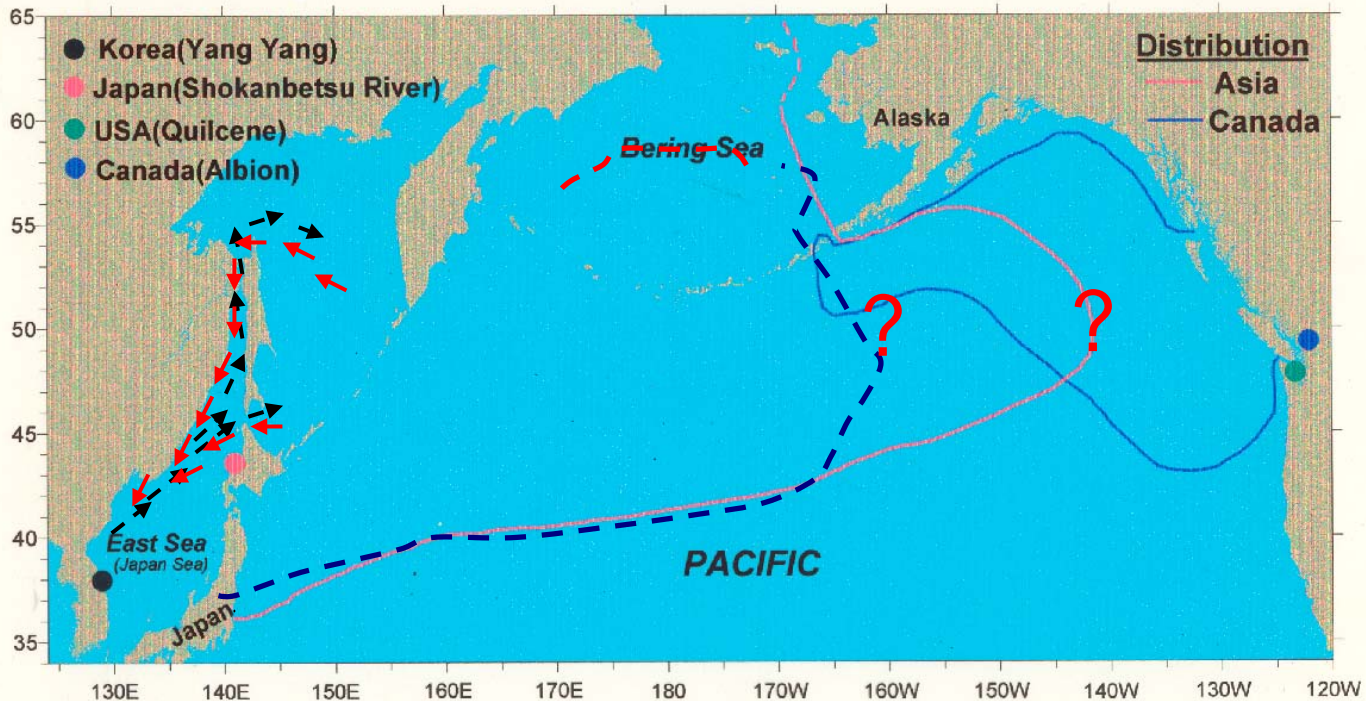
The scatter plots of $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ in otoliths of adult chum salmon, which were collected in 1997~1999.





Mean seawater temperatures at 20~50m depth during May through October in each subregion of the North Pacific in 1997-1999.

Answer ?



