DIETS AND FOOD WEB RELATIONSHIPS OF SEABIRDS IN THE GULF OF ALASKA AND ADJACENT MARINE REGIONS

BY

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ABSTRACT

Overall diets of 39 species of marine birds (four procellariiforms, three cormorants, six sea ducks, one phalarope, two jaegers, 17 gulls, two terns, and 13 alcids) inhabiting the Gulf of Alaska and adjacent marine regions are summarized with food web diagrams, tables, and text. Diets of the Northern Fulmar, Sooty and Short-tailed Shearwaters, Pelagic Cormorant, Black-legged Kittiwake, Common and Thick-billed Murres, Marbled and Kittlitz's Murrelets, and Horned and Tufted Puffins are compared among seasons and geographic regions. Overall food web relationships within the procellariiforms, cormorants, Larus gulls, kittiwakes, terns, murrelets, auklets, and puffins are each compared and discussed.

Pacific Sand Lance (Ammodytes hexapterus), Capelin (Mallotus villosus), the euphausiid Thysanoessa inermis, and unidentified squids were generally the most important prey to pelagic birds in the Gulf of Alaska, as were Blue Mussels (Mytilus edulis), and the clams Protothaca staminea, Spisula polynyma, Macoma spp. and Mya spp. to sea ducks. In general, seabirds appear to utilize commercially-important species of prey in the Gulf of Alaska to only a small degree, but possible future fisheries for Capelin and Pacific Sand Lance could have serious consequences to breeding seabirds if other suitable prey were not available.

Future studies of seabird feeding ecology in the Gulf of Alaska should focus on the relationship between reproductive success and the distribution and availability of prey, and on defining annual, seasonal and geographic variations in diets and the trophic relationships between primary producers, seabirds, fishes, and other apex predators.

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INTRODUCTION

Sowl and Bartonek (1974) drew attention to the magnitude of seabird populations in Alaska, and pointed out the lack of the most basic information about them. From the onset of the Alaskan Outer Continental Shelf Environmental Assessment Program (OCSEAP), seabirds were recognized as important components of coastal and offshore ecosystems (NOAA 1975). Although little data were available, seabirds were presumed to play an important role in recycling nutrients (NOAA 1975; Sanger 1972), and in helping stabilize populations of forage fishes by cropping superabundant concentrations during the spring-summer nesting season (NOAA 1975).

Marine birds have long been known to be particularly vulnerable to direct oiling from oil spills (e.g., Vermeer and Vermeer 1974; Bourne 1972; King and Sanger 1972). They also are believed to suffer indirectly from marine oil pollution from its effect on populations of prey animals and through the effect of petroleum contaminants being concentrated in succeeding trophic levels of the food chain (NOAA 1975); however, there are few substantiating data for the latter idea (Krasnow and Sanger 1982).

A key to understanding and mitigating possible indirect effects of oil pollution to marine birds is through knowledge of their diets (feeding habits) and trophic relationships. Guidelines for baseline OCSEAP studies prior to petroleum exploration and development on the outer continental shelf of Alaska included a list of official tasks for work needed on seabirds (NOAA 1975). Task A-6 stated the need to, "Describe (the) dynamics and trophic relationships of selected species (of seabirds) at offshore and coastal study sites."

A research program that considered the status and distribution of populations, reproductive ecology, and trophic relationships (OCSEAP Research Unit 341: Population dynamics and trophic relationships of marine birds in the Gulf of Alaska and southern Bering Sea) was developed in order to address major concerns as to the effects of petroleum development. Field studies were conducted from 1975 to 1978, and focused mainly in the Gulf of Alaska and the southeastern Bering Sea. Prior reports have provided detailed descriptions of the feeding ecology of marine birds in Kachemak Bay (Sanger and Jones 1982) and at Kodiak Island (Krasnow and Sanger 1982).

The main objective of this report is to summarize information on the diets of 39 species of marine birds, based on data pooled from all seasons and geographic areas studied. Secondary objectives are to describe food web relationships in selected, phylogenetically-related groups of birds based on the pooled data, and as data allow, to compare the diets of birds by season and geographic region. A description of the diets of the birds is emphasized, and more detailed analyses and interpretation will be published in the scientific literature.

METHODS

ORIGIN OF FOOD SAMPLES

Food samples were obtained from birds collected at sea during all seasons, but primarily between spring and early fall, and from nestlings or their parents on breeding colonies, primarily between early summer and early fall, depending on species of bird.

Birds collected at sea came from four main areas or periods: 1. From the Kodiak Island area during the spring-summer seasons of 1977 and 1978 and during the intervening winter (Krasnow and Sanger 1982); 2. From Kachemak Bay in Cook Inlet (Sanger and Jones 1982, in press); 3. From collections during OCSEAP cruises from 1975 through 1978 in the Gulf of Alaska and southeastern Bering Sea, mostly incidental to other research activities aboard the vessels; and 4. From specimens that had drowned in salmon gillnets deployed from research vessels of the National Marine Fisheries Service (NMFS) south of the Aleutian Islands and the Alaska Peninsula from 1969 to 1971, and from collections by personnel of the NMFS Marine Mammal Division in the southeastern Bering Sea in 1973 and 1974.

Food samples were collected from nestlings or their parents at a number of breeding colonies in the Gulf of Alaska and the southeastern Bering Sea (Figure 1). Analyses of resulting data has been reported elsewhere for each colony (e.g., Moe and Day 1977; Leschner and Burrell 1977; and especially Baird 1983). Such sampling was the most consistent in the Kodiak area (Baird and Moe 1978), and along with simultaneous collections at sea in adjacent areas, produced the most comprehensive data among the geographic regions (Krasnow and Sanger 1982; and below).

FIELD METHODS

Birds were generally collected at sea by shotgun, from skiffs deployed from the larger research vessels. Less frequently, birds were collected directly from the larger vessel. Whenever possible, attempts were made to collect birds that appeared to be actively feeding. Due to limited opportunities for collecting birds on the open ocean, however, they were sometimes collected regardless of their behavior. Whenever possible, series of specimens were collected at the same time and location, and attempts were made to collect samples of all species from feeding flocks of mixed species.

Usually within five minutes of collection, specimens were weighed with a small spring scale to the nearest g, and their stomachs were injected with buffered 10% formalin to stop post-mortem digestion (van Koersveld 1950). They were tagged with a label indicating field number, weight, and time of collection.

When possible, specimens were processed aboard ship. Standard ornithological measurements were recorded, the age and sex of the specimen was determined, and the digestive tract was removed and preserved in buffered 10% formalin. When this was not possible, specimens were frozen intact in the ship's freezer and processed at the FWS laboratory at a later date.

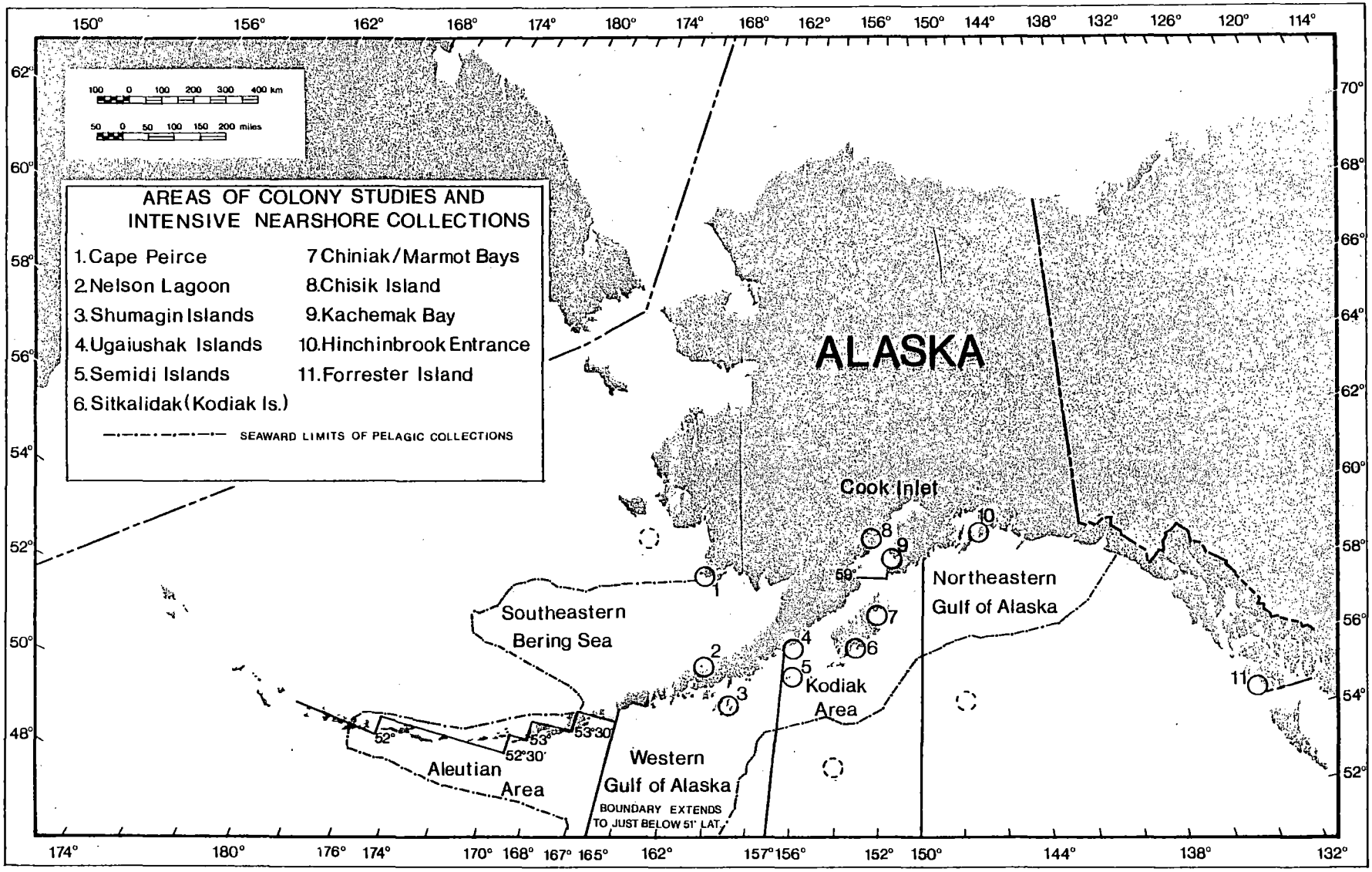


Figure 1. Map of Alaska, showing locations of study camps and marine regions.

Food samples from nestlings on breeding colonies were collected by various means, depending on species of bird and individual field situation (Baird 1983). Generally, samples were collected from cormorants, gulls and terns by startling chicks on the nest; this usually caused them to regurgitate their most recent meal. Most samples from nestlings of terns and puffins were collected by startling parent birds returning to their nests or burrows with prey in their bills, which usually caused them to drop the prey. Some samples were collected from chicks of horned and tufted puffins by taping their bills shut, and then later collecting prey left in their burrows by their parents (Baird and Moe 1978). All food samples from chicks were preserved in plastic bags with either 50% isopropal alcohol (earlier samples) or buffered 10% formalin.

LABORATORY METHODS

Frozen specimens were stored in a laboratory freezer until processing. Specimens were thawed and processed as noted above. Depending on the workload of laboratory personnel, stomach contents were then analyzed, or they were stored in 50% isopropanol and analyzed at a later date.

To analyze the stomach contents, the digestive tract was opened with fine-pointed scissors and any non-food items such as rocks or plastic debris were removed. Stomach contents were drained of excess moisture, weighed to the nearest 0.1 g, and their volume measured to the nearest ml by water displacement. Prey items were then counted and identified to the lowest possible taxon, and the volume of each kind of prey was visually estimated as a percent of the total. Prey identifications were verified by consultation with taxonomic specialists (see Acknowledgments) and voucher specimens were accumulated for comparison with subsequent collections.

The greatest length of whole specimens was measured to the nearest mm, and recognizable parts such as fish otoliths (Frost and Lowry 1981), fish vertebral columns and parasphenoid bones (Sanger *et al.* 1978), and cephalopod beaks were measured to the nearest 0.1 mm.

ANALYSES AND PRESENTATION OF DATA

Data are analyzed and presented in three general modes: 1. The general feeding habits of each species is described, based on data pooled from all regions, seasons and years of data collection; 2. The general food web relationships of selected, phylogenetically-related groups of birds are described, based on data pooled as above; and 3. Where data permit, the feeding habits of species of seabirds are compared among major geographic regions (Figure 1) and seasons, based on data pooled from all years of collection. Seasons are defined here as: Winter, November through March; Spring, April through 15 May; Summer, 16 May through August; and Fall, September and October.

