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Herring and Euphausiid population dynamics

Spatial, temporal and life-stage variation in herring diets in British Columbia

Douglas E. Hay and Bruce McCarter
Pacific Biological Station, 3190 Hammond Bay Road, Nanaimo, B.C., Canada. V9R 5K6
E-mail: hayd@pac.dfo-mpo.gc.ca

Over the last 70 years in British Columbia (B.C.), herring stomachs have been examined by different people, in different years, at different places and at different herring life history stages. This brief report summarizes this information and attempts to provide some general conclusions.

Wailes (1935) summarized the food of young herring mainly in the first summer of life. At very young stages, eggs (ova) and nauplii from various invertebrates are most important. Copepod nauplii seem to dominate the food. Wailes noted that food varies with location and concluded that young herring fed on whatever food source was available. A more recent project (1990-1994) gathered data on juvenile herring stomach contents in Georgia Strait, B.C. The juveniles were distinguished by size and age as age 0+ (3-6 months), 1+ (15-18 months) and 2+ (29-32 months). The youngest juveniles (age 0+) fed mainly on copepods. The older and larger juveniles took various zooplankton, with euphausiids being common in the largest fish. The data indicate that diets and juvenile growth varied among areas. There are a number of reports commenting on the diets of herring off the southwestern coast of B.C., and many comment on the frequency of euphausiids (mainly *Euphausia pacifica*, in herring guts. This euphausiid species also is known to be a major component in the diets of other species, such as hake (*Merluccius productus*). One example of the intensity of feeding was made by examination of stomach weights of herring feeding on *E. pacifica* during the fall of 1979. Most guts examined contained *E. pacifica*. In some individuals the gut weight was approximately 20% of their total body weight. In contrast to the apparently high incidence of euphausiids in southern BC herring adults, northern BC herring appear to rely more on copepods. Adult herring guts, from Hecate Strait in northern BC were sampled in the summer and winter of 1985 and 1987 (Tables 1 and 2). The data indicates that copepods were dominant in the diets of herring in 1985 and that euphausiids and amphipods were more common in 1987. In general, the composition of food appeared to be more varied than that of herring found in southern B.C.

Some general conclusions from this brief review are that herring diets vary with: (1) life history stage (compared in the same time and place, herring food varies with size and age); (2) space (compared among herring of same size and age, there are different food items among different locations), (3) time (food varies among seasons but within the same place and among years, compared at the same place).

In general, larval herring rely mainly on copepods with the main diet consisting of copepod eggs and nauplii. Juvenile herring ($<$ 1 year) eat mainly copepods (in BC) but older juvenile herring ($>$ 1 year) eat many items. The incidence of euphausiids increases with juvenile size. Adult herring diets vary: euphausiids are important, but so are copepods in some areas.

This review does not address the major issues

regarding the relationship between zooplankton and herring. Perhaps the major question concerns the relationship(s) between plankton abundance and herring, and how it affects herring growth, population size and recruitment? One may ask: after more than a century of research in this area, why do we not understand it better? A partial answer is that we have lack suitable time-series data on plankton abundance. Further, we know enough to understand that the relationships may be complex and affected by factors that we are only beginning to realize are important.

Reference:

Wailes, G.H. 1936. Food of *Clupea pallasii* in southern British Columbia. J. Biol. Bd. Can. 1: 477-486.

Table 1 Prey species found in herring stomachs from Hecate Strait in 1985.

Fishing date				*Total*		PREY SPECIES
Jul-Aug 1985		*Nov-Dec 1985*				
Wgt (*g*)	%	Wgt(*g*)	%	Wgt (*g*)	%	
328.379	64.5	0.019	0.1	328.398	61.0	*Calanus pacificus*
94.231	18.5	0.983	3.4	95.214	17.7	*Thysanoessa spinifera*
23.432	4.6	1.088	3.8	24.520	4.6	Arthropoda
23.680	4.6	0.218	0.8	23.898	4.4	*Parathemisto spp.*
0.016	0.0	16.914	58.7	16.930	3.1	*Euphausia pacifica*
11.759	2.3	1.644	5.7	13.403	2.5	Copepoda calanoida
1.023	0.2	7.243	25.1	8.266	1.5	Monstrilloidae
6.644	1.3	0.000	0.0	6.644	1.2	*Calanus cristatus*
4.233	0.8	0.000	0.0	4.233	0.8	*Metridia okhotensis*
3.975	0.8	0.003	0.0	3.978	0.7	*Euchaeta elongata*
3.609	0.7	0.000	0.0	3.609	0.7	*Calanus plumchrus*
2.734	0.5	0.000	0.0	2.734	0.5	*Cancer spp.* zoea & megalops
1.994	0.4	0.000	0.0	1.994	0.4	*Hyperia spp.*
1.141	0.2	0.000	0.0	1.141	0.2	Chaetognatha
0.364	0.1	0.271	0.9	0.635	0.1	Euphausiid remains
0.041	0.0	0.272	0.9	0.313	0.1	*Cyphocaris challengeri*
0.293	0.1	0.015	0.1	0.308	0.1	Fish
0.253	0.0	0.000	0.0	0.253	0.0	*Natantia* (shrimp) zoea
0.225	0.0	0.015	0.1	0.240	0.0	*Calanus spp.*
0.230	0.0	0.000	0.0	0.230	0.0	*Primno spp.*
0.212	0.0	0.000	0.0	0.212	0.0	*Gaidius pungens*
0.136	0.0	0.000	0.0	0.136	0.0	Ostracoda
0.117	0.0	0.000	0.0	0.117	0.0	*Candacia columbiae*
0.082	0.0	0.026	0.1	0.108	0.0	Mysidaceae
0.000	0.0	0.070	0.2	0.070	0.0	Fossaridae
0.070	0.0	0.000	0.0	0.070	0.0	*Pleuromamma quadrungulata*
200		*150*		*350*		Number of stomachs examined