Thinkable migration route and distribution of Asian chum salmon in the North Pacific Ocean



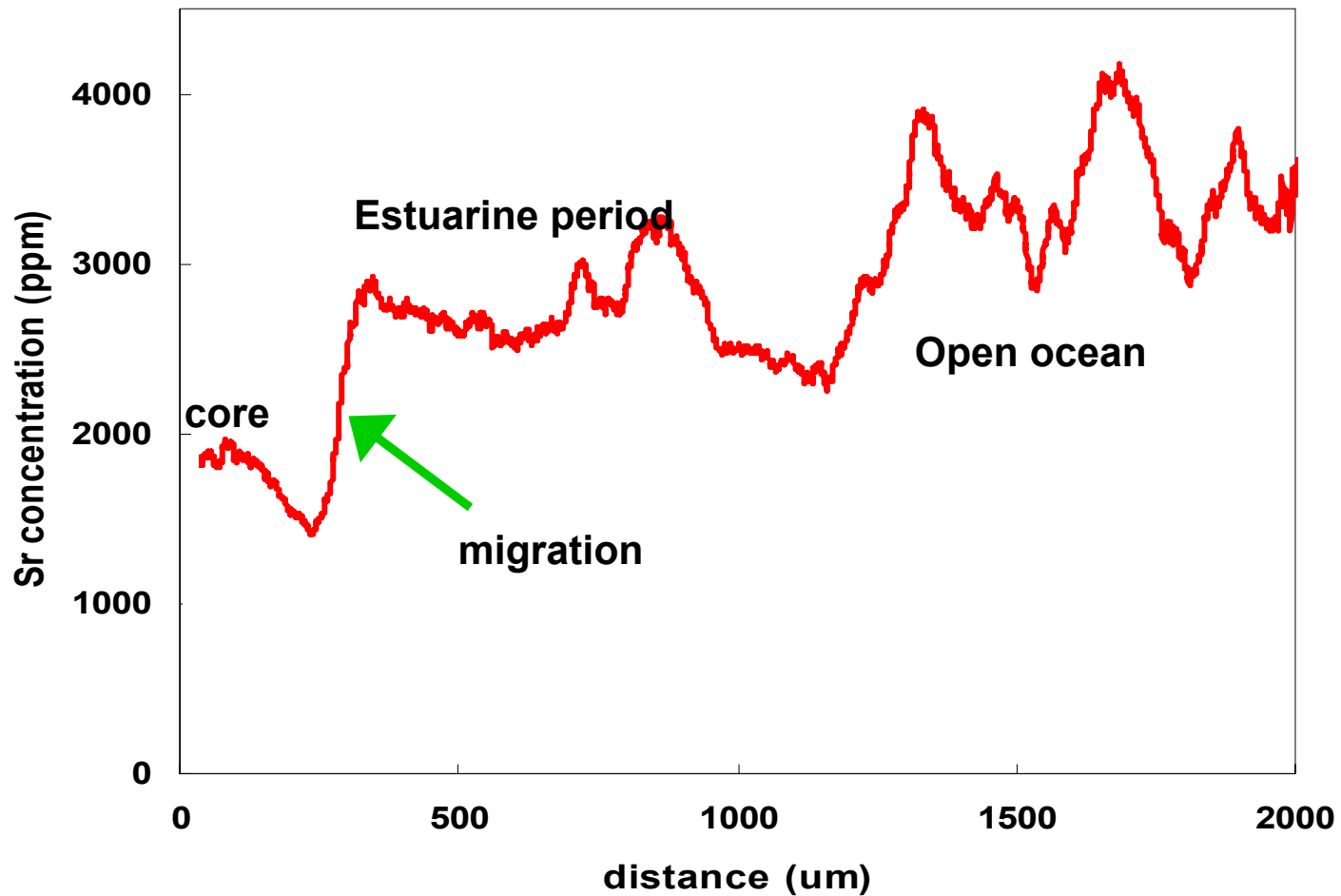
Summary I

- **Area-specific pattern of stable isotopes ($\delta^{18}\text{O}$ and $\delta^{13}\text{C}$) was shown persistently throughout 1997-1999.**
- **Asian salmon might reside in cooler areas than North American salmon.**
- **Feeding ground of the Asian salmon would be the Okhotsk Sea, the Northwest Pacific, and the Bering Sea and Gulf of Alaska.**
- **Migration route of Korea salmon**
East/Japan Sea- Tartar strait/Soya strait- Okhotsk Sea
– Northwest Pacific-Bering Sea-Gulf of Alaska

