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

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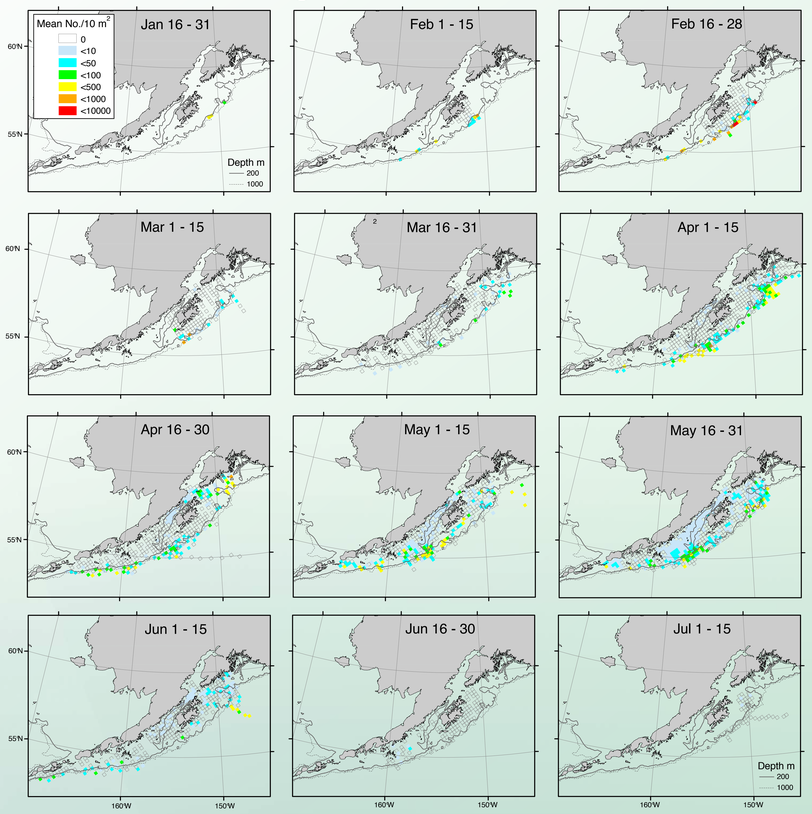
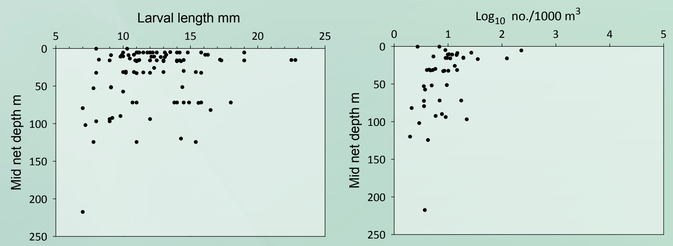
Seasonal Patterns

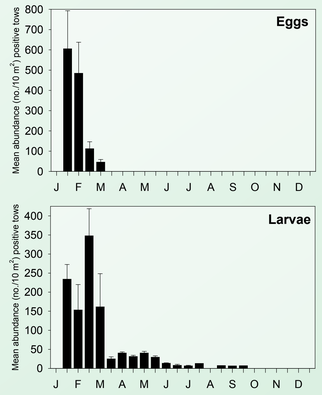
Seasonal Progression in Distribution of Larvae

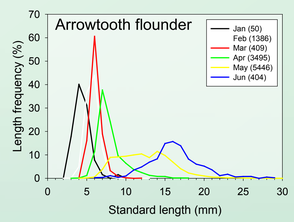


Vertical Distribution



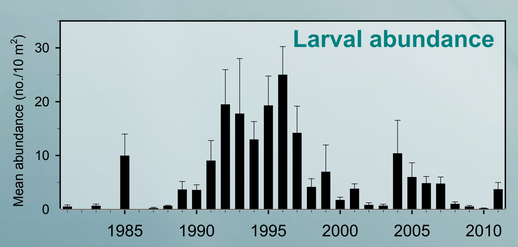
Larval abundance x half month





- Arrowtooth flounder (ATF) eggs and larvae are most abundant in deep water along the slope during January and February in the western GOA. Larvae continue to be abundant during March and common though less abundant during spring through summer. Larvae >20 mm are not sampled efficiently by 60 cm Bongo nets.
- Larvae occur primarily in the upper 100 m of the water column with highest densities, especially of the largest larvae, in the upper 50 m.
- Length frequency distributions indicate slow growth of larvae from January through April and a more rapid rate of development during late spring.
- Larvae are most abundant over the continental slope and particularly in association with Amatuli Trough and outer Shelikof Sea Valley which seem to be significant regions of cross shelf transport of larvae, especially during spring. The appearance of larvae in Shelikof Strait seems to result from ingress of larvae in these locations.