Data on feeding habits of each species are presented in appendix tables that list for each kind of prey the aggregate percent volume (*cf.* Martin *et al.* 1946; Swanson *et al.* 1974), aggregate percent numbers, per-

cent frequency of occurence in the pooled sample of birds, and an Index of Relative Importance (see below). Species accounts summarize information in the appendix tables, which are often quite extensive, and food web diagrams convey a visual summary of the relative importance of the main foods of each bird species.

Pinkas et al. (1971) discussed the shortcomings of using either volume, numbers, or frequency of occurrence alone to depict the importance of prey. Differential digestion rates of hard and soft-bodied prey may distort their original relative volumes, percent numbers can make an abundant small prey seem more important than sparse larger ones, and percent frequency of occurrence ignores numbers and volume. To overcome these problems, these authors combined the three values into an Index of Relative Importance (IRI), as defined below:

IRI = %FO (%V + %N), where

%FO = percent frequency of occurrence of a prey taxon or group of taxa in a sample of n birds

%V = percent aggregate volume of a prey taxon or group of taxa in the combined volume of all taxa in the stomachs of the sample of n birds

%N = percent aggregate numbers of a prey taxon, or group of taxa in the combined numbers of all taxa in the stomachs of the sample of n birds.

Generalized information about the seasonal distribution and abundance of the birds is given below for orientation, but the reader is referred to Gould et al. (1982) for full details.

RESULTS

SEASONAL AND GEOGRAPHIC CHARACTERISTICS OF THE SAMPLES

In total, there are data from 2,995 food samples from 39 species of seabirds. Sample sizes varied considerably among months, with about 71% of the samples between June and August, 10% from the five months between November and March, 10% in April and May, and about 9% in September and October.

Disparity also existed in numbers of birds collected among geographic regions. Most food samples (2,188 or 74%) were from the Kodiak Island area. Numbers of samples from other regions were: Northeastern Gulf of Alaska, 264 (8.9%); Cook Inlet, 201 (6.8%); southeastern Bering Sea, 179 (6.1%); western Gulf of Alaska, 79 (2.7%); and, Aleutian Islands, 44 (1.5%).

Even when all samples are pooled, sample sizes are very small for some birds. The average sample size for all species was 74, but for 16 (40%) of these, it was fewer than 10. Only 15 species (38%) had samples greater than 30, and the following seven of these had samples of 100 or more: Sooty shearwater (Puffinus griseus), short-tailed shearwater (P. tenuirostris),

glaucous-winged gull (Larus glaucescens), black-legged kittiwake (Rissa trydactyla), common murre (Uria aalge), marbled murrelet (Brachyramphus marmoratum), and tufted puffin (Fratercula cirrhata).

DIETS, POOLED DATA

Order Procellariiformes (Tube-nosed Birds)

We have data on four of the forteen species of procellariiformes known to occur in Alaskan waters: Northern fulmar (Fulmarus glacialis), sooty shearwater, short-tailed shearwater; and, fork-tailed storm-petrel (Oceanodroma furcata). Fulmars and fork-tailed storm-petrels occur in Alaskan waters year-round, but the two shearwaters breed in the southern hemisphere and migrate to the North Pacific during the boreal summer, when they usually dominate seabird numbers in Alaskan waters from spring through fall (Gould et al. 1982).

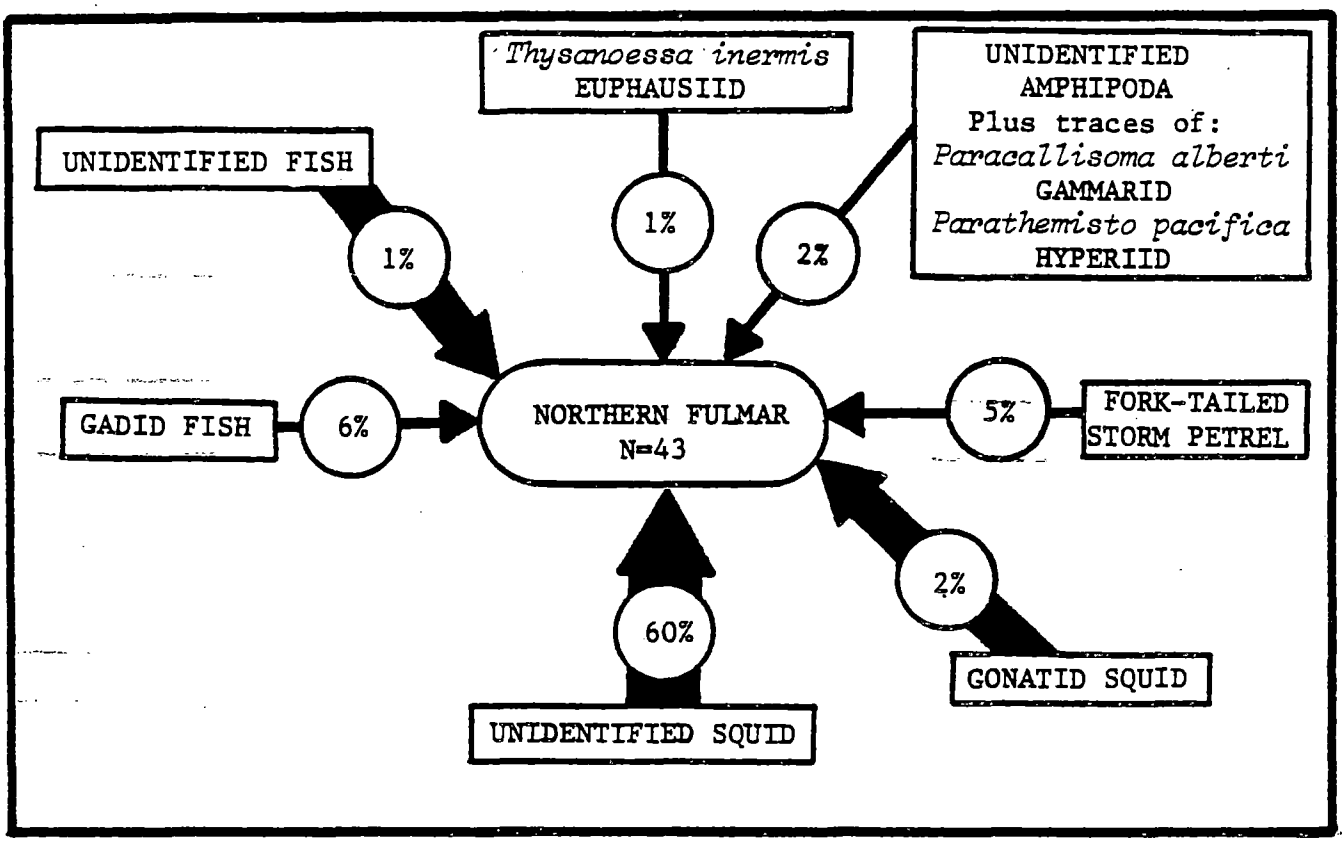
Compared with other seabirds, the feeding ecology of the procellariiforms is relatively uncomplicated. In the subarctic North Pacific Ocean, procellariiforms range in size from storm petrels of 45 - 50 g, to albatrosses of 3 - 3.5 kg. All species feed on a relatively few prey species. Storm petrels feed right at the surface, fulmars are able to dive for their food to at least 0.5 M (S. Hatch, pers. commun.) and perhaps as deep as "several meters" (Nelson 1979), and the two shearwaters pursue their prey to depths of at least 5 M (Brown et al. 1978).

Northern Fulmar. Forty-six birds were sampled, of which 43 (93.5%) had food in their stomachs. Most were from the Kodiak Island area (N = 21) and the northeast Gulf of Alaska (N = 16). At least 10 species of prey were in the birds' stomachs.

Squid dominated the diet of fulmars; they accounted for 72% by numbers, 63% by volume, and occurred in 81% of all samples (Figure 2, Appendix Table 1). Squid of the family gonatidae were identified from five (12%) of the stomachs, but identification to lower taxa was impossible. Crustaceans and unidentified fish were of secondary importance to fulmars. Capelin and walleye pollock were the only fish identified, and were present in only trace amounts.

The euphausiid Thysanoessa inermis was found in only one bird, but it accounted for 4.7% of numbers and 1.4% of the total prey volume. The amphipods Parathemisto pacifica and Parcallisoma alberti were present in the stomachs in trace amounts. Unidentified gammarid amphipods accounted for 1.7% of prey numbers and 2.3% of the volume. In view of the common occurence of P. alberti (Gammaridea, Lysianassidae) in a number of seabird species in the Gulf of Alaska (Sanger and Boersma, in prep.) these unidentified amphipods may well have been P. alberti.

Other trace prey included nereid polychaetes, unidentified bivalves and remains of a fork-tailed storm-petrel in one bird. The medusae (jellyfish) Cyanea capillata and unidentified medusae are sometimes important prey of fulmars in the vicinity of the eastern Aleutian Islands (R. Day, pers. commun. to P. J. Gould), but we found none in the samples we studied.



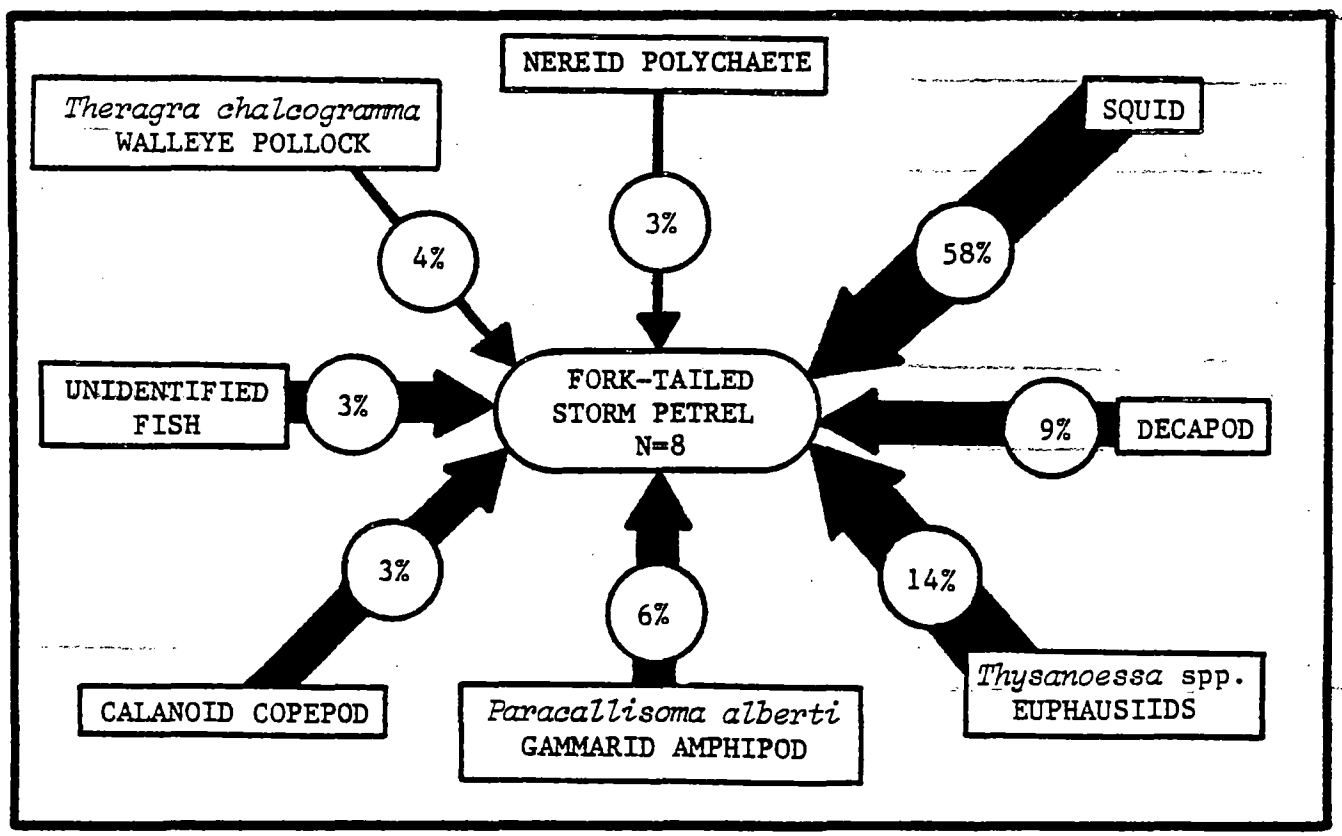


Figure 2. Food webs for northern fulmars (top) and fork-tailed storm petrels (bottom), showing main prey as indicated by pooled data. % aggregate volumes shown, and arrow sizes based on exponential increments of prey's IRI: small = 10 - 99; medium = 100 - 999; large = 1,000 and up. Only prey with both an IRI of at least 10 and which comprised at

However, it seems unlikely that medusae remain recognizable in bird stomachs very long after ingestion, and the birds may pick the medusae apart while eating them.