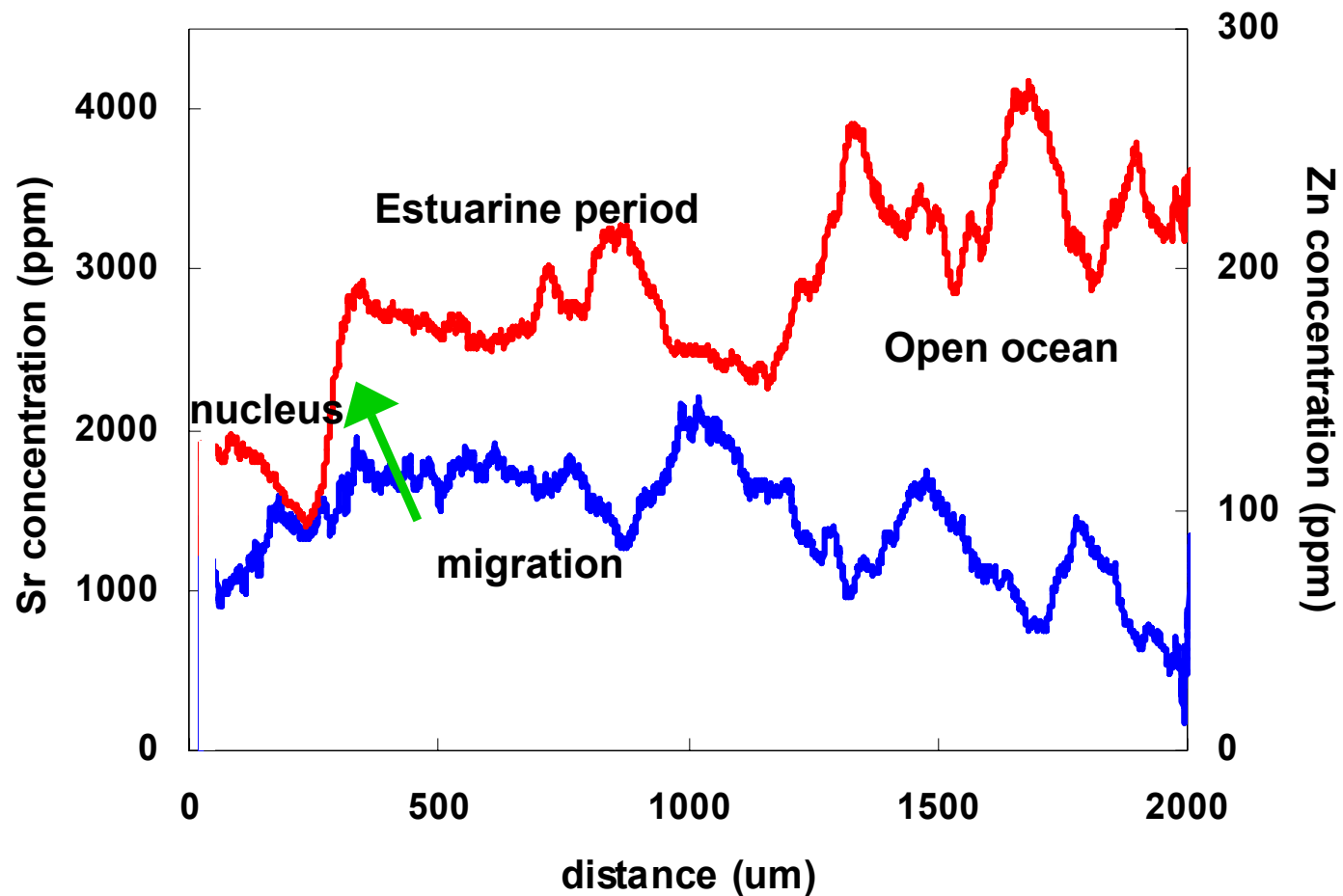


Trace element analysis

