SPATIAL AND TEMPORAL VARIATION IN OTOLITH ELEMENTAL CHEMISTRY OF YOUNG-OF-YEAR PACIFIC COD IN THE GULF OF ALASKA

Mary Elizabeth Matta, Jonathan Short, Thomas Helser, Olav Ormseth | Alaska Fisheries Science Center, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Seattle, Washington 98115 | beth.matta@noaa.gov
Jessica Miller | Oregon State University, Hatfield Marine Science Center, Coastal Oregon Marine Experiment Station, 2030 S.E. Marine Science Drive, Newport, Oregon 97365

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Abstract

Shallow coastal waters of the Gulf of Alaska (GOA) serve an important function as nursery habitats for young-of-year Pacific cod (*Gadus macrocephalus*). However, relatively little is known regarding the relative contribution of these areas to the adult offshore stock. Chemical signatures within otoliths act as data recorders of the environments to which a fish has been exposed during its lifetime. In particular, trace elements such as strontium and barium are related to salinity and temperature; when analyzed together, a suite of elements is analogous to a fingerprint and may be characteristic of a particular environment. In this project, we evaluate the potential of otolith elemental signatures to determine whether habitats of age-0 Pacific cod are chemically unique within two large regions: the Eastern and Western GOA. By sampling nearshore sites within each region, we assess whether it is possible to discriminate among nursery bays and whether individuals can accurately be assigned to their early juvenile habitat sites. The temporal persistence of otolith signatures within sites is also assessed by comparing a subset of samples collected during summer with those collected during fall. Ultimately, our goal is to develop a baseline map of elemental signatures to enable future elemental analysis of adult otoliths from the same cohort, thereby allowing us to retrospectively link individuals to their natal source habitats.

Methods

- Otoliths from age-0 Pacific cod were sampled opportunistically in summer and fall 2011 from several bays during nearshore surveys of the North Pacific Research Board GOA Integrated Ecosystem Research Project. Bays were also sampled for temperature and salinity.
- Laser ablation-inductively coupled plasma mass spectrometry (LA-ICPMS) was used to sample two otolith transects for trace elements: one transect ("edge transect") along the edge that represents environmental conditions experienced just prior to capture, and one transect ("life history transect") that represents conditions over the entire life of the fish.
- Because fish were not sampled in all bays in both summer and fall, the life history transect was averaged over two time periods: a contemporaneous 100 micron section corresponding to early July and a section spanning from early July (likely when settlement in nearshore areas occurs) to time of capture.
- Elemental concentrations were compared among bays and between summer and fall. A quadratic discriminant function was used to quantify the ability to correctly classify fish to collection site based on elemental signatures. Relationships between elemental concentrations and environmental variables were explored through linear regressions.

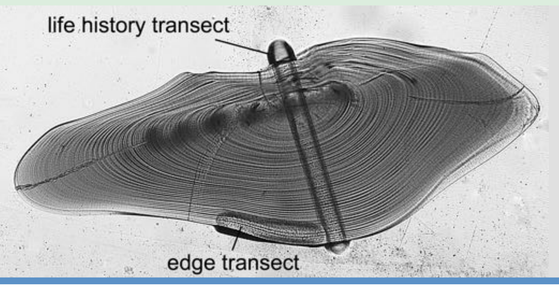
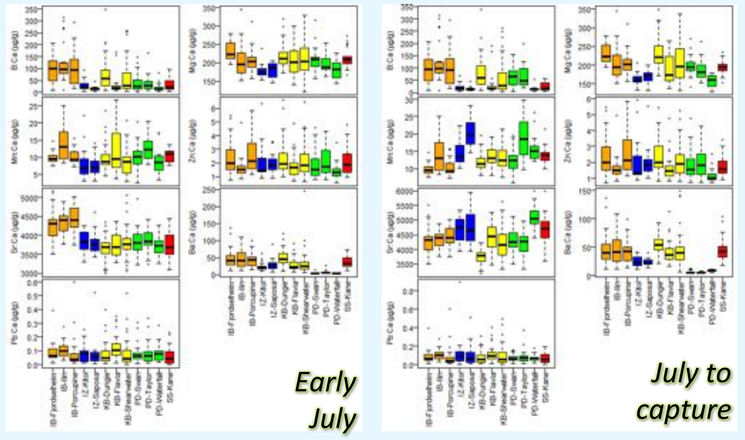
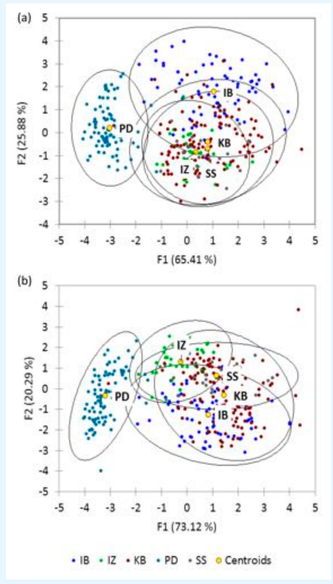