Sooty Shearwater. A total of 187 sooty shearwaters was collected, of which 178 (95.2%) had food in their stomachs; 161 of these (86%) were from the Kodiak Island area.

Of the 14 kinds of prey identified, capelin was overwhelmingly the most important; it comprised 23% of all numbers and 83% of the volume, and occured in 50% of birds with food in their stomachs (Figure 3, Appendix Table 2). Other major prey, in descending order of importance, included squid, Pacific sand lance, and the euphausiid Thysanoessa inermis.

Although squid accounted for low proportions of total volume, unidentified squid comprised 38% of numbers and occured in 41% of the birds with food in their stomachs. Unidentified cephalopods were likely squid, but the condition of beaks remaining in stomachs rendered them indistinguishable from octopus beaks. Unidentified gonatids and Onychoteuthis spp. squids were present in trace amounts.

T. inermis was moderately important to sooty shearwaters, but other crustaceans were of only minor or trace importance. Other fish, present in trace amounts only, included Pacific tomcod, Pacific sandfish, and a myctophid (lantern fish), Stenobrachius nannochir.

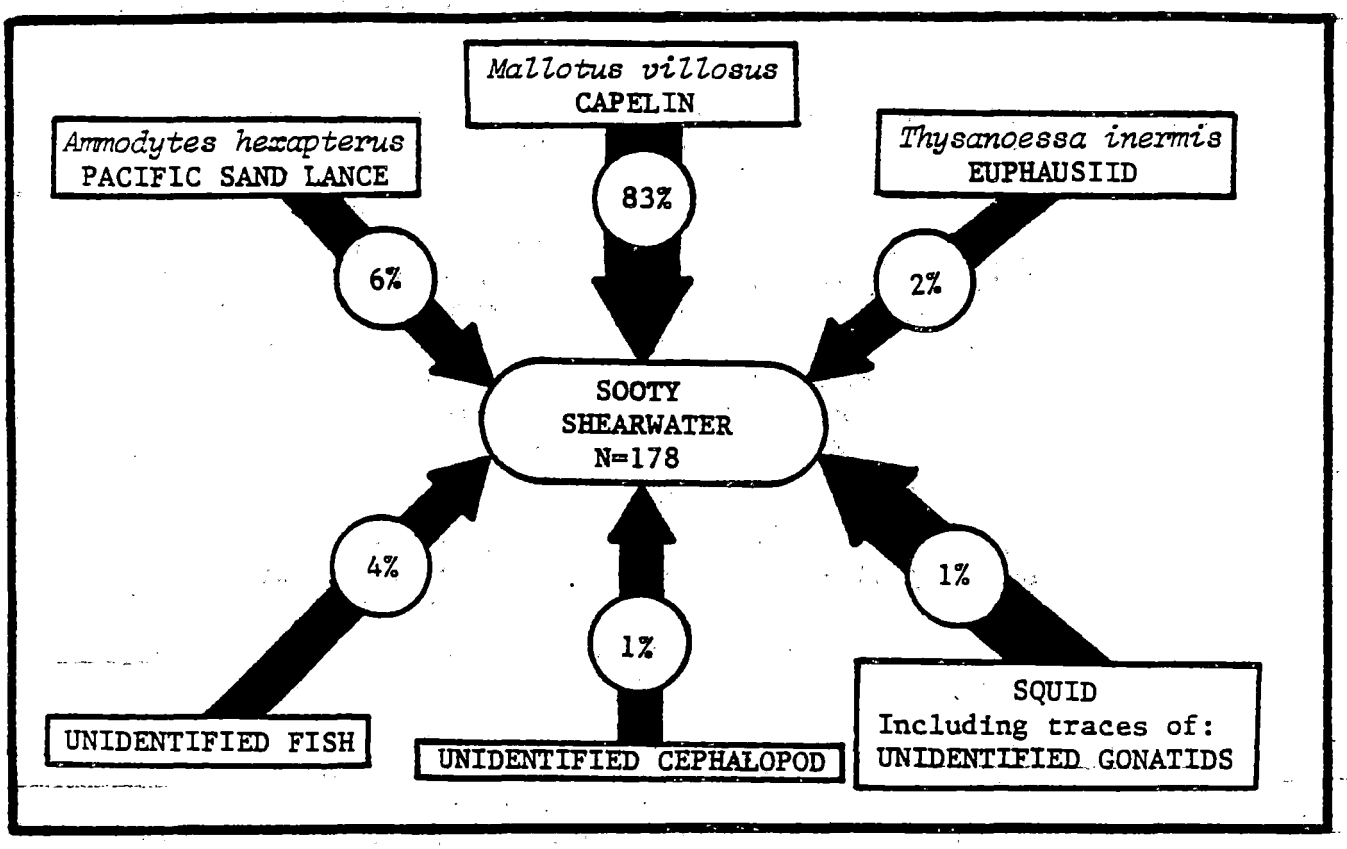
Short-tailed Shearwater. Two-hundred-twenty-eight (228) birds were collected, of which 201 (88.2%) had food in their stomachs; 184 (80.7%) were from the Kodiak area, and 31 (13.6%) were from the southeastern Bering Sea. Fourteen prey species were identified.

Euphausiids dominated the diet of short-tailed shearwaters, comprising 85% of the numbers, 46% of the volume, and occurring in 22% of all stomachs with food (Figure 3, Appendix Table 3). Most euphausiids could be identified only to genus (Thysanoessa); of those identifiable to species, T. inermis was the most important, while T. raschii and T. spinifera were of relatively minor importance.

Capelin was the next most important prey, comprising 41% of the volume. Walleye pollock and Pacific sand lance were present in trace amounts. Squid, including unidentified cephalopods, were of relatively minor importance. Unidentified gonatids were present in trace amounts. Squid occurred in 37% of birds with food in their stomachs, however, so squid may be more important to short-tails than these data suggest.

Fork-tailed Storm-petrel. Fourteen storm-petrels were sampled, of which eight (57%) had food in their stomachs. Six prey species were identified. Squid, including unidentified cephalopods, was the most important kind of prey (Figure 2, Appendix Table 4), but none were identifiable to a taxa lower than order.

Cephalopods accounted for 58% of the prey volume. Euphausiids were also important prey, accounting for 60% of their numbers, and 14% of their volume. Prey of secondary or minor importance included unidentified



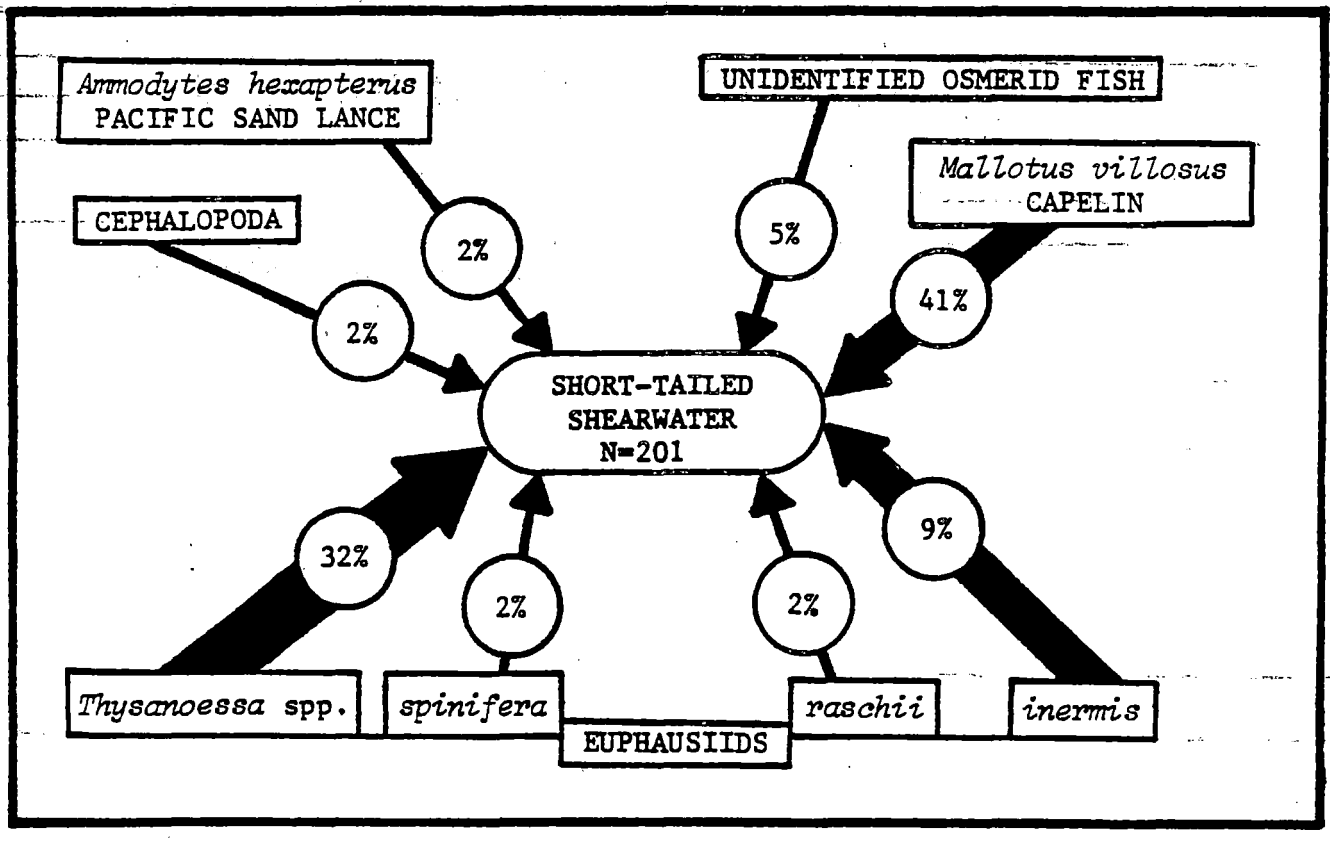


Figure 3. Food webs for sooty shearwaters (top) and short-tailed shearwaters (bottom), showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

decapods (probably shrimp), the gammarid amphipod Paracallisoma alberti, calanoid copepods, walleye pollock, and nereid polychaetes.

Capelin was the major prey in regurgitations of parent birds returning to the Barren Islands to feed their nestlings (D. Boersma, pers. commun.).

Food Web Relationships. Table 1 and Figure 4 compare the relative importance of all kinds of prey among the four procellariiformes. Capelin was the main fish prey; it was of at least moderate importance to all species except fulmars. Pacific sand lance were moderately important to both species of shearwaters. Gadids were present in trace or minor amounts in the diets of all four bird species. The commercially important walleye pollock was not found in the abundant shearwaters and it was of only minor importance to fulmars and storm-petrels.

The procellariiforms ate a minimum of nine species of crustaceans, of which Thysanoessa euphausiids were important to all four species, particularly short-tailed shearwaters. T. inermis was the most important species to fulmars and both shearwaters, while T. spinifera was most important to the storm-petrels.

Calanoid copepods were also found in all four bird species; they were most important to the storm-petrels, but were of minor or trace importance to the other three. Similarly, amphipods were found in all four species of birds. The pelagic gammarid amphipod Paracallisoma alberti was moderately important to the storm-petrels. A large predatory hyperiid, Parathemisto libellula, was a trace prey of short-tailed shearwaters, but it should be considered important in the Bering Sea where it is a major component of micronekton over shelf waters (Bowman 1960; Wing 1976).

Although data indicate that cephalopods are of major importance in the diet of procellariiforms, this animal group was particularly difficult to identify to species because of their usual advanced state of digestion in stomachs samples. The relative importance of different species of cephalopods to procellariiformes therefore remains unknown.

Phalacrocoracidae (Cormorants)

Cormorants are rather large seabirds, averaging about 1.6 to 2.8 kg in weight, depending on species. They feed on or near the bottom by swimming with their large feet in pursuit of their prey (by pursuit diving of Ashmole 1971). Three species are included in our samples: Double-crested cormorant, Phalacrocorax auritus; pelagic cormorant, P. pelagicus; and red-faced cormorant, P. urile. All three are year-round residents in nearshore waters of Alaska (Gould et al. 1982). Sample sizes for adults and nestlings of all three species were generally small, but those from pelagic cormorants included 16 adults and 15 nestlings.