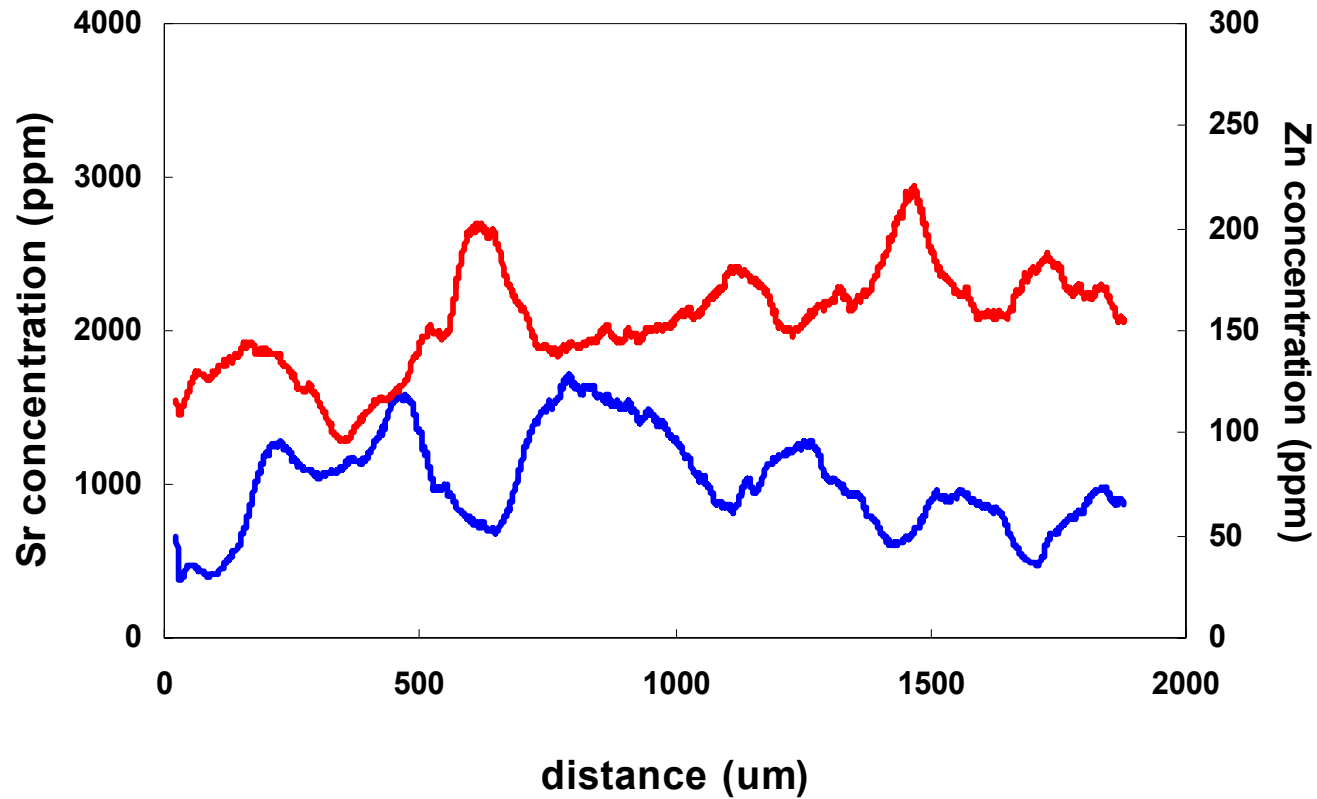




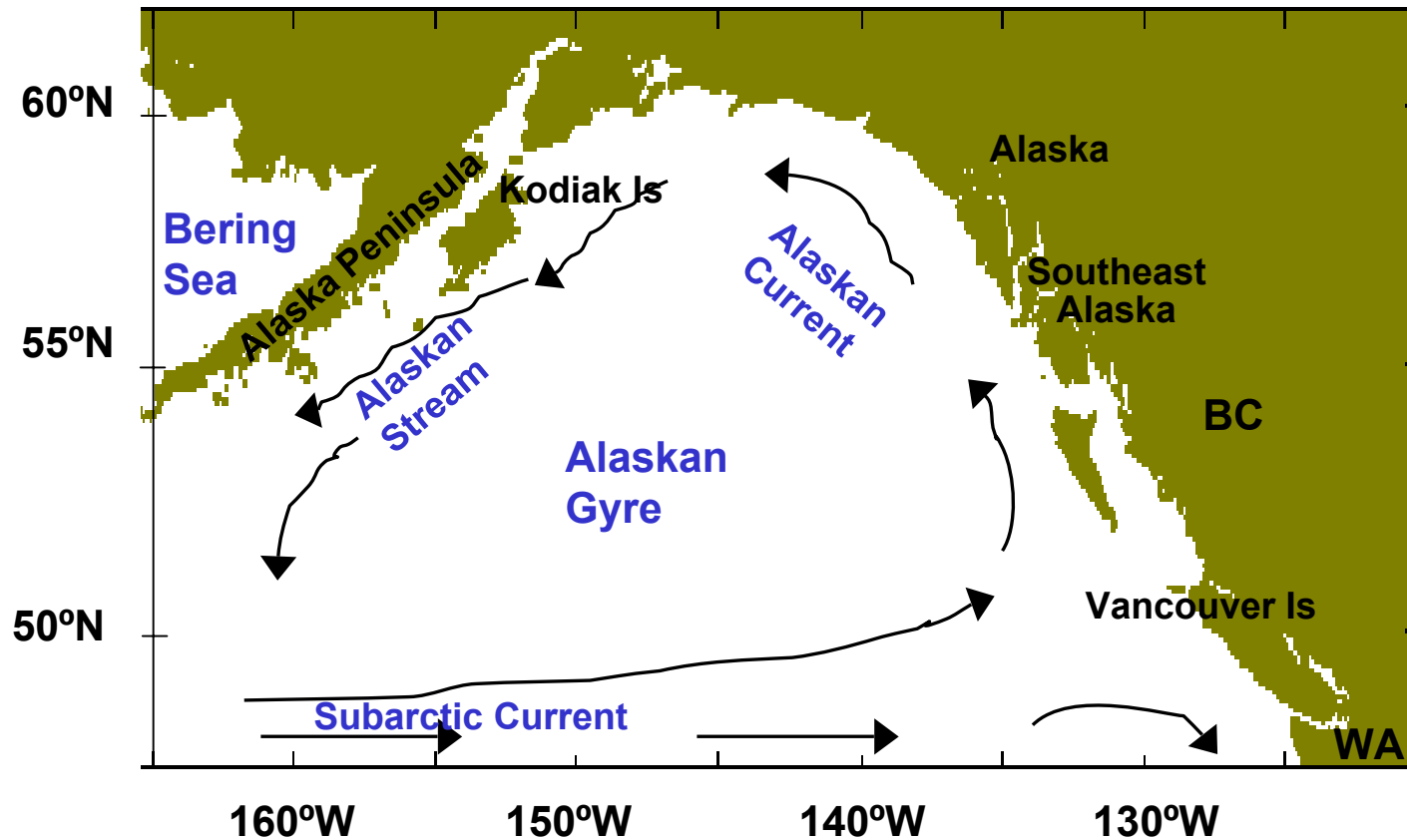
Profile of Sr concentration in otolith collected from Canada.



