Building Early Ontogeny Pelagic Exposure Profiles for GOA-IERP Species based on Historical Ichthyoplankton Data—Pacific Cod

GULF of ALASKA

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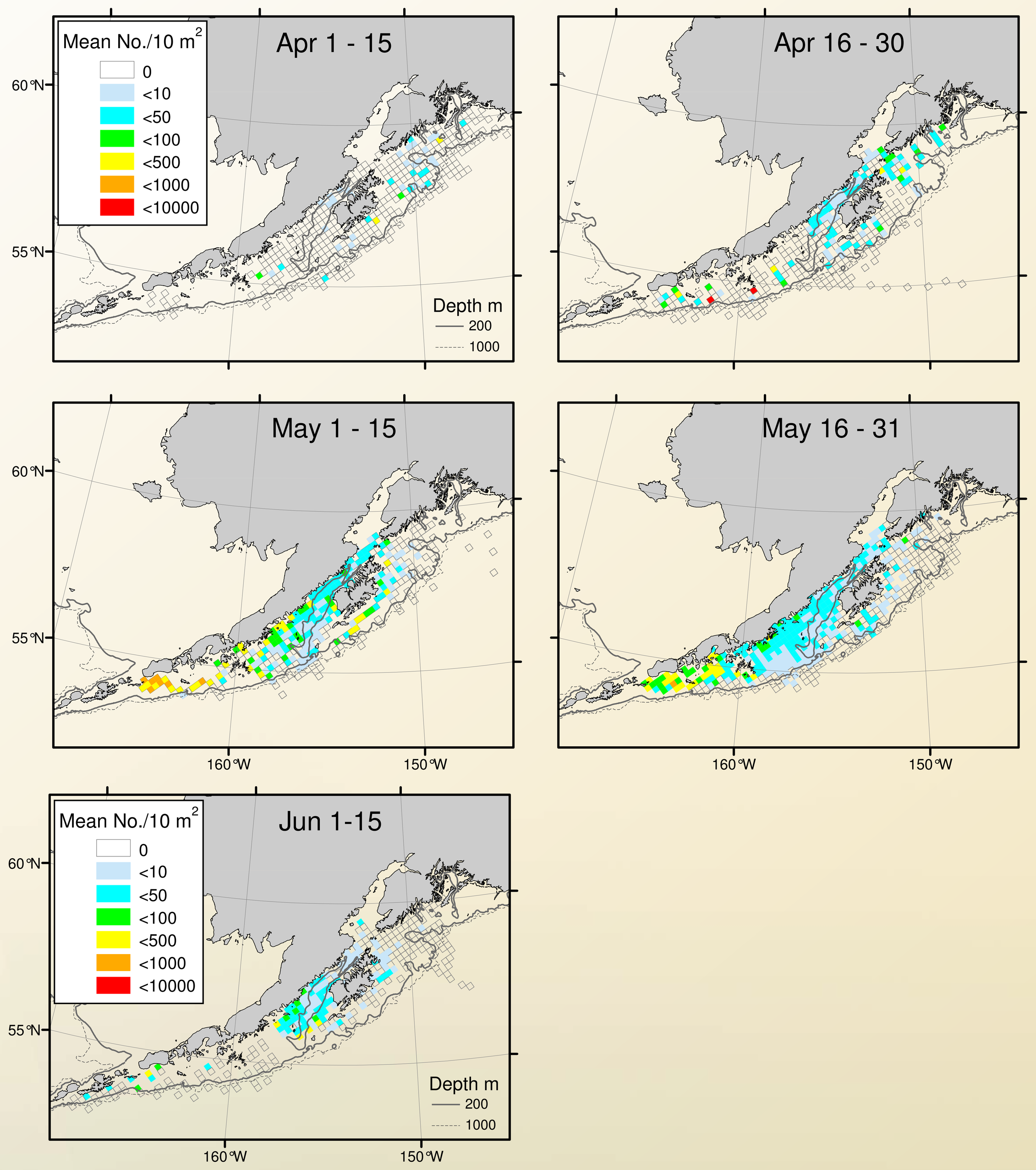
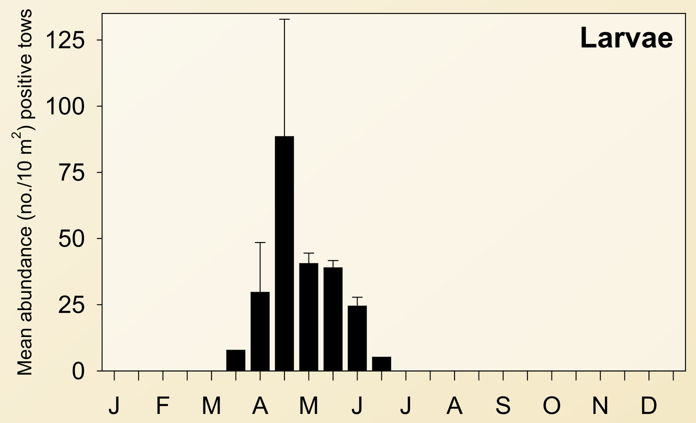
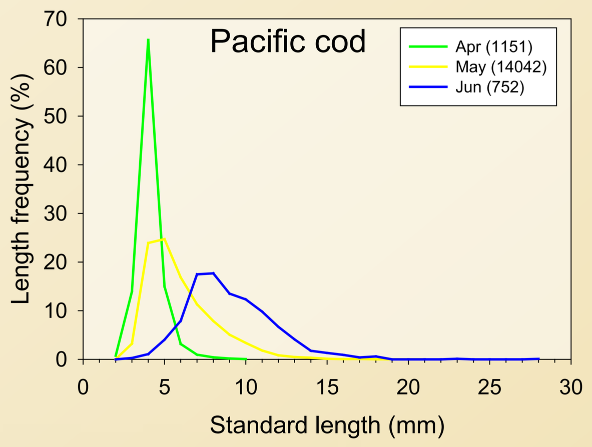
Seasonal Patterns