Double-crested Cormorant. Two adult birds were collected and regurgitations from two nestlings were obtained. The stomach of one adult was empty, and the other had unidentified fish remains. Both nestlings

Table 1. Comparative importance of prey to procellariiform seabirds, based on data pooled from food samples from birds in Alaskan waters. Importance levels of prey based on their Indices of Relative Importance: 0-9 = trace(tr); 10-99 = 1; 100-999 = 2; 1,000-9,999 = 3

PREY NAME	Importance of Prey to Bird Species			
	Northern Fulmar N = 43	Sooty Shearwater N = 178	Short-tailed Shearwater N = 201	Fork-tailed Storm-petrel N = 8
POLYCHAETA				
Unidentified Nereid	tr	tr	tr	1
GASTROPOD, Unidentified	-	-	tr	-
BIVALVE, Unidentified	tr	-	-	-
CEPHALOPODA				
Unidentified	2	2	1	2
Unidentified Gonatid	2	tr	tr	-
Onychoteuthis borealijaponicus	-	tr	-	-
Unidentified Squid	3	3	tr	3
CRUSTACEA				
Calanoid Copepod	1	tr	tr	2
Amphipoda				
Paracallisoma alberti	tr	tr	-	2
Unidentified Gammarid	1	-	tr	-
Parathemisto pacifica	tr	tr	tr	-
Parathemisto libellula	-	-	tr	-
Euphausiacea				
Thysanoessa inermis	1	2	2	-
Thysanoessa raschii	-	tr	1	-
Thysanoessa spinifera	-	tr	1	2
Thysanoessa sp.	-	tr	3	2
Decapoda				
Telmesus chieragonus	-	-	tr	-
Unidentified	-	-	tr	2
FISHES				
Mallotus villosus	tr	3	2	-
Stenobrachius nannochir	-	tr	-	-
Theragra chalcogramma	tr	-	tr	1
Microgadus proximus	-	tr	-	-
Unidentified Gadid	1	-	-	-
Trichodon trichodon	-	tr	-	-
Ammodytes hexapterus	-	2	1	-
Unidentified	2	2	1	1
BIRDS				
Oceanodroma furcata	1	-	-	-

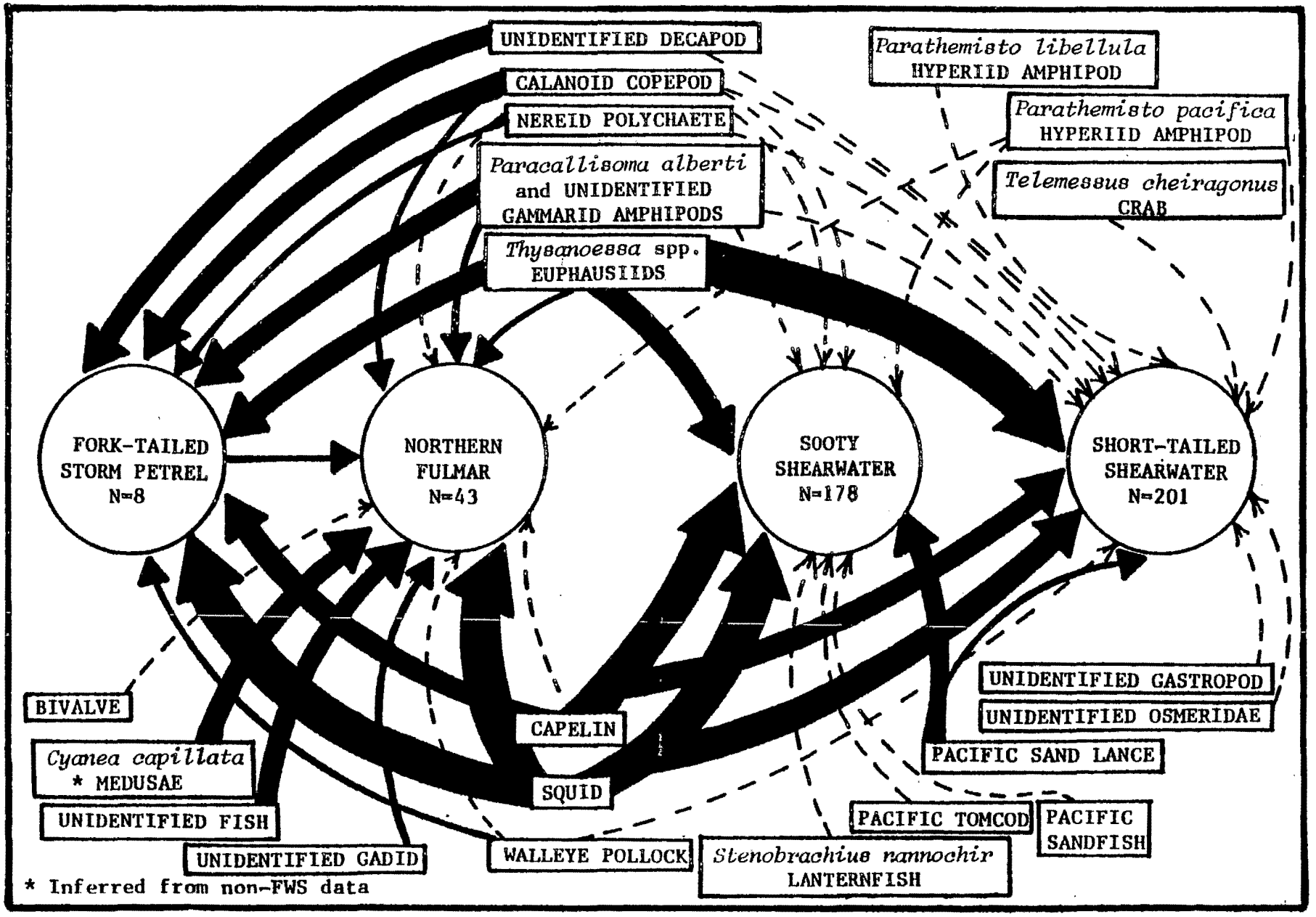


Figure 4. Food web relationships among four species of procellariiform seabirds, based on pooled data. Arrow sizes based on exponential increments of prey's IRI for each bird species: Dashed = 0 - 9; small = 10 - 99; medium = 100 - 999; large = 1,000 and up.

regurgitated unidentifiable fish remains, and one had eaten the shrimp Crangon septemspinosa (Appendix Table 5).

Pelagic Cormorant. Sixteen adults were collected, and all had food in their stomachs. The birds had eaten at least nine kinds of prey; fish predominated, particularly Pacific sand lance. Sand lance occured in 62% of the stomachs, and accounted for 46% of total prey volume; their IRI was 7,424 (Figure 5, Appendix Table 6). The next most important prey was capelin (IRI = 160). Walleye pollock was of minor importance (IRI = 52). Other fish, crustaceans, and sea urchins were of minor or trace importance.

Fifteen regurgitation samples were collected from nestlings, all from the Kodiak area. At least five kinds of prey were present. Fish and dipteran flies (attracted to the birds' generally-dirty nests) were the main prey items, unidentified decapods were of minor importance, and unidentified polychaetes were present in trace amounts (Figure 5, Appendix Table 7). Fish prey were mostly sand lance (IRI = 3,889) and unidentified fish (IRI = 3,595), plus unidentified gadids (IRI = 18).

Red-faced Cormorant. Two adults, one each from the southeastern Bering Sea and Kodiak Island, had eaten at least six species of prey. Pacific sand lance (71% of total volume) and the shrimp Lebbeus polaris (12% of volume) were the main kinds of prey (Appendix Table 8). Other prey, in descending order of importance, included unidentified fish, Irish lord (Hemilepidotus sp.), a pandalid shrimp (Pandalus jordani), unidentified nereid polychaetes, and valviferan isopods (crustacea).

Seven regurgitation samples from Kodiak nestlings revealed at least four kinds of prey. Pacific sand lance was dominant (65% of numbers, 81% of volume, and 71% frequency of occurence), capelin was moderately important, and other prey included dipteran flies, and unidentified osmerid and gadid fishes (Figure 6, Appendix Table 9).

Food Web Relationships. The generally small samples prevent all but the most tentative of conclusions about food web relationships in the cormorants. However, comparisons of the relative importance of all kinds of prey of adults and nestlings of all three species (Table 2, Figure 7) reveal general trends. Fish was the only general prey category eaten by adults and nestlings of all three species. Pacific sand lance stood out as major prey of adults and nestlings of both pelagic and red-faced cormorants. Capelin, heavily utilized by a number of other seabird species, was of only moderate importance to nestling red-faced cormorants. The two adult red-faced cormorants in our samples had eaten three species of crustaceans, but crustaceans in general were sparsely utilized by the cormorants in our samples.

Anatidae (Subfamily Athyinae, Sea Ducks)

Sea ducks are medium-sized diving birds that feed by swimming under water with their webbed feet. They eat sessile or slowly moving benthic and demersal prey, and some species include plant material in their diets. Most species breed inland near fresh water, and all species winter

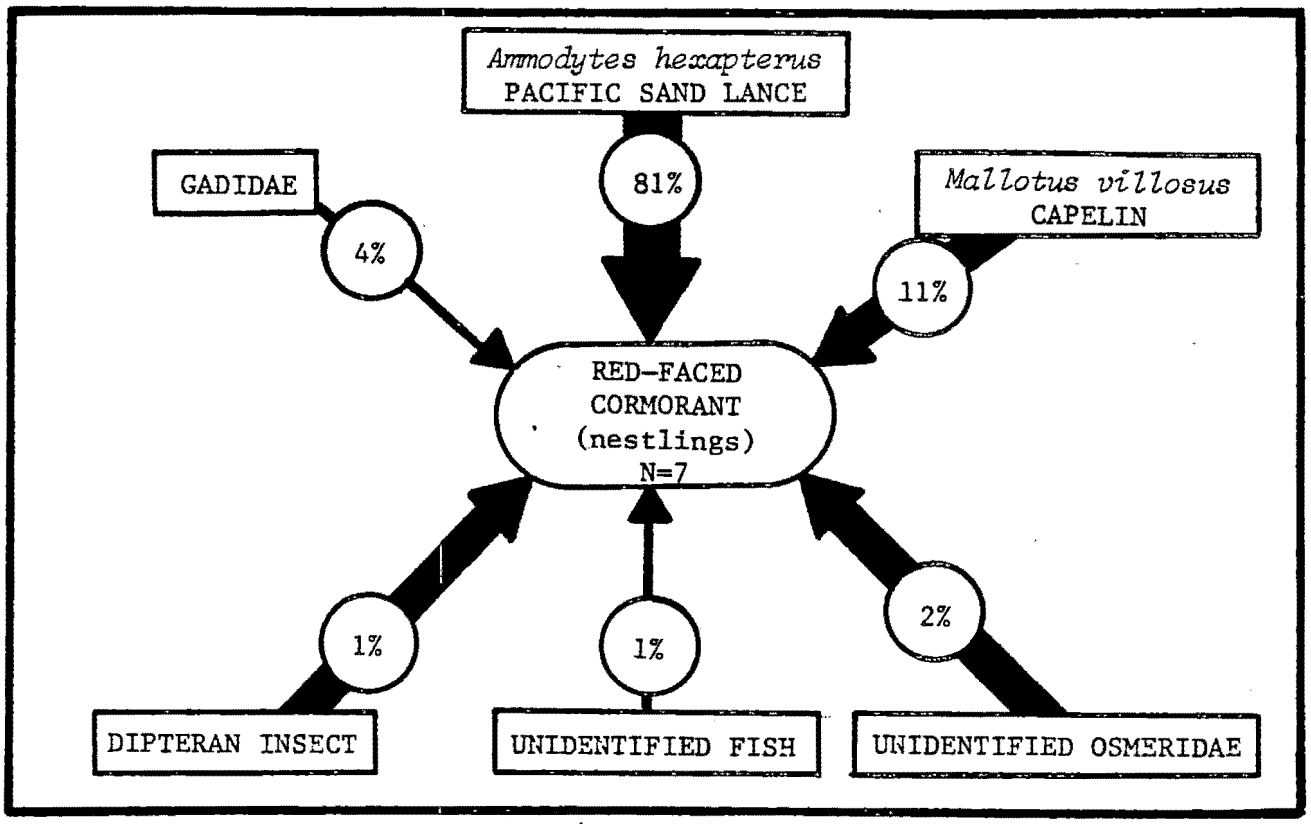
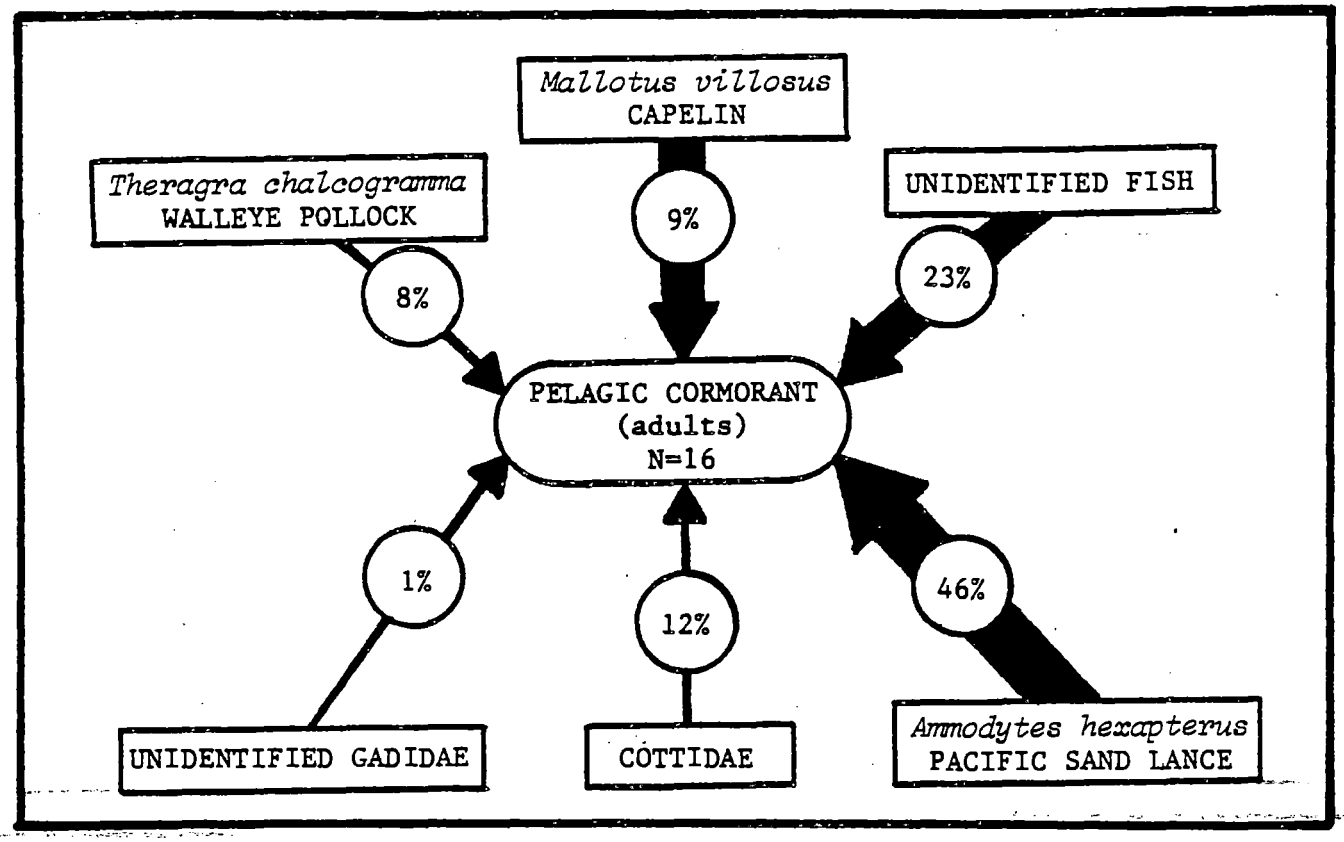


