W9: Puffins as Samplers of Forage Nekton in the North Pacific

PICES 2024, Honolulu, Hawaii 26 October 2024

Workshop Goals and Agenda

Introduction (William Sydeman, Farallon Institute)

- 1. Present information on puffins as samplers of forage nekton in the North Pacific (Yutaka Watanuki Hokkaido University)
- 2. Present information on analytical and statistical issues facing researchers using puffins (predators) as samplers of forage nekton (Jim Thorson, NOAA)
- 3. Present information on a key, but poorly known forage fish in North Pacific food webs, Pacific Sand Lance, and how puffins and other predators can be used to better understand PSL population dynamics (Matt Baker, NPRB)
- 4. Present information on the use of puffin sampling in the study and management of Sablefish (Mayumi Arimitsu, USGS).
- 5. Discussion a) opportunities, challenges; b) review paper





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Rhinoceros Puffin (Auklet)

Why Study Puffins to Study Forage Nekton?

- North Pacific forage nekton: key to trophic transfer, diverse assemblage, very difficult/expensive to sample and study.
- Puffins (3 spp. in Pacific) forage within ~50-100km of colonies (shelf/shelf break habitats), obtain forage nekton and bring them back to the colonies ("central place foraging") where they can be sampled by researchers (sampling relatively easy, without undue impact on the birds).
- Large samples of fresh, whole fish can be obtained for morphometric, compositional, and genetic analyses.
- 4. Long-term spatially-comprehensive datasets on puffin-sampled forage nekton are available for analysis and insight.



Horned Puffin

5. Samples contain species (e.g. Pacific sand lance, capelin) and/or age classes (e.g., age-0 gadids/hexagrammids) that are difficult to sample by conventional means.

6. Samples are interpretable relative to changes in ocean conditions and climate.

7. Sample data has application(s) in both seabird and fisheries management and conservation.

8. Similar puffin sampling data is available in the Atlantic for ecosystem to hemisphericscale comparative investigations.



Tufted Puffin





What Makes Puffins Such Great Samplers? (Samples May Contain Multiple Fish)



Morphological Adaptation for Multiple Prey Items in Samples



Puffins hold fish with denticles in the back of their mouth with their tongue while they can continue to forage, resulting in multiple fish in each sample (this also presents analytical challenges though)

Table 1. Species contained within the 16 prey groups observed at the sites in this study.

Table	1.	(Continued)
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	They opened	They common Name	Prey Group		Prey Species			Prey Com	mon Name	
Capelin Flatfish	Mallotus villosus Atheresthes stomias (71%) Pleuronectidae Hippoglossoides elassodon (18%) Reinharditus hippoglossoides (6%) Hitobolosus sendetis (5%)	Capelin Arrowtooth flounder Flatfish Right-eyed flatfish Flathead sole Greenland turbot Pacific halibut	Squid		Psychrolutes <u>t</u> Blepsias bilob Blepsias cirrho Hemitripterus Nautichthys o Decabrachia	aradoxus (1%) us (<1%) osus (<1%) bolini (<1%) culofasciatus (<1%)		Tadpole so Crested sc Silver-spo Bigmouth Sailfin scu Squid	culpin culpin tted sculpin sculpin ılpin	
Lepidopsetta spp. Glyptocephalus zachirus (<1%) Limanda spp.	Rock sole		Gonatidae Cephalopoda:Gonatidae				Squid			
	Rex sole						Squid			
	Limanda spp.	Limanda spp.			Gonatus kam	tschaticus (96%)		Squid		
Gadid Gadus chalcogrammus (90%) Gadidae Gadus macrocephalus (9%) Microgadus proximus (<1%) Eleginus gracilis (<1%)	Gadus chalcogrammus (90%)	Walleye pollock			Berryteuthis n	1agister (2%)		Squid		
	Gadidae	Gadid			Gonatopsis m	akko (2%)		Squid		
	Gadus macrocephalus (9%)	Pacific cod	Th		(.66.1.:1		- 1			
	Microgadus proximus (<1%)	Pacific tomcod	The percentage of each species in each group (of fish identified to the species level) is shown in parentheses.							
	Eleginus gracilis (<1%)	Saffron cod			The					
Hexagrammid	Hexagrammidae	Greenling			65°N 1					
	Hexagrammos decagrammus (82%)	Kelp greenling			1 mg	Sp. ate "	Notes -			
	Heurogrammus monopterygius (17%)	A tka mackerel			-	The Const .	1			
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	Hexagrammos octogrammus (<1%)	White enotied greening					the start and a start and a start and a start and a start a st			
ingood	Othiodon alongatus	Lingcod		55	w./	Joseph St.	Middleton			
Mesopelagic	Myctophidae	Lanternfish					St. Lezane w			
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	Sterior delinas encopsarias (0070)	rtorthern uniphon		N. N.	- Opicier	Aktak Complex		1		
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FIGURE 1 Colonies of tufted puffins in Alaska (black dots) where diet samples were collected. Colonies are ringed with a colored circle (50 km radius) in which habitat characteristics were measured. Colors represent different diet community types and were assigned by cluster analysis of diet composition (Red—Coastal residents; Green—Shelf transients; Blue—Oceanic; see text for details). Two passes in the Aleutian Islands are indicated by red dashed lines: (1) Amchitka Pass and (2) Samalga Pass