Seasonal Progression in Distribution of Larvae

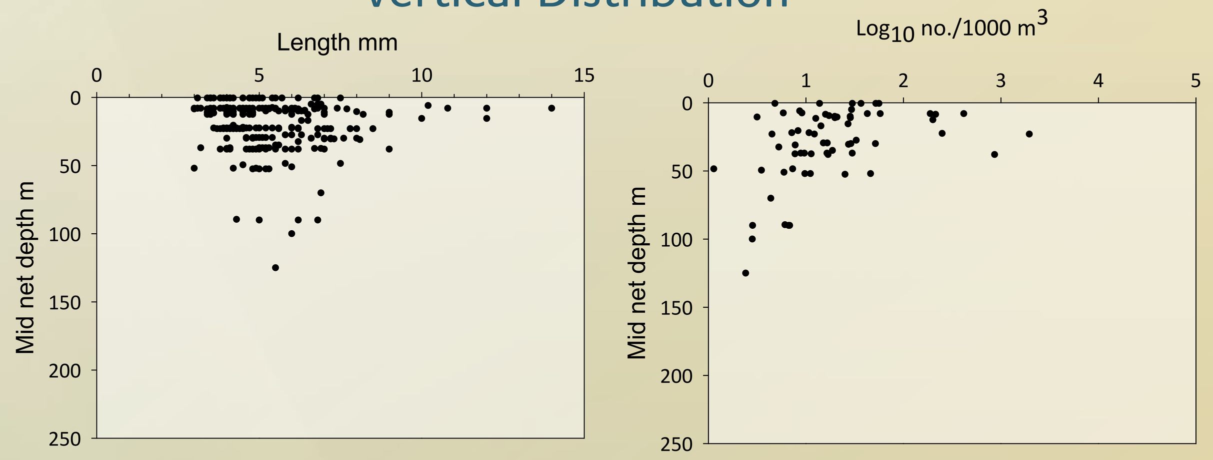


Larval abundance x half month





Vertical Distribution

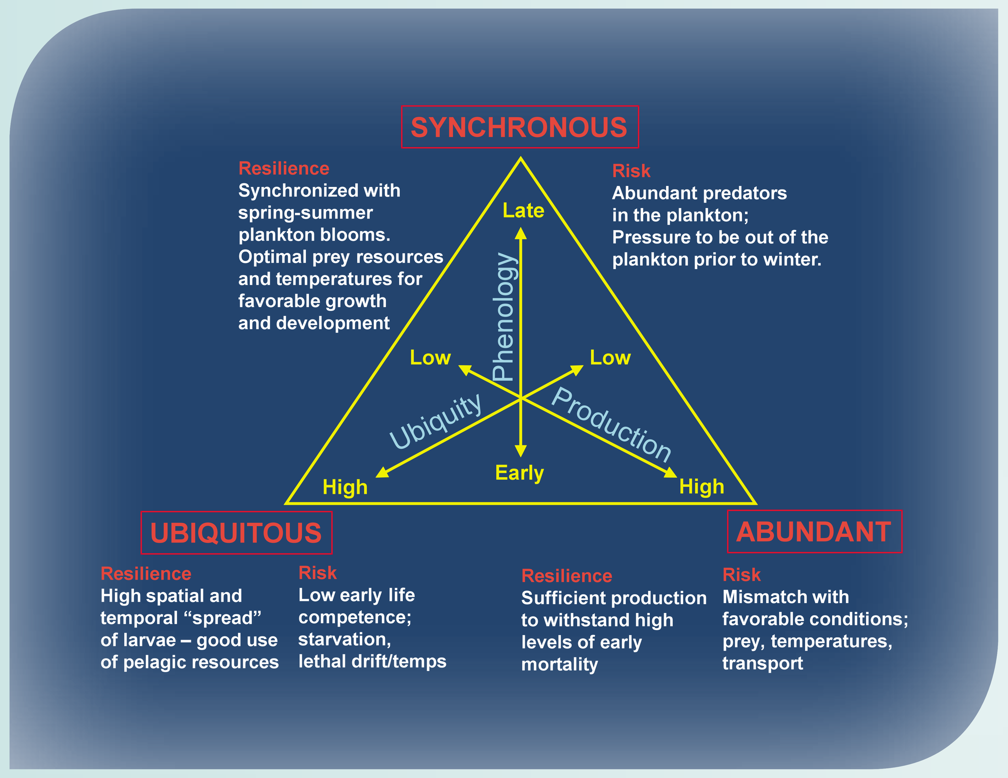


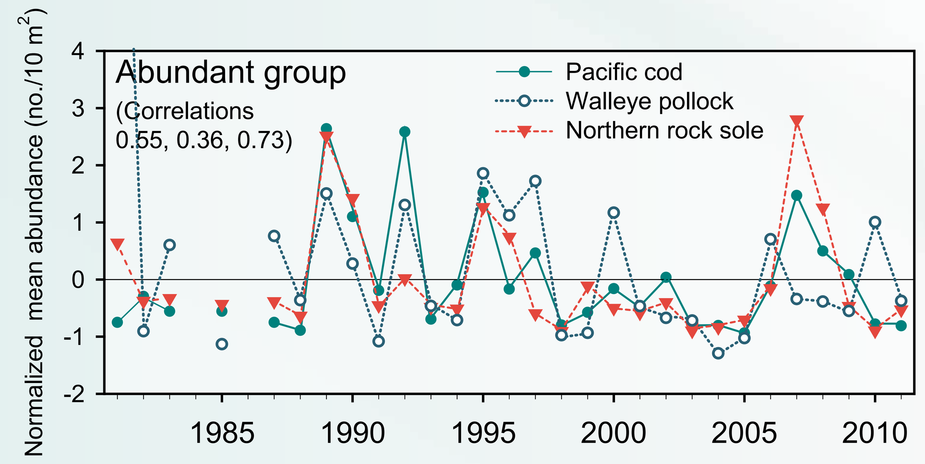
- Larvae occur in the plankton in March, peak in abundance during late April, and continue to be abundant through early June. Larvae >15 mm are not sampled efficiently by 60 cm Bongo nets..
- Larvae are primarily associated with the upper 50 m of the water column to which they migrate rapidly on hatching.
- Length frequency distributions indicate that growth rates of larvae are higher between May and June than between April and May.
- Larvae are common during spring months throughout the WGOA shelf but are most abundant between the Shumagin Islands and Unimak Pass.