Figure 6. Food web for red-faced cormorant nestlings, showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.



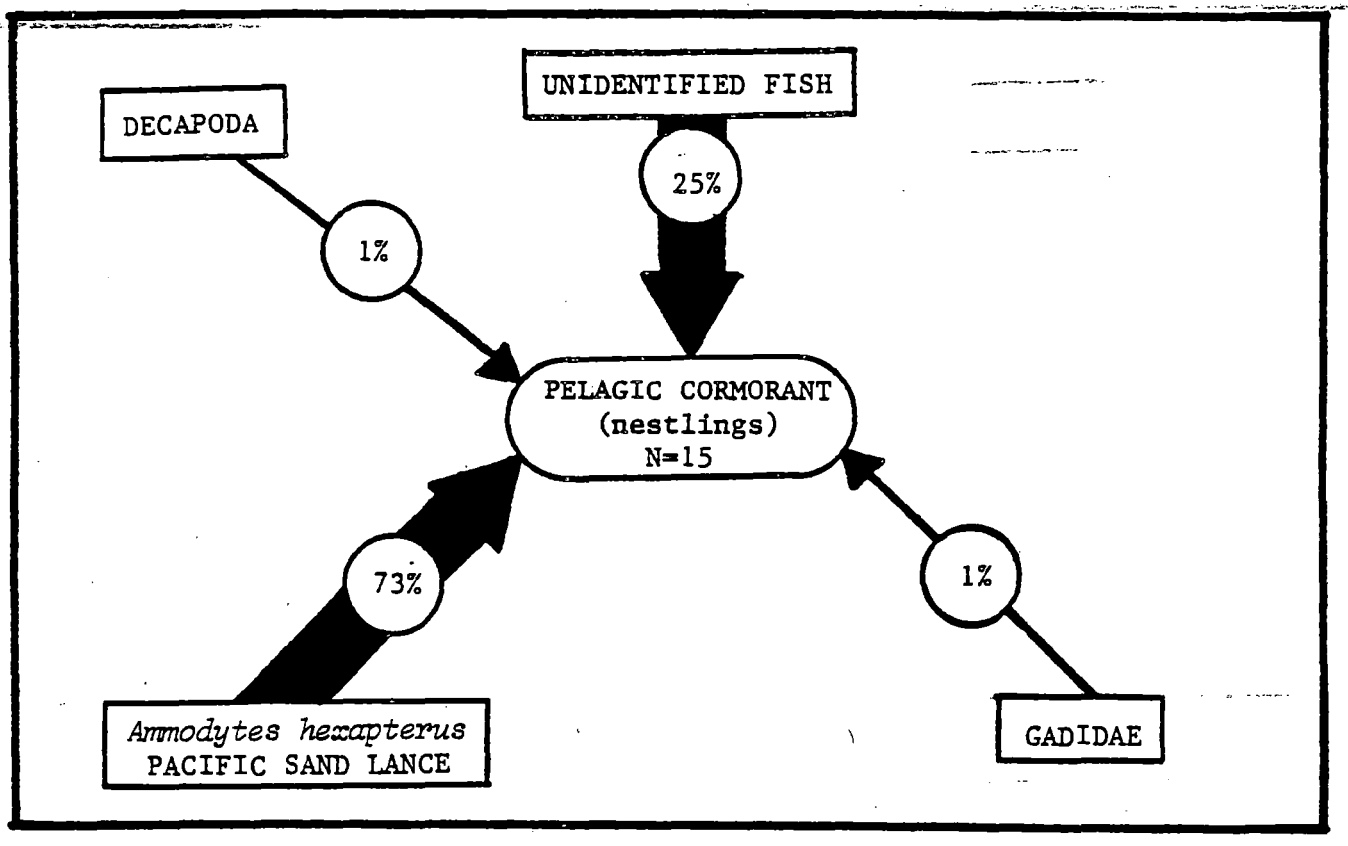


Figure 5. Food webs for adult (top) and nestling (bottom) pelagic cormorants, showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

Table 2. Comparative importance of prey to adult and nestling cormorants, based on data pooled from food samples from birds in Alaskan waters. Importance levels of prey based on their Indices of Relative Importance: 0-9 = trace(tr); 10-99 = 1; 100-999 = 2; 1,000-9,999 = 3

	Importance of Prey to Cormorant Species					
	Pelagic		Double-crested		Red-faced	
PREY NAME	(adult) N = 16	(nestling) N = 15	(adult) N = 1	(nestling) N = 2	(adult) N = 2	(nestling) N = 7
POLYCHAETA						
Nereidae	—	—	—	—	2	—
Unidentified	—	1	—	—	—	—
ECHINODERMATA						
Echinoida	tr	—	—	—	—	—
INSECTA						
Diptera	—	2	—	—	—	2
CRUSTACEA						
Mysida	tr	—	—	—	—	—
Gammaridean Amphipoda	1	—	—	—	—	—
Valviferan Isopod	—	—	—	—	2	—
Unidentified Crab	—	1	—	—	—	—
Shrimp						
Lebbeus polaris	—	—	—	—	3	—
Pandalus jordani	—	—	—	—	2	—
Crangon septemspinosa	—	—	—	3	—	—
Unidentified	1	—	—	—	—	—
FISH						
Mallotus villosus	2	—	—	—	—	2
Unidentified Osmeridae	—	—	—	—	—	2
Hemilepidotus sp.	—	—	—	—	2	—
Theragra chalcogramma	1	—	—	—	—	—
Unidentified Gadidae	1	1	—	—	—	1
Ammodytes hexapterus	3	3	—	—	3	3
Unidentified Cottidae	1	—	—	—	—	—
Unidentified	2	3	3	3	2	1

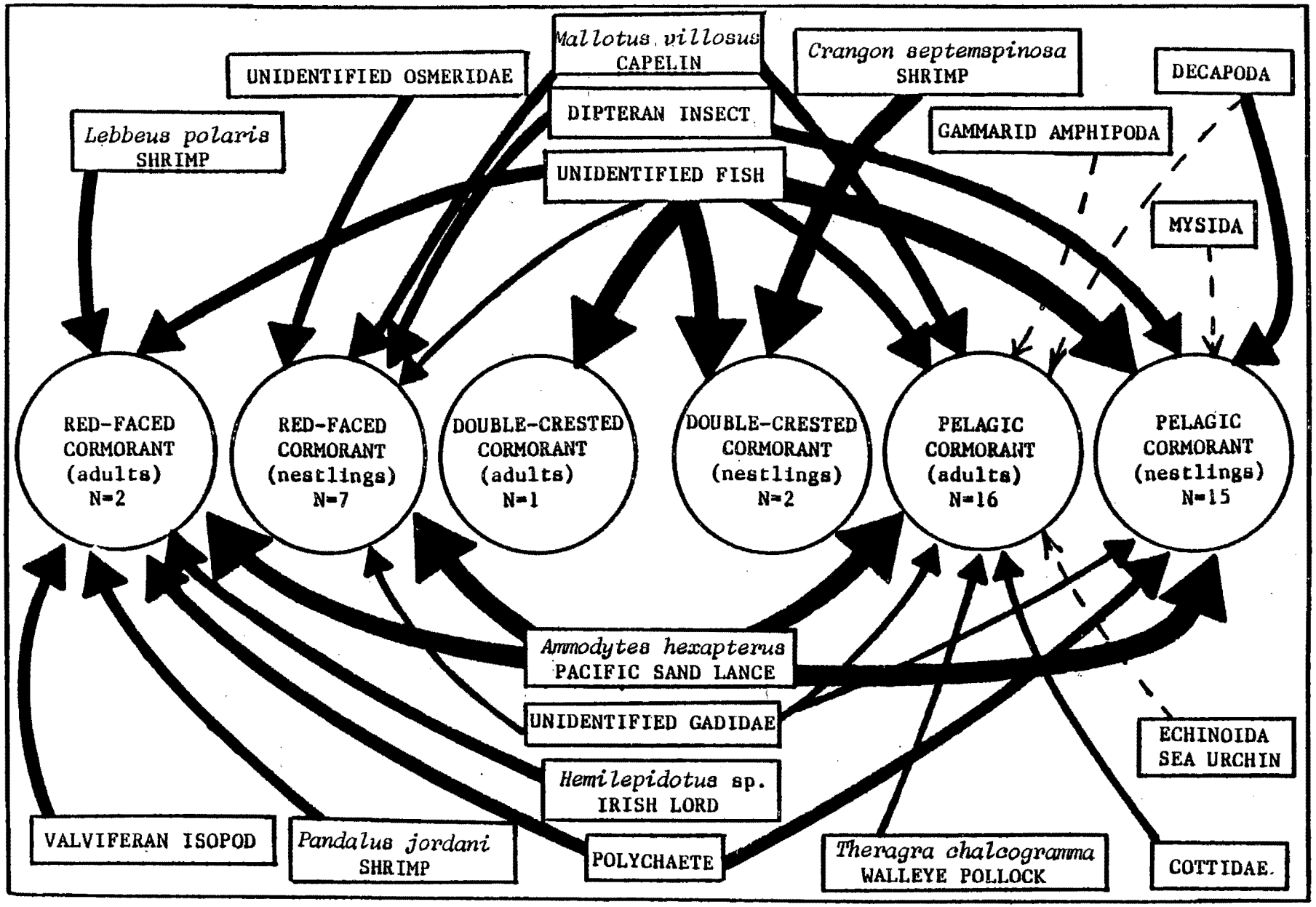


Figure 7. Food web relationships among adults and nestlings of double-crested, pelagic, and red-faced cormorants, based on data pooled from all years, seasons, and regions. See Fig. 4 caption.

on coastal marine waters. Juvenile birds spend at least their first year of life at sea. The species for which we have data are: Oldsquaw, Clangula hyemalis; harlequin duck, Histrionicus histrionicus; Steller's eider, Polysticta stelleri; white-winged scoter, Melanitta deglandi; surf scoter, M. perspicillata; and, black scoter, M. nigra.