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Some Key Literature









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ORIGINAL ARTICLE



Integrating seabird dietary and groundfish stock assessment data: Can puffins predict pollock spawning stock biomass in the North Pacific?

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FIGURE 1 Map showing 15 sites in the Western Gulf of Alaska where age-0 gadids were sampled by puffins over 31 years, 1985–2015. A 75-km foraging/sampling radius for the birds is shown for each site. Approximate walleye pollock spawning regions in the Shelikof Strait area and Eastern Bering Sea are shown as green hatched areas (based on Bacheler et al. 2009, 2010; Hinckley et al., 2016). Larval pollock produced in/near Shelikof Strait are advected along the Alaska Peninsula and through Unimak Pass (Hinckley, 1987; Parada et al., 2016) where Aiktak Island is located. The 2000-m isobath is shown for context



FIGURE 2 (a) Length-frequency distribution with normal distribution curve across all years for walleye pollock 0-120 mm in length at WGoA sites; 23 fish longer than 120 mm are not shown. (b) Length-frequency distribution with normal distribution curve across all years at Aiktak Island for fish 0-120 mm in length; 4 fish longer than 120 mm are not shown. (c) Growth index anomalies for walleye pollock over 16 years based on a linear regression of length by date within each year for all sites in the WGoA and Aiktak Island alone. Dashed lines show + 1 SD for the WGoA data. Years without bars reflect no data

FIGURE 3 Pollock spawning stock biomass (bars) and age-0 abundance index at Aiktak Island (points) through time, with Loess smoothing lines (black, biomass; blue, age-0 abundance). (a) WGoA SSB and (b) EBS SSB





FIGURE 4 Spearman rank cross-correlations between SSB and age-0 abundance or growth from all WGoA sites or Aiktak Island alone. (a) WGoA SSB vs. age-0 abundance, (b) WGoA SSB and growth, (c) EBS SSB and age-0 abundance, and (d) EBS SSB and growth. Spearman ρ is shown on the y-axis, and lags/leads of up to 3 years are shown on the x-axis. Negative lags indicate age-0 abundance or growth leading SSB, while positive values indicate SSB leading age-0 abundance or growth. WGoA correlations are hatched bars, while Aiktak correlations are grey bars. Significance (*p*-value) of the correlations is shown by asterisks: *<1, **<.01, and ***<.001. Regressions of key selected key relationships are shown in Table 2, with corresponding scatter-plots of relationships in Figure 5

Model description	Ν	F	<i>p</i> > F	R ²	Coefficient	t	$p > \mathbf{t} $
Can SSB predict age-0 abundance?							
WGoA SSB and age-0 abundance, no lead/lag	27	18.61	.000	.43	0.2377	4.31	<.001
WGoA SSB leads age-0 abundance by 1 year	27	23.48	.001	.48	1.8100	4.85	<.001
Can age-0 abundance predict SSB?							
Age-0 abundance leads EBS SSB by 1 year	27	17.03	.000	.41	0.1949	4.13	<.001
Age-0 abundance leads EBS SSB by 2 years	27	9.67	.005	.28	0.1611	3.11	.005
Age-0 abundance leads EBS SSB by 3 years	27	6.36	.018	.20	0.1324	2.52	.018
Can growth predict SSB?							
Growth leads EBS SSB by 3 years (all years)	14	2.67	.128	.18	0.1184	1.63	.128
Growth leads EBS SSB by 3 years (2009 outlier removed)	13	12.30	.005	.53	0.1046	3.51	.005

TABLE 2 Linear regressions for Aiktak Island age-0 abundance or growth against WGoA or EBS SSB

Note: Shading indicates nominal significance of p < .05.



North Atlantic Data



Norwegian Sea Röst, Atlantic puffin