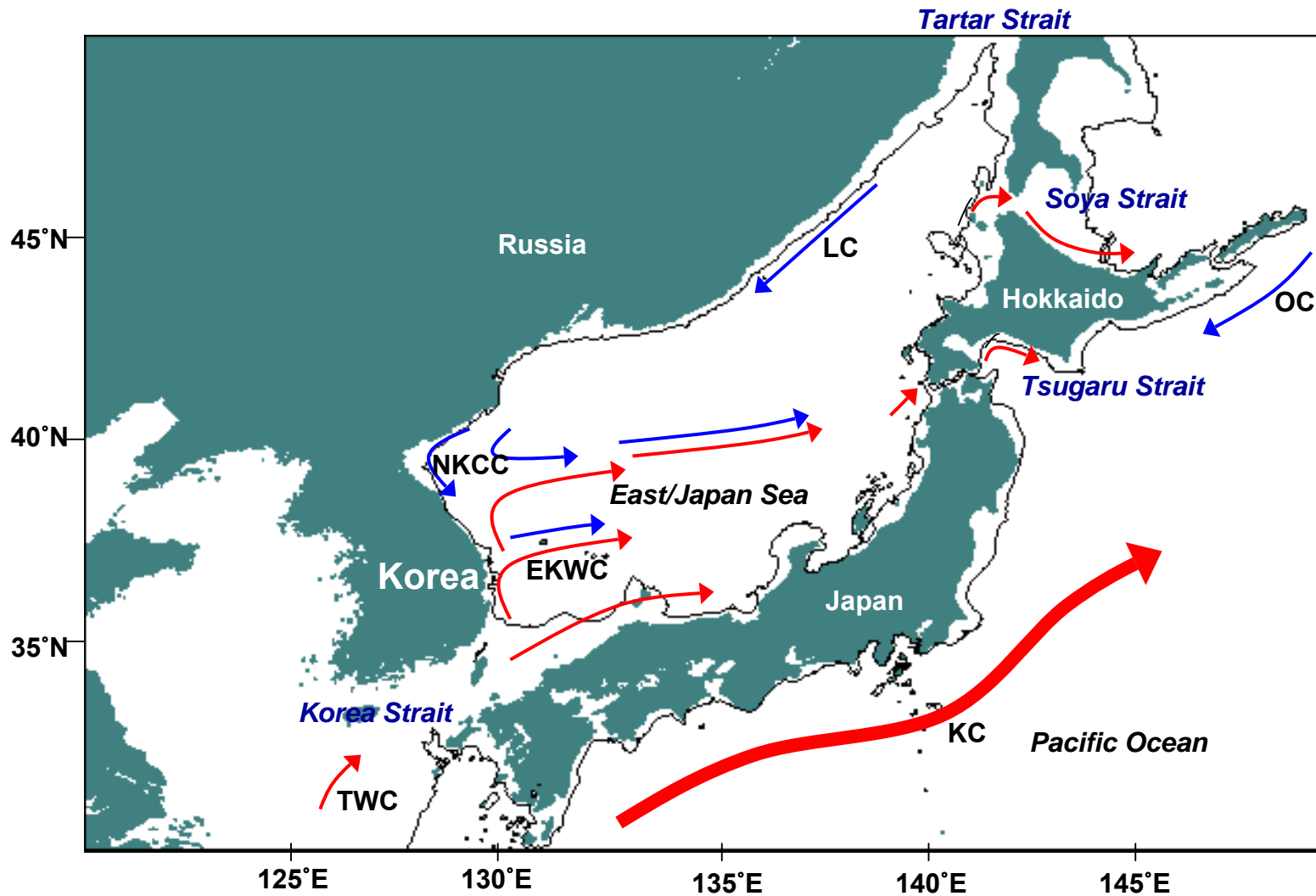
Profiles of Sr and Zn concentration in otolith collected from Canada.