Oldsquaw. Seventy birds were collected, mostly from Kodiak Island (N = 41) and Cook Inlet (N = 28). There were no empty stomachs. Oldsquaws were extreme generalists. They ate at least 94 species of prey, but at least 40 (43%) of these were of trace importance only (Appendix Table 10).

The most important major taxa of prey, in descending order of their IRI values were: Crustaceans, 1,830; bivalves, 1,015; gastropods, 782; fish, 301; echinoderms, 137; and, polychaetes, 123 (Figure 8, Appendix Table 10).

No single species of prey stood out in importance. The mysid crustacean Acanthomysis sp. was the most important species of prey overall, with an IRI of 250, and an overall prey volume of 9%. Other relatively important prey were (IRI and % volume): Pacific sand lance (202 and 12%), the bivalves Mytilus edulis (167 and 3%) and Glycymeris subobsoleta (171 and 1%), and the gastropods (snails) Lacuna vareigata (177 and 3%) and Alvinia compacta (113 and 1%) (Figure 8, Appendix Table 10).

Harlequin Duck. Five birds were collected in lower Cook Inlet in summer, and all had food in their stomachs. Two species of periwinkle snails were found in their stomachs: Littorina saxatilis and L. sitkana, which comprised 38% and 6% of the volume, respectively (Figure 9, Appendix Table 11). In addition, gastropods formed 46% of the volume of prey, and unidentified molluscs, 10%.

Steller's Eider. Three Steller's eiders were collected at Kodiak Island in winter. All had food in their stomachs, including at least 38 species of prey. The IRI values of the major groups of prey are: Holothurians (sea cucumbers) (4,956); crustaceans (3,810); polychaete worms (2,648); bivalves (2,008); and, gastropods (420) (Figure 10, Appendix Table 12).

The most important species of prey were (IRI and % volume): Cucumeria sp. (sea cucumber) (4,901 and 50%); gammarid amphipods (3,110 and 7%); Hiatella sp. (boring clam) (1,473 and 13%); and the polychaete families opheliidae (600 and 6%), phyllodocidae (561 and 3%), and nereidae (258 and 1%).

White-winged Scoter. Forty-six white-winged scoters were collected, and 44(96%) had food in their stomachs. Together they had eaten at least 36 species of prey; eight (17%) of these were of trace occurence only.

Bivalves were overwhelmingly the most important major group of prey (IRI = 4,204; vol = 80%)(Figure 11, Appendix Table 13). Other major taxonomic groups of prey present in the stomachs were as follows (IRI and % volume): Gastropods, 246 and 12%; fishes (and fish eggs), 163 and 4%; crustaceans, 16 and 1%; polychaetes, 4 and 1%; echinoderms, 2 and 1%.

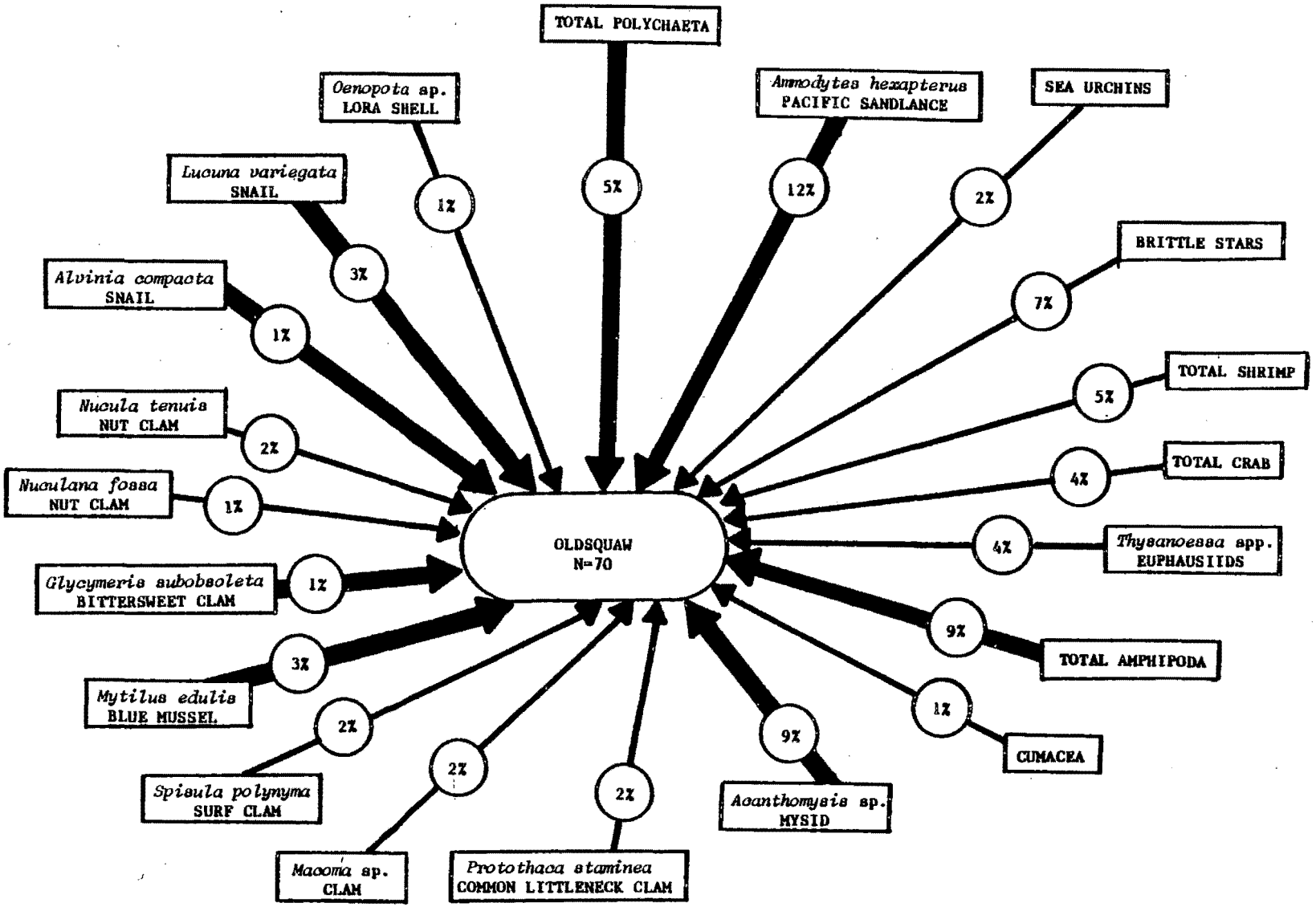


Figure 8. Food web for oldsquaws, showing main prey items as indicated by data pooled from all years, seasons and regions. See Fig. 2 caption.

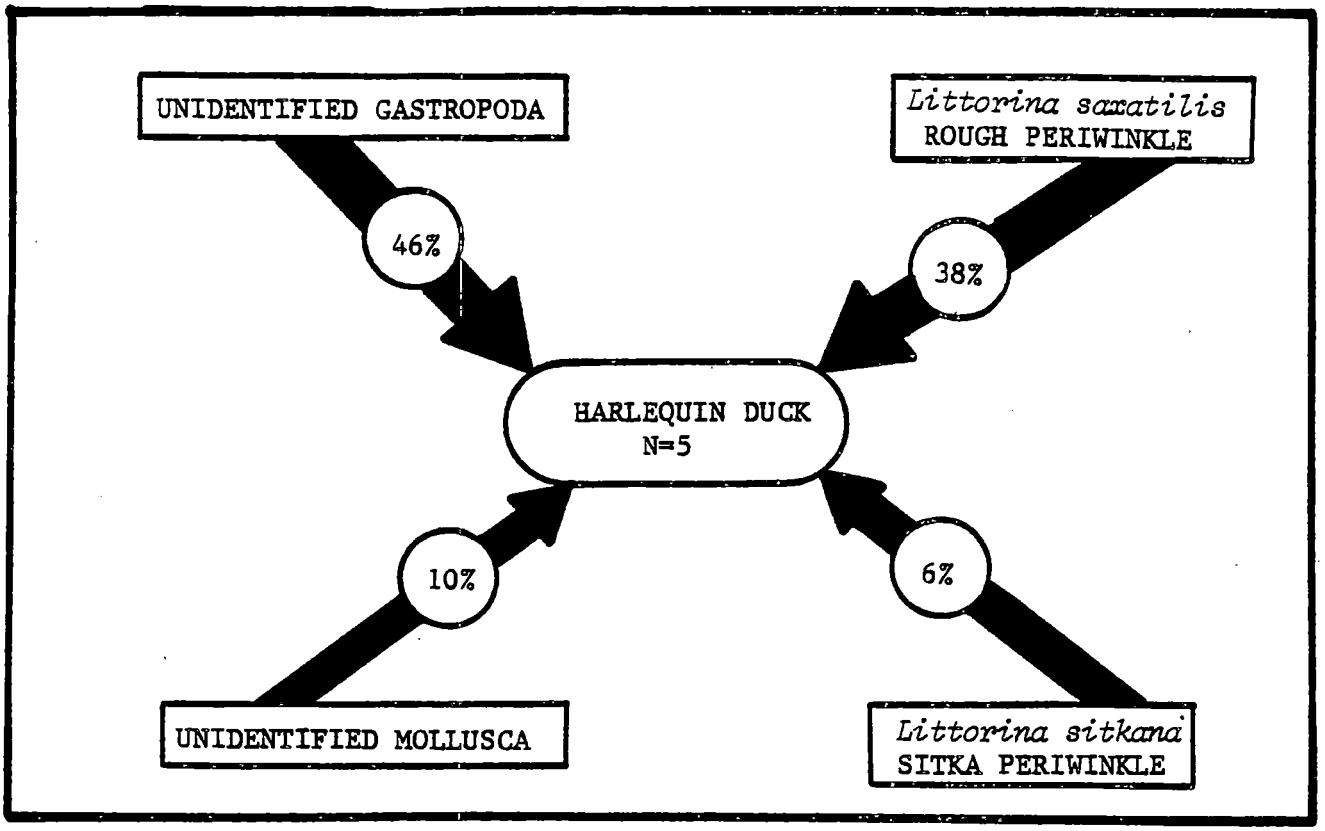


Figure 9. Food web for harlequin ducks, showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