Multispecies Perspective

Early Life History (ELH) Exposure-Response Framework

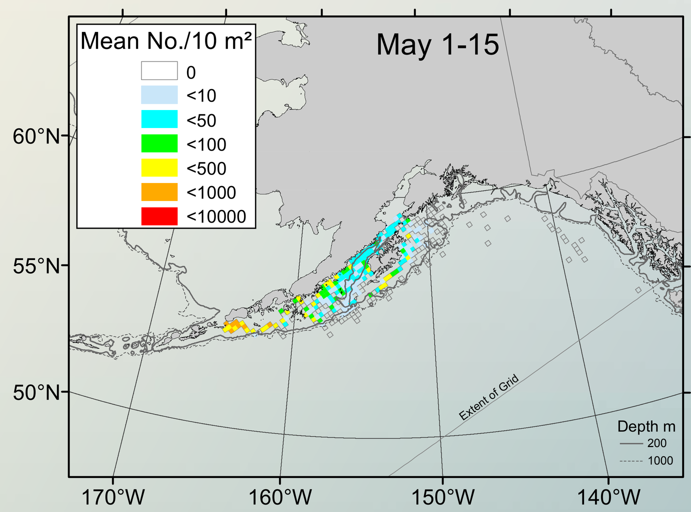
Doyle and Mier 2012



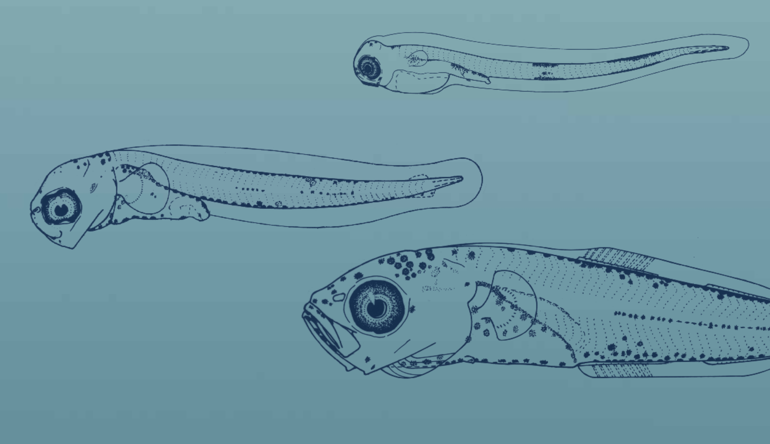


- Pacific cod larvae belong to a shelf assemblage of larval fish species that prevails April-June in the WGOA (Doyle et al., 2002).
- Pacific cod, walleye pollock, and northern rock sole belong to an early life history strategy "Abundant" (high fecundity) group that is characterized by high production of eggs/larvae with peak abundance of larvae in April, relatively limited larval duration, and moderate to high spatial ubiquity of larvae (Doyle and Mier, 2012).
- Synchronicity is observed in the abundance of these species' larvae across the time-series, with tightest synchrony between Pacific cod and northern rock sole.

Eastern vs. Western GOA



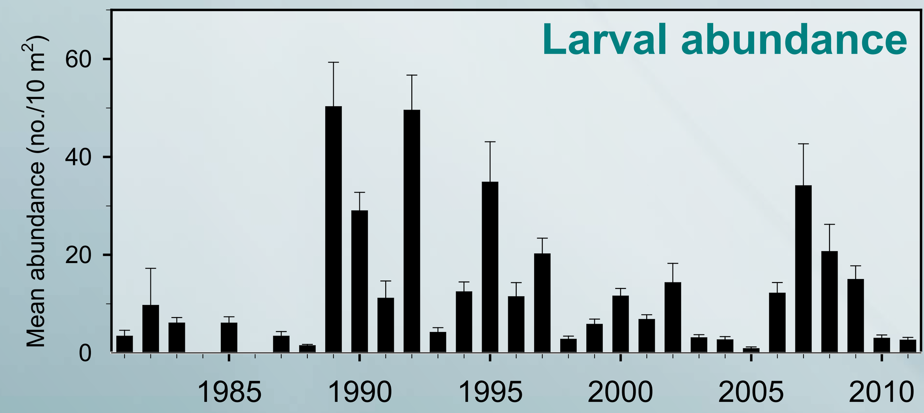
- During the historical peak period of abundance of larvae in the WGOA, Pacific cod larvae seem to be rare in the EGOA.