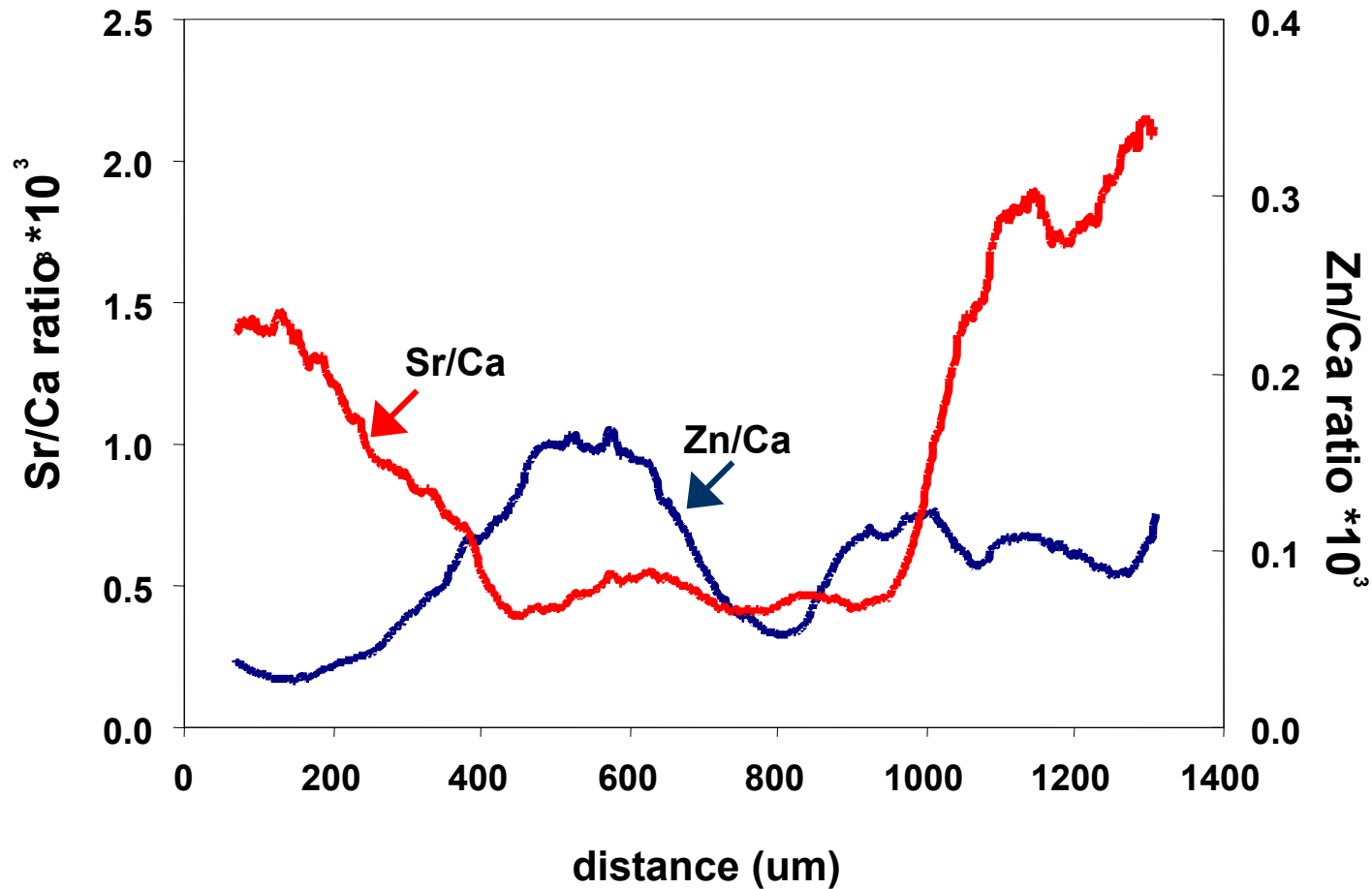
Profiles of Sr/Ca and Zn/Ca ratios in otolith collected from Korea in 1997.