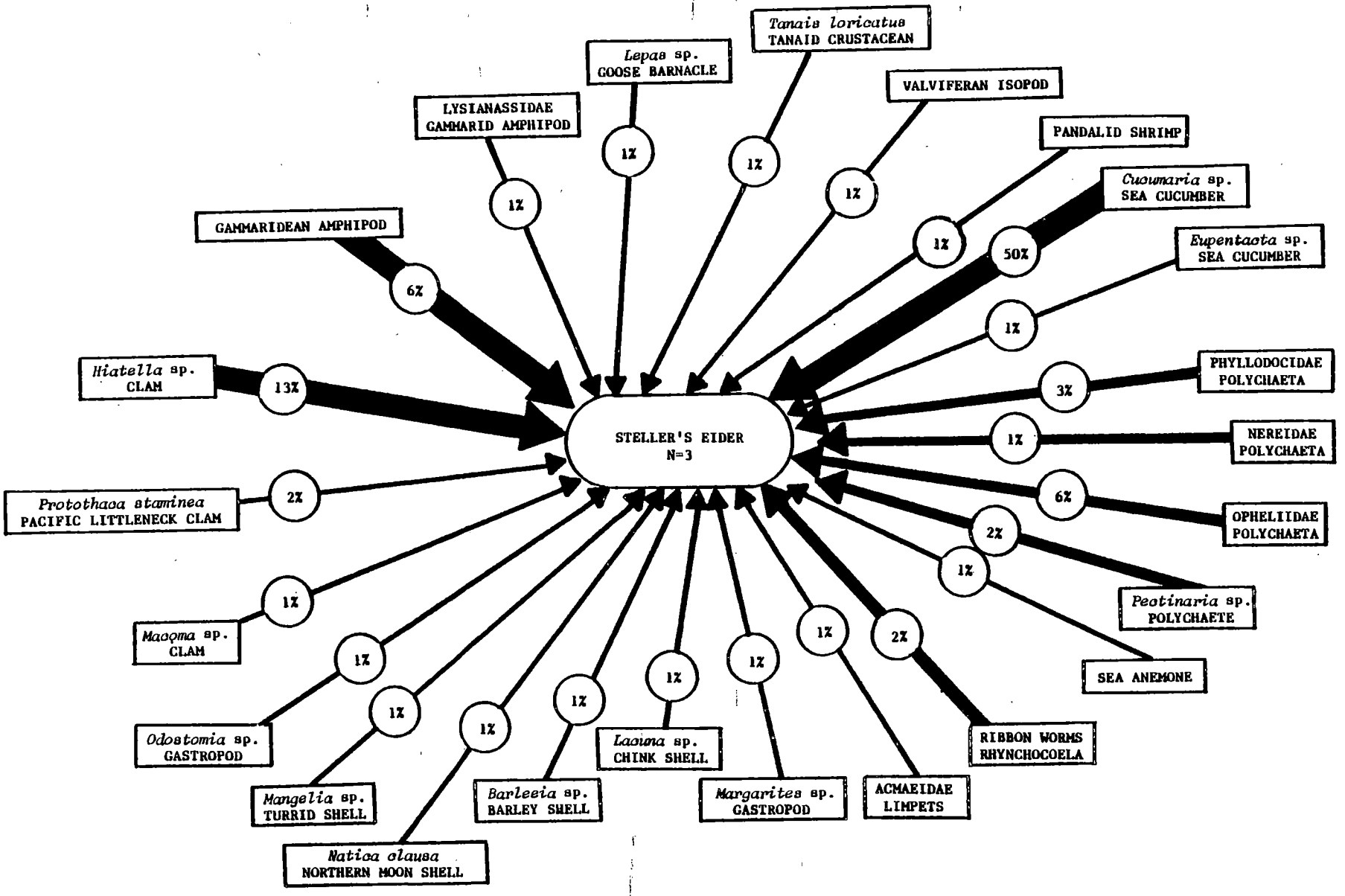


Figure 10. Food web for Steller's eiders, showing main prey items as indicated by data pooled from all years, seasons and regions. See Fig. 2 caption.

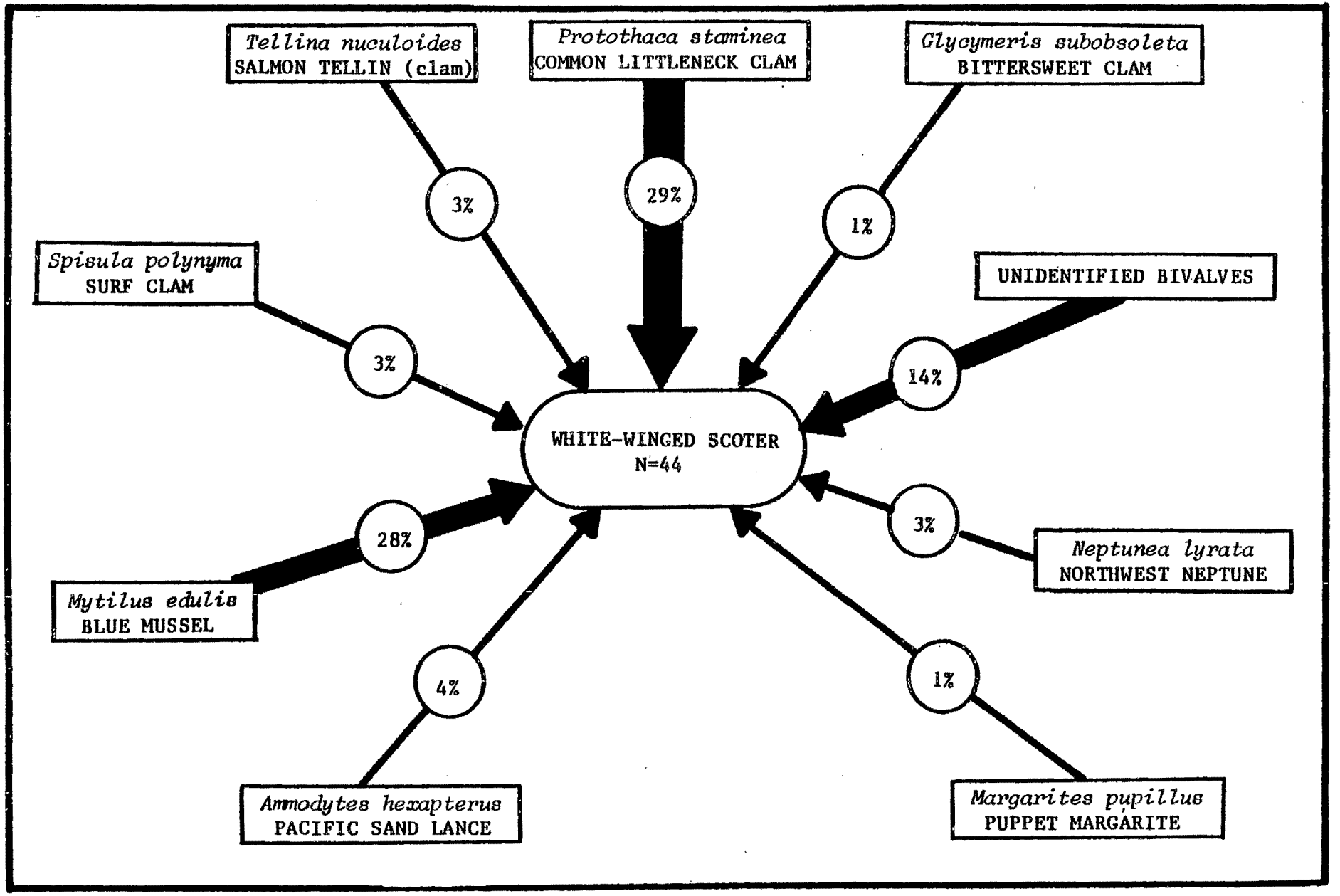


Figure 11. Food web for white-winged scoters, showing main prey items as indicated by data pooled from all years, seasons and regions. See Fig. 2 caption.

The most important prey species overall were (IRI and volume) the common littleneck clam (1,068 and 36%) and the blue mussel (611 and 28%) (Figure 11, Appendix Table 13). The most important gastropods were Margarites pupillus (10 and 1%) and Neptunea lyrata (13 and 3%). The scoters had eaten Pacific sand lance (11 and 4%), possibly when the fish were buried in the substrate. Unidentified fish eggs comprised 66% of the numbers of prey, but their low overall volume ($\leq$ 0.1%) and frequency of occurence (one bird, 2.3%) resulted in a moderately low IRI of 150.

Surf Scoter. Ten of 11 surf scoters had food in their stomachs. The birds had eaten a minimum of 12 species of prey, as well as plant material.

The IRI of bivalves in total was 7,310. They accounted for 75% of prey numbers, 71% of the volume, and they occured in five of the 10 birds with food in their stomachs (Figure 12, Appendix Table 14). Mytilus edulis (blue mussel) was the single most important prey species (IRI 816, vol 16%), and other bivalves of moderate importance were Nucula tenuis and Musculus discors (1% and 10% of volume, respectively). However, unidentified bivalves accounted for 14% of prey numbers, 40% of the volume, and had an IRI of 2,700 (Appendix Table 14).

The polychaete worm Nephtys sp. accounted for 14% of the volume, and had an IRI of 198. The rest of the prey species were all considerably less important. The surf scoter was the only species of waterfowl that had eaten plant material.

Black Scoter. Six of seven black scoters collected had food in their stomachs, and they had eaten at least four species of prey. Mytilus edulis was overwhelmingly the most important prey species; it had an IRI of 19,210, it occured in all six birds, comprised 98% of the prey volume, and 94% of the numbers (Figure 12, Appendix Table 15). Three other species of prey each occured in a single bird; they were the gastropod Margarites pupillus, the common littleneck clam (Protothaca staminea), and unidentified barnacles.

Phalaropodidae (Phalaropes)

Red and red-necked phalaropes (Phalaropus fulicarius and Lobipes lobatus) occur in pelagic waters off Alaska during spring and fall migrations (Gould et al. 1982). Phalaropes feed by seizing small prey while sitting on the water's surface. They often swim rapidly in small circles, which stirs their prey to the surface of the water. We collected seven red-necked phalaropes, but no red phalaropes.

Red-necked Phalarope. All seven birds collected had food in their stomachs, and together they had eaten at least seven kinds of prey. Nereid polychaetes were the most important overall; they comprised 66% of the numbers, 47% of the volume, occured in five (71%) of the seven birds, and had an IRI of 8,068 (Figure 13, Appendix Table 16). The next most important prey and their IRI values were unidentified fish (1,025), unidentified insects (680), and unidentified decapods (443).

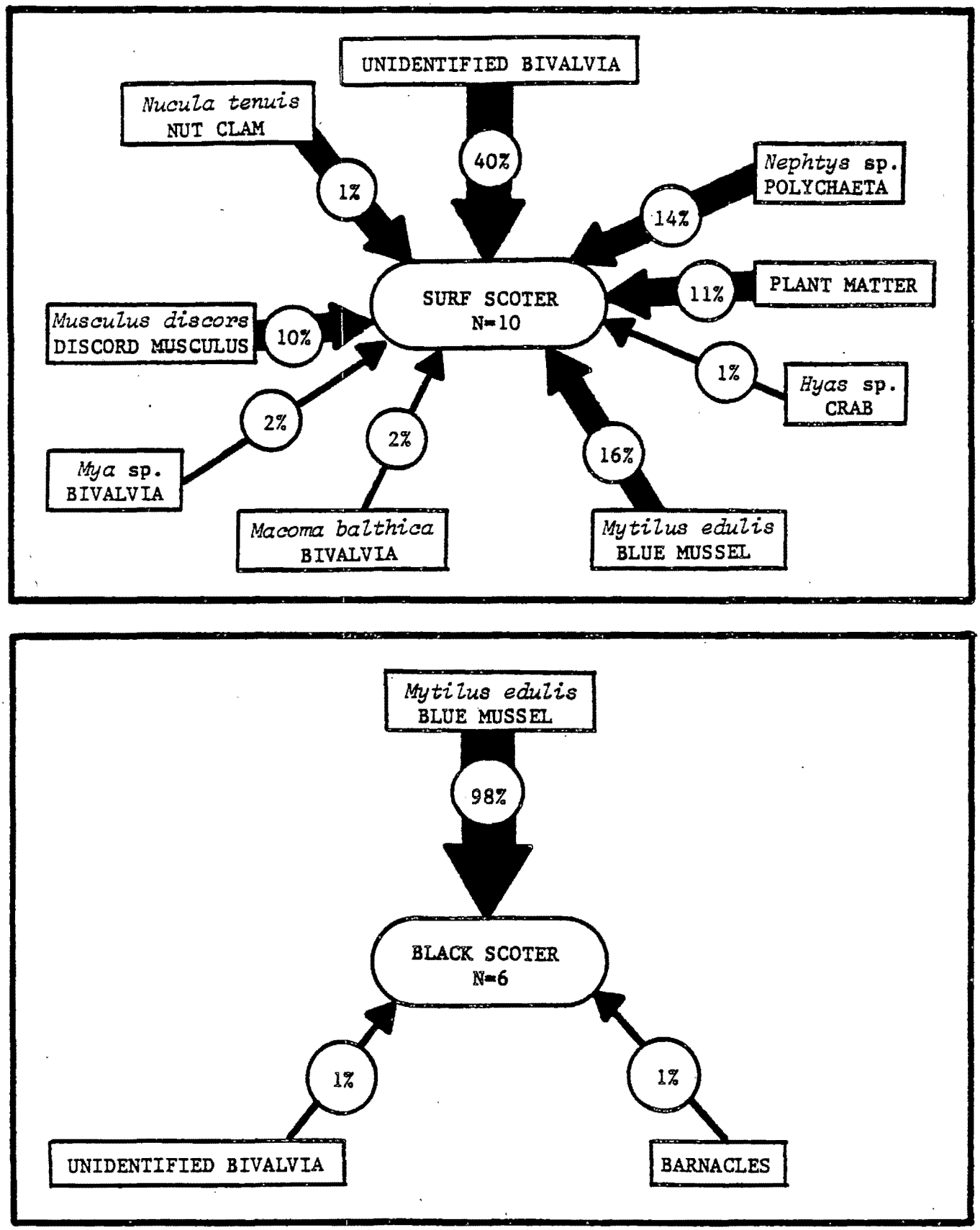


Figure 12. Food web for surf scoters (top) and black scoters (bottom), showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