Interannual Patterns: Late-Spring Shelikof Time-Series



- The late-spring GOA time-series for ATF larvae is characterized by a period of highest abundance anomalies in the 1990s with average to low levels of abundance in all other years except for 1985 and 2004.
- Late spring abundance of larvae in the Shelikof region has been associated with strong alongshore winds and negative temperature anomalies during spring (Doyle et al., 2009).
- Interannual variation in larval length frequency distributions indicate a weak positive relationship between larval length and temperature with a tendency for larger larvae to be encountered in spring samples during warmer years.

Interannual Variation in Larval Length Distributions

% Frequency of catch by larval length bins (mm): Arrowtooth flounder

Year	Mid-Cruise Julian Day	Mid-Cruise Shift (JD)	N	WML	J-M SST Cumulative mean	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	WMA
1981	144	-4	8	9.71																																	0.48
1982	147	-1	4	7.65	22.56																																0.00
1983	145.5	-2.5	6	8.13	24.15																																0.63
1985	148	0	258	7.96	22.86																																9.94
1987	142	-6	1	7.33	25.03																																0.19
1988	150	2	34	8.36	24.43																																0.61
1989	152.5	4.5	108	7.86	19.51																																3.65
1990	152	4	49	9.33	20.91																																3.56
1991	141.5	-6.5	131	5.27	19.67																																9.01
1992	143.5	-4.5	199	5.69	23.22																																19.46
1993	148.5	0.5	130	7.68	23.04																																17.76
1994	148	0	193	6.45	23.58																																12.96
1995	145	-3	217	5.98	20.99																																19.28
1996	149	1	519	9.37	23.21																																24.99
1997	147	-1	207	6.30	23.31																																14.18
1998	146	-2	129	9.75	26.51																																4.13
1999	149	1	128	5.66	20.06																																6.95
2000	151.5	3.5	23	8.06	23.25																																1.70
2001	149	1	79	9.02	25.31																																3.79
2002	148	0	21	6.67	23.07																																0.79
2003	149.5	1.5	25	8.20	27.56																																0.64
2004	149.5	1.5	152	9.20	22.70																																10.39
2005	148	0	226	9.30	25.31																																5.97
2006	147	-1	92	8.76	23.23																																4.83
2007	144	-4	67	6.09	18.88																																4.74
2008	147	-1	11	6.33	20.15																																0.99
2009	152.5	4.5	9	6.00	18.69																																0.49
2010	147	-1	10	7.08	24.28																																0.17
2011	156.5	8.5	30	11.43	22.56																																3.70

N = number of larvae measured
WMA = weighted mean abundance (no./10 m % Frequency: 0 >0<1 1<5 5<10 10<15 15<20 20<25 25<30 30<35 35<55
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)

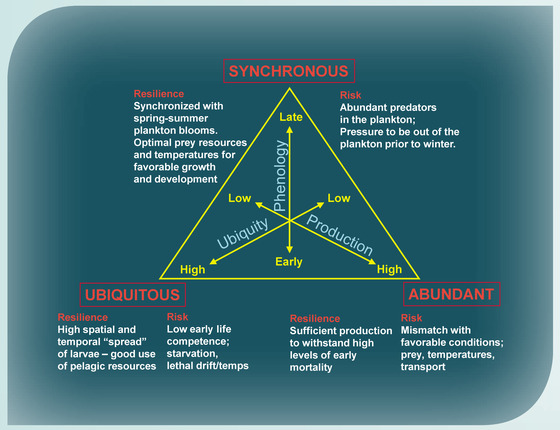
Correlations:
WML vs WMA: 0.06 **WML vs Cum J-M SST:** 0.32 **WML vs. Mid-cruise Shift:** 0.31
WMA vs Cum J-M SST: -0.09 **WMA vs. Mid-cruise shift:** -0.15