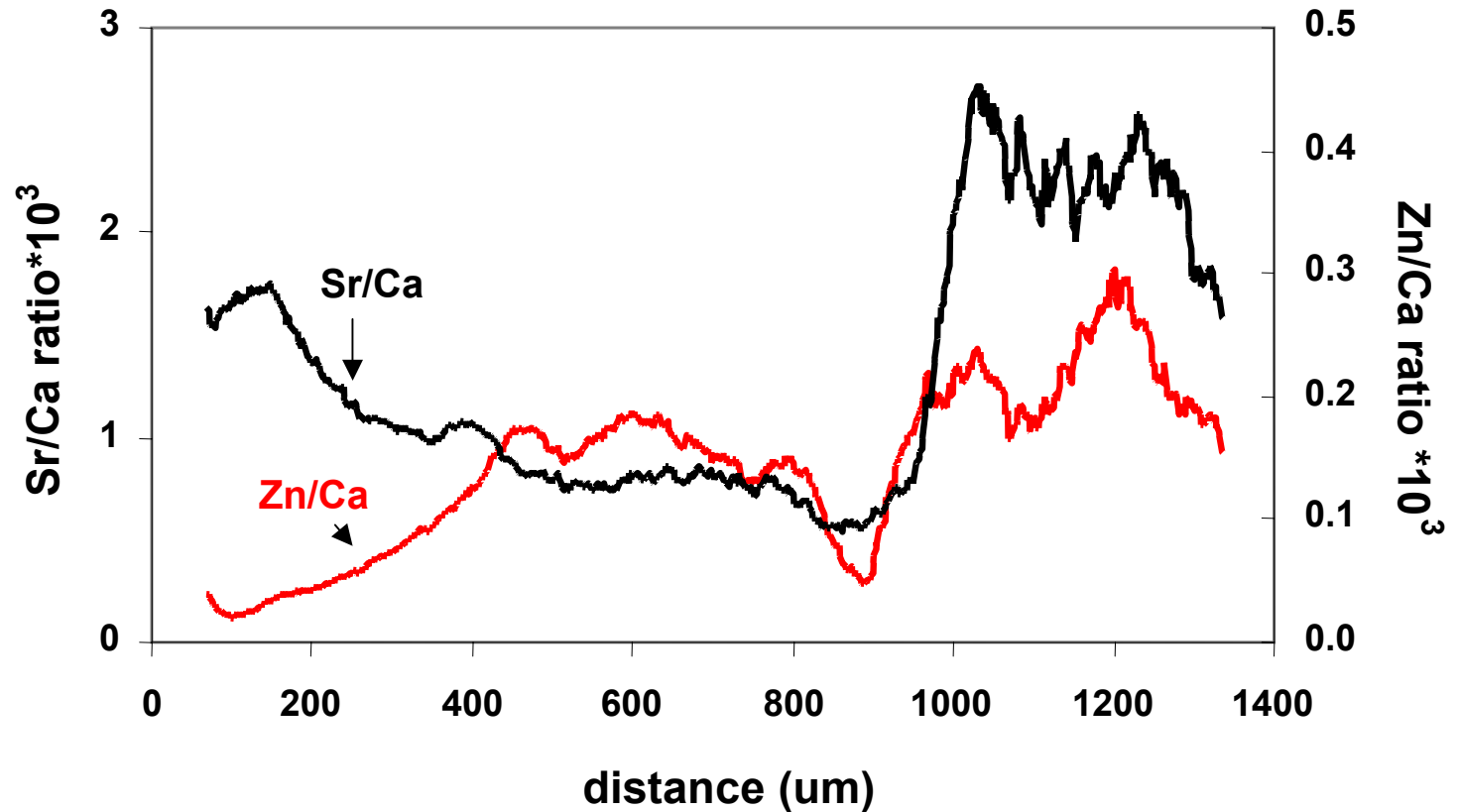
A migration pattern of North American salmon with major surface currents of the North Pacific Ocean (Healey 2000)



Geographical features with major surface currents near chum salmon hatchery in Korea



Profile of Sr/Ca and Zn/Ca ratio in otolith of juvenile sockeye collected off Auke Bay.



Profile of Sr/Ca and Zn/Ca ratio in otolith of juvenile chinook collected off Auke Bay.

Summary II



Area-specific patterns were shown:

- long estuarine trait in the North American salmon
- short estuarine trait in the Asian salmon



Determination of migration timing

- freshwater to open ocean



Thank you