Photo credit: AFSC, NOAA Fisheries Service

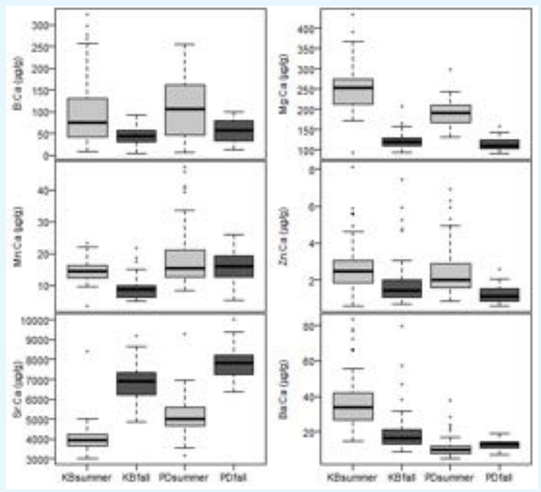
Results



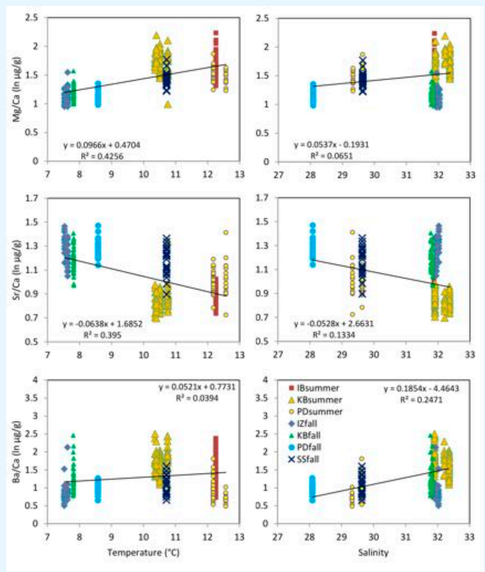
Elemental ratios measured from two different segments of the life history transect. Left panels: contemporaneous 100-micron segment (early July). Right panels: segments measured from early July to capture date. Horizontal bars show median values for each subsite, the top and bottom of each box represent the 25th and 75th percentiles, hatched lines are values within 1.5 times the interquartile range (IQR), and circles are outliers (values > 1.5 times IQR).
Sites indicated by the following abbreviations and colors: IB=Islas Bay (orange), IZ=Izhut Bay (blue), KB=Kiliuda Bay (yellow), PD=Port Dick (green), SS=Salisbury Sound (red)



Multivariate plots of discriminant functions based on age-0 Pacific cod elemental signatures in a) contemporaneous 100-micron segments (early July) and b) during time in residency. IB=Islas Bay, IZ=Izhut Bay, KB=Kiliuda Bay, PD=Port Dick, SS=Salisbury Sound

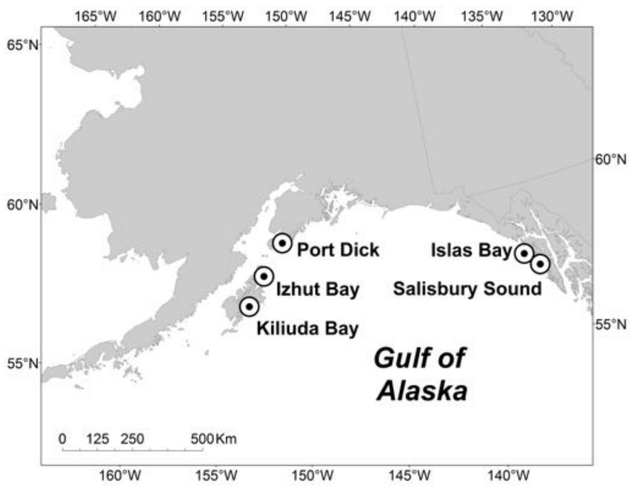


Differences between elemental concentrations at the otolith edge (time of capture) in summer (light gray) and fall (dark gray) in twice-sampled bays, Kiliuda Bay (KB) and Port Dick (PD).