Synthesis

- **Temporal Exposure** of Pacific cod larvae is characterized by a narrow spring peak in abundance - likely coincides with early production in GOA zooplankton.
- **Spatial Exposure** extends throughout WGOA shelf waters and the area from the Shumagin Islands to Unimak Pass seems to be a hot spot for larval production.
- **Vertical Distribution** of larvae indicates that circulation models representing the upper 50 m (primarily upper 30 m) of the water column during April-June will be suitable for describing potential transport pathways for larvae.
- The **Early Life History strategy** (ELH) common to Pacific cod, walleye pollock, and northern rock sole results in sufficient production of eggs and larvae to withstand high levels of early mortality but with limited larval duration that may risk potential mismatch with peaks in food resources, or exposure of the bulk of the larval population to other unfavorable conditions (e.g. sub-optimal temperatures and transport).
- **Pelagic exposure-response coupling:** Evidence in support of this is provided by the synchrony observed among the above three species in the time-series of larval abundance and similarities in links with environmental variables (Doyle et al., 2009; Doyle and Mier, 2012.).
- Occurrence and abundance of larvae seems diminished in the **EGOA** relative to the **WGOA**.
- **Gaps in ELH knowledge:**
  - Spawning areas and ELH habitat in the EGOA
  - Larval feeding ecology
  - Larval predation
  - Habitat and ecology of late stage and transitioning larvae
  - Age-0 through juvenile stage ecology

Interannual Patterns: Late-Spring Shelikof Time-Series



- The late-spring GOA time-series shows the occasional occurrence of anomalously high levels of abundance during the years 1989-1997 and 2007-09.
- Doyle et al. (2009) have identified a positive association between late spring larval abundance and cooler winters, and strength and direction of alongshore winds during spring.
- Interannual variation in length frequency distributions of larvae reflect a shift in timing of sampling from year to year but also indicate diminished and enhanced growth of larvae during cold and warm years, respectively.

Interannual Variation in Larval Length Distributions

Year	Mid-Cruise Julian Day	Mid-Cruise Shift (JD)	N	WML	J-M SST Cumulative mean	WMA
1981	144	-4	135	9.71		3.40
1982	147	-1	158	7.65	22.56	9.68
1983	145.5	-2.5	78	8.13	24.15	6.08
1985	148	0	174	7.96	22.86	6.07
1987	142	-6	19	7.33	25.03	3.40
1988	150	2	87	8.36	24.43	1.46
1989	152.5	4.5	1590	7.86	19.51	50.27
1990	152	4	521	9.33	20.91	29.00
1991	141.5	-6.5	161	5.27	19.67	11.15
1992	143.5	-4.5	694	5.69	23.22	49.53
1993	148.5	0.5	64	7.68	23.04	4.18
1994	148	0	266	6.45	23.58	12.46
1995	145	-3	647	5.98	20.99	34.86
1996	149	1	324	9.37	23.21	11.46
1997	147	-1	313	6.30	23.31	20.20
1998	146	-2	33	9.75	28.53	2.76
1999	149	1	831	5.66	20.06	5.82
2000	151.5	3.5	570	8.06	23.25	11.59
2001	149	1	161	9.02	25.31	6.81
2002	148	0	424	6.67	23.07	14.33
2003	149.5	1.5	183	8.20	27.56	3.09
2004	149.5	1.5	99	9.20	22.70	2.65
2005	148	0	398	9.30	25.31	0.87
2006	147	-1	733	8.76	23.23	12.18
2007	144	-4	578	6.09	18.88	34.13
2008	147	-1	311	6.33	20.15	20.70
2009	152.5	4.5	404	6.00	18.69	14.98
2010	147	-1	107	7.08	24.28	2.99
2011	156.5	8.5	38	11.43	22.56	2.59

% Frequency of catch by larval length bins (mm): Pacific cod — bins 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25

N = number of larvae measured
WMA = weighted mean abundance (no./10 m²)
WML = weighted mean length mm,
Time-series (May 16-Jun 9) Julian Day mid-point of sampling coverage: 148
J-M SST = Cumulative mean SST for Jan through May from monthly mean values NOAA Optimum Interpolation (OI) SST V2; at Long 155.5, Lat 57.5 (color coded: light blue coldest to dark green warmest)

% Frequency: 0, >0<1, 1<5, 5<10, 10<15, 15<20, 20<25, 25<30, 30<35, 35<55

Correlations:
WML vs WMA: -0.43 **WML vs Cum J-M SST:** 0.49 **WML vs. Mid-cruise Shift:** 0.46
WMA vs Cum J-M SST: -0.53 **WMA vs. Mid-Cruise shift:** -0.07

Expected tendency for smaller larvae to be more abundant than larger larvae.
Interannual variation in larval length positively related to shift in sampling dates and SST.
Interannual variation in larval abundance negatively related to SST, and not related to shift in sampling dates.

References

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