Table 2 Prey species found in herring stomachs from Hecate Strait in 1987 (prey counts converted to weights using 1985 average weight/species).

Fishing date				*Total*		
July 1987		*Nov. 1987*				PREY SPECIES
Wgt (*g*)	%	Wgt (*g*)	%	Wgt (*g*)	%	
1.829	2.6	65.243	48.0	67.073	32.7	*Parathemisto spp.*
41.452	59.7	21.747	16.0	63.199	30.8	Euphausiidae
14.113	20.3	16.388	12.1	30.501	14.9	*Euphausia spp.*
1.840	2.6	23.238	17.1	25.078	12.2	Copepoda calanoida
7.778	11.2	6.364	4.7	14.142	6.9	*Thysanoessa spp.*
0.006	0.0	1.272	0.9	1.278	0.6	*Oikopleura*
0.721	1.0	0.203	0.1	0.924	0.5	*Metridia spp*
0.867	1.2	0.000	0.0	0.867	0.4	*Cancer spp*
0.147	0.2	0.499	0.4	0.646	0.3	Hyperiidae
0.215	0.3	0.088	0.1	0.303	0.1	*Cyphocaris spp.*
0.000	0.0	0.285	0.2	0.285	0.1	*Mesocalanus spp.*
0.177	0.3	0.077	0.1	0.254	0.1	*Calanus spp.*
0.116	0.2	0.007	0.0	0.123	0.1	*Neocalanus spp.*
0.114	0.2	0.006	0.0	0.120	0.1	*Euchaeta spp.*
0.000	0.0	0.118	0.1	0.118	0.1	*Corycaeus spp.*
0.009	0.0	0.081	0.1	0.090	0.0	*Pseudocalanus spp.*
0.000	0.0	0.058	0.0	0.058	0.0	*Acartia spp.*
0.009	0.0	0.046	0.0	0.055	0.0	*Primno spp.*
0.034	0.0	0.002	0.0	0.037	0.0	Paguridae
0.013	0.0	0.022	0.0	0.036	0.0	*Epilabidocera spp.*
0.013	0.0	0.022	0.0	0.036	0.0	Amphipoda
0.000	0.0	0.014	0.0	0.014	0.0	*Scolecithricella spp.*
0.002	0.0	0.011	0.0	0.014	0.0	*Limacina helicina*
101		*350*		*451*		Number of stomachs examined

Over winter energy changes in herring from Prince William Sound, Alaska

Augustus J. Paul and J. M. Paul
University of Alaska, Institute of Marine Science, Seward Marine Centre Laboratory, Seward, AK 99664, U.S.A. E-mail: ffajp@aurora.alaska.edu

During the fall of 1995 and spring of 1996, the whole body energy content (WBEC) of *Clupea pallasi* from Prince William Sound (PWS), was examined. Somatic energy exhibited a wide range of values relative to length (SL). In the fall age 0 recruits had an average of 5.7 $kJ \cdot g^{-1}$ wet wt for whole body samples vs 8.0 for age 1 and 0.4-10.2 $kJ \cdot g^{-1}$ for fish of ages 2 to 7. The following spring the 1995 year class, which had just survived their first winter, averaged 4.4 $kJ \cdot g^{-1}$ wet wt for somatic samples, and age 1 fish had similar values, while herring ages 2 to 7 had WBEC > 5 $kJ \cdot g^{-1}$. The fall measures of WBEC showed the young-of-year and age 1 fish stored markedly less energy for overwintering than older herring.

In PWS many sea birds prey on juvenile herring. During the spring and summer, we examined WBEC of herring $\leq$ 165 mm SL.