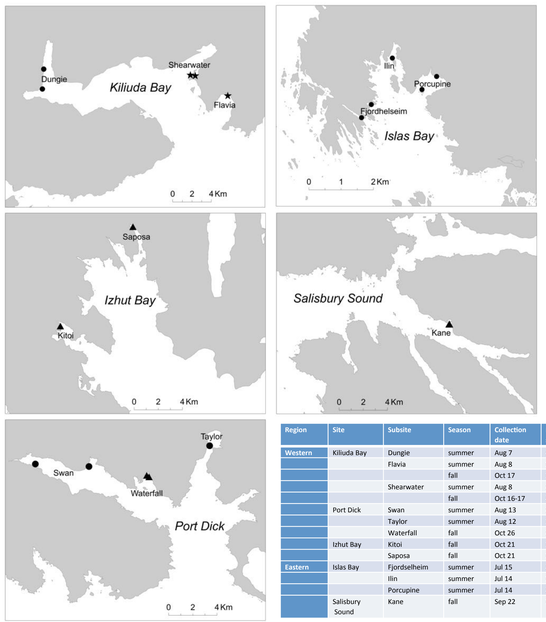


Linear regressions of temperature (left panels) and salinity (right panels) against concentrations (ln-transformed) of magnesium (top), strontium (middle), and barium (bottom) measured at otolith edge (time of capture). Each symbol represents a different bay and season. IB=Islas Bay, IZ=Izhut Bay, KB=Kiliuda Bay, PD=Port Dick, SS=Salisbury Sound

Otolith collection



Pacific cod otolith sampling sites in the Gulf of Alaska



Individual bays sampled for Pacific cod otoliths in the Gulf of Alaska in 2011. Circles represent summer collections, triangles represent fall collections, and stars represent collections in both seasons.

Table shows region, site, subsite, season, date, number of stations, number of otoliths collected, and fish fork length ranges and averages.

Region	Site	Subsite	Season	Collection date	n stations	n otoliths	Size range (mm)	Avg length (mm ± SD)
Western	Kiliuda Bay	Dungie	summer	Aug 7	2	52	53-88	67 (± 9)
		Flavia	summer	Aug 8	1	11	56-105	85 (± 19)
			fall	Oct 17	1	19	80-125	99 (± 14)
		Shearwater	summer	Aug 8	2	27	55-85	68 (± 10)
			fall	Oct 16-17	2	28	78-115	94 (± 8)
	Port Dick	Swan	summer	Aug 13	2	45	50-91	75 (± 8)
		Taylor	summer	Aug 12	1	22	60-125	86 (±18)
		Waterfall	fall	Oct 26	2	19	92-124	103 (± 9)
	Izhut Bay	Kitoi	fall	Oct 21	1	21	89-135	103 (± 13)
		Saposa	fall	Oct 21	1	15	81-103	91 (± 6)
Eastern	Islas Bay	Fjordselheim	summer	Jul 15	2	36	52-86	66 (± 8)
		Ilin	summer	Jul 14	1	25	50-77	66 (± 7)
		Porcupine	summer	Jul 14	2	19	52-86	63 (± 9)
	Salisbury Sound	Kane	fall	Sep 22	1	24	87-144	116 (± 15)

Conclusions

- Elemental concentrations varied among collection sites and over relatively short (2 month) time periods.
- Classification success to collection bay was variable, but was generally higher using elemental signatures averaged over a longer time period, ranging from 48% correctly classified for Salisbury Sound to 96% correctly classified in Port Dick.
- Significant relationships were found between environmental variables and concentrations of elements at the otolith edge. Strontium and magnesium were most strongly related to temperature, and barium was most strongly related to salinity.

Acknowledgments
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