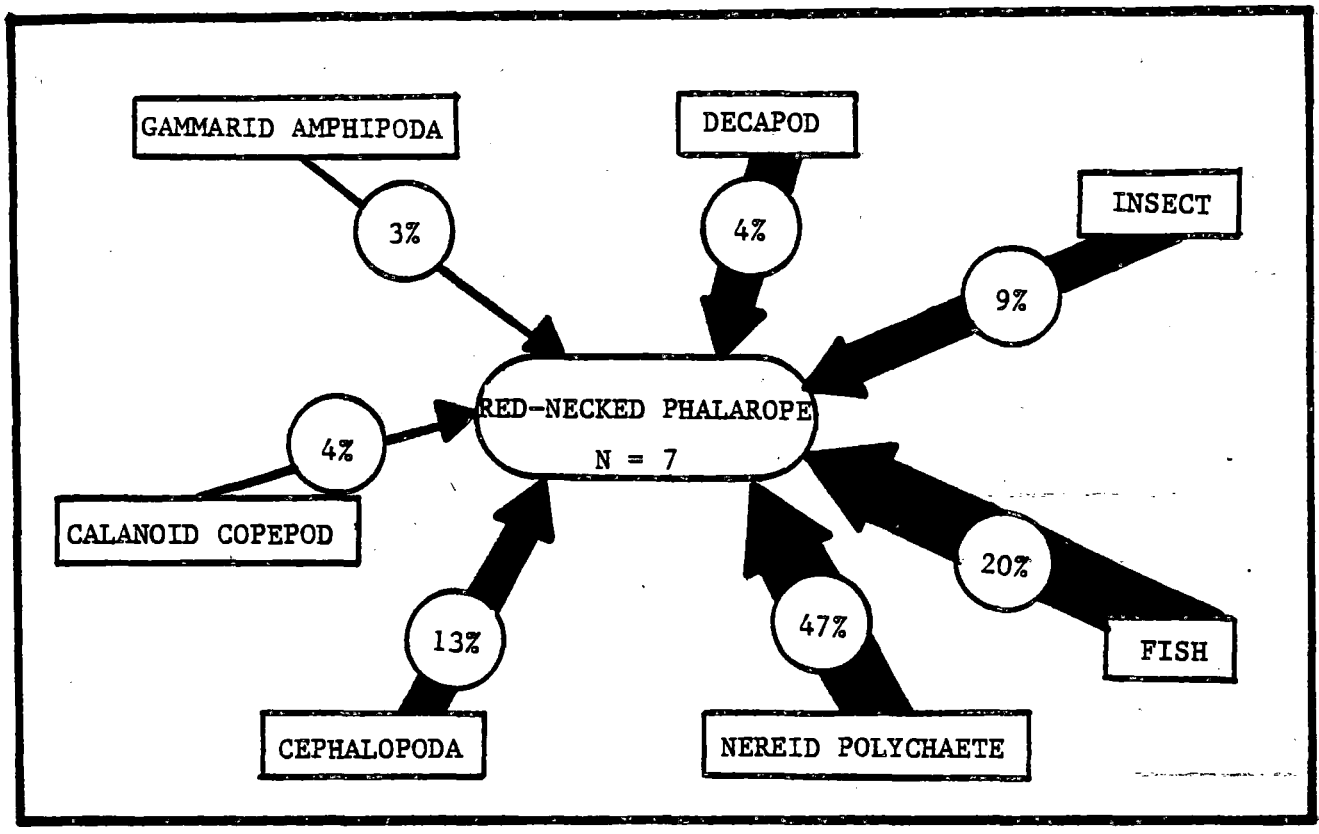


Figure 13. Food web for red-necked phalaropes, showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

Stercorariidae (Jaegers)

Jaegers are strong flying pelagic birds that generally resemble gulls in appearance. They are best known for their feeding behavior of aerial piracy (Ashmole 1971), where they chase other seabirds and force them to drop or disgorge their prey. The overall importance of this mode of feeding in relation to other feeding methods is quite unclear, however, and it may be overated.

Four species of jaegers occur in Alaskan waters from spring through early fall (Gould et al. 1982). We have a very limited amount of data for two, pomerine and parasitic jaegers (Stercorarius pomerinus and S. parasiticus): Capelin and Pacific sand lance were found in the stomachs of two pomerine jaegers, and capelin were in the stomachs of two parasitic jaegers (Appendix Table 17).

Laridae (Subfamily Larinae, Gulls)

Gulls occur in a variety of terrestrial and marine habitats in Alaska, including oceanic and coastal marine waters, and the intertidal zone (Gould et al. 1982). Most species for which we have dietary data occur in Alaskan waters year round, although some display considerable seasonal shifts in distribution. Gulls are well known as scavengers, but the importance of this mode of feeding may be over rated (Pierotti, in press). Gulls also feed by surface seizing, dipping, piracy, and intertidal foraging (Ashmole 1971).

We have data for eight of the 17 species of gulls which have occurred in Alaska (Kessel and Gibson 1978): Glaucous gull, Larus hyperboreus; glaucouswinged gull, L. glaucescens; herring gull, L. argentatus; mew gull, L. canus; Bonaparte's gull, L. philadelphia; black-legged kittiwake, Rissa tridactyla; red-legged kittiwake, R. brevirostris; and, Sabine's gull, Xema sabini. Sample sizes for glaucous-winged gulls and black-legged kittiwakes are in the 100's, but range only from two to 14 for the other six species.

Glaucous Gull. Six of seven glaucous gulls collected in the Bering Sea had food in their stomachs, and together they had eaten a minimum of five species of prey. Decapod crustaceans comprised 78% of the total prey volume and had an IRI of 1,324 (Figure 14, Appendix Table 18). Unidentified fish comprised another 14% of the volume and had an IRI of 240. Other prey, whose IRI values ranged from 207 to 415, included gammarid amphipods, dipteran flies, and unidentified salmonid fishes and small mammmals.

Glaucous-winged Gull. Sixty-eight adult birds were collected for feeding studies, and 66 (97%) of these had food in their stomachs. A minimum of 23 species of prey was found. The general category of prey most prevalent was fish. Total fish had an IRI of 5,667 and made up 95% of prey numbers and 61% of the volume (Appendix Table 19). Unidentified fish had an IRI of 4,484 and they comprised 29% of the volume. Identifiable fish included capelin (IRI 165, vol 12%) and Pacific sand lance (IRI = 80, vol = 10%). There were no walleye pollock in the stomachs.

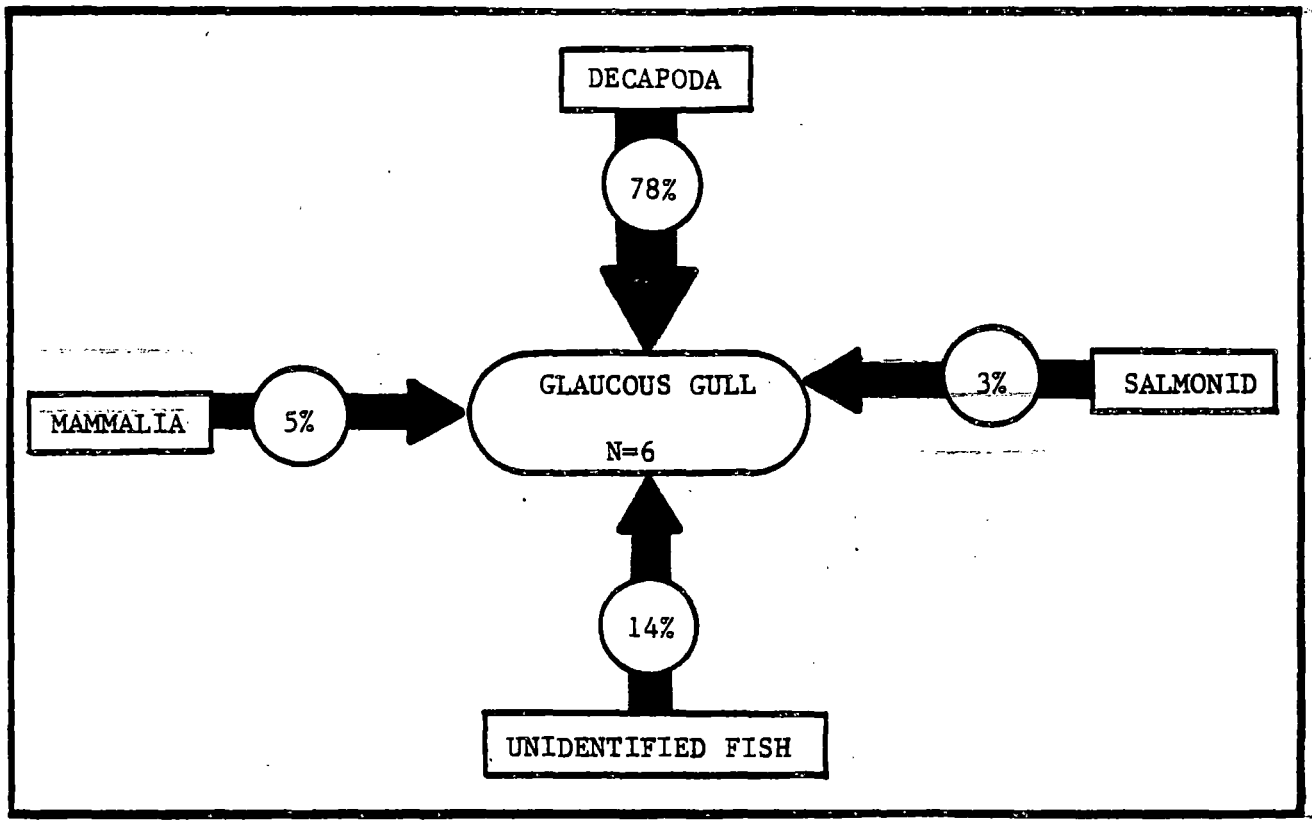


Figure 14. Food web for glaucous gulls, showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

One bird had eaten an ancient murrelet (Synthliboramphus antiquus) chick that accounted for 19% of total prey volume. Other kinds of prey were relatively insignificant to adult gulls; these included pelagic polychaetes, gastropods, chitons, bivalves, pelagic and intertidal crustaceans, flies, and sea urchins (Figure 15, Appendix Table 19).

Food samples from sub-adult glaucous-winged gulls totaled 157, and included 115 regurgitations from nestlings, and stomach contents from 42 flying birds. Data from these samples are pooled for this analysis. Twenty-four (57%) of the 42 flying young had food in their stomachs (Appendix Table 20).

Fish predominated in the diet of sub-adults as well as adults; their IRI's and % volumes were: Total fish (4,841, 87%); unidentified fish (2,260, 30%); sand lance (1,466, 35%); and, capelin (1,096, 19%). Fish of minor importance to sub-adult birds included walleye pollock, Pacific sandfish and unidentified gunnels (Figure 15, Appendix Table 20). Blue mussels had an IRI of 108 and comprised 5% of the volume. Other prey of minor importance included polychaetes, gastropods, chitons, bivalves, pelagic and intertidal crustaceans, flies, sea stars and sea urchins.

Herring Gull. Five adult herring gulls all had food in their stomachs, which included at least four species of prey. Four of the birds were collected in the northeast Gulf of Alaska in fall, and one was collected in lower Cook Inlet in summer. Unidentified fish and gooseneck barnacles (lepadidae) were the most important prey, with the latter accounting for 62% of total prey volume (Figure 16, Appendix Table 21). Other prey included unidentified bivalves and decapods, and the shrimp Crangon septemspinosa.

Mew Gull. Thirteen adults were collected; 11 (85%) of these had food in their stomachs, which included at least 10 prey species. The most important general category of prey was crustaceans, which had an IRI value of 6,152 and comprised 80% of the volume (Figure 16, Appendix Table 22). Total fish was of secondary importance (IRI = 549; vol = 17%). The most important species of prey was Crangon septemspinosa (IRI = 442, vol = 22%). Pacific sand lance comprised 10% of the volume. Other prey included unidentified polychaetes, gastropods, bivalves, dipteran and tipulid flies, and gadid fishes.

Food Web Relationships Among the Larger Larus Gulls. Table 3 & Figure 17 compare the relative importance of the different kinds of prey among the four larger species of Larus gulls. Fish was by far the most important group of prey; the birds ate at least eight species in seven families. Each gull species had at least one species of fish with an importance level of two or more in its diet. Capelin were quite important to both adult and sub-adult glaucous-winged gulls, but they were not eaten by the other gulls. Sand lance were important to glaucous-wings, particularly sub-adults, and to mew gulls. Other identifiable fish were generally of little importance to only one or two gull species (Table 3). Unidentified fish occured in each of the four species at importance level two or three.

Other kinds of prey were generally less important to the gulls than