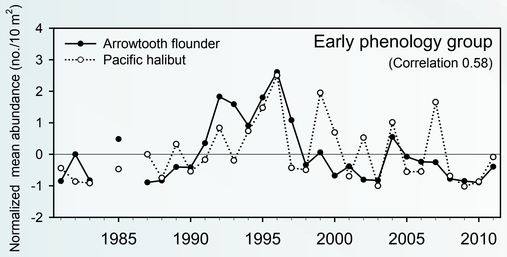
Expected tendency for smaller larvae to be more abundant than larger larvae not apparent.
Interannual variation in larval length positively but weakly related to shift in sampling dates and SST.
Interannual variation in larval abundance not related to SST or shift in sampling dates.

Multispecies Perspective

Early Life History (ELH) Exposure-Response Framework

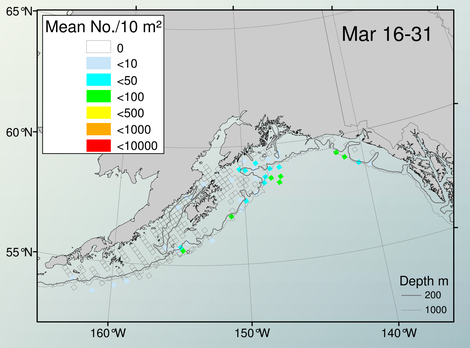
Doyle and Mier 2012



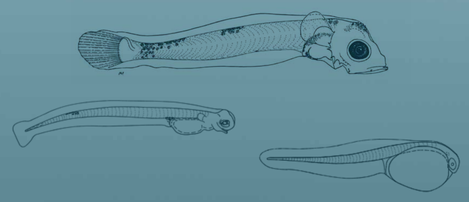


- ATF larvae belong to a winter spawned slope assemblage of larval fish species that has an extended pelagic duration through spring and early summer in the WGOA (Doyle et al., 2002).
- Their early life history strategy places them in an "Early Phenology" group which is at the opposite end-point to the "Synchronous" group, and thus is not well matched with abundant zooplankton prey resources (Doyle and Mier, 2012). Their extended larval duration likely modifies the "mismatch" effect and facilitates their transport onto the shelf. Another prominent member of this group is Pacific halibut.
- Interannual variation in abundance of ATF and Pacific halibut larvae is well synchronized and likely reflects the shared pelagic exposure patterns for these species.

Eastern vs. Western GOA



- During the late winter peak in larval abundance, ATF larvae seem equally abundant in slope and deep water of the EGOA and WGOA.



Synthesis

- **Temporal Exposure** of ATF larvae is characterized by an extended pelagic duration from winter through early summer that likely facilitates their cross shelf transport and provides maximum exposure to spring zooplankton food resources. Food resources are limited for first feeding larvae.
- **Spatial Exposure** extends throughout WGOA and EGOA waters primarily along the continental slope and in deep water, with highest densities of larvae associated with troughs that likely are important for on-shelf transport of larvae.
- **Vertical Distribution** of larvae indicates that circulation models representing the upper 100 m of the water column are suitable for tracking larval drift, and that highest densities of larvae occur in the upper 50 m.
- The **Early Life History strategy** (ELH) common to ATF and Pacific halibut results in an early ontogeny pelagic phase that is poorly synchronized with abundant larval food resources in the plankton, but is likely advantageous in terms of predator avoidance for the youngest larvae. The deep water production of larvae confers reliability on cross-shelf transport to get to inshore nursery grounds. This transport seems to be enhanced by onshore drift in troughs and gullies intersecting the slope.
- **Pelagic exposure-response coupling:** The shared pattern of deep water early ontogeny and extended winter-spring larval duration of these species may be reflected in their high degree of synchrony across the larval abundance time-series (Doyle and Mier, 2012). A shared association with winter-spring alongshore winds, and spring temperatures, supports this hypothesis (Doyle et al., 2009).
- **Gaps in ELH knowledge:**
  - Spawning areas and ELH habitat in the EGOA
  - Larval feeding ecology, especially during the first feeding stage
  - Larval predation
  - Habitat and ecology of late stage and transitioning larvae
  - Age-0 through juvenile stage ecology

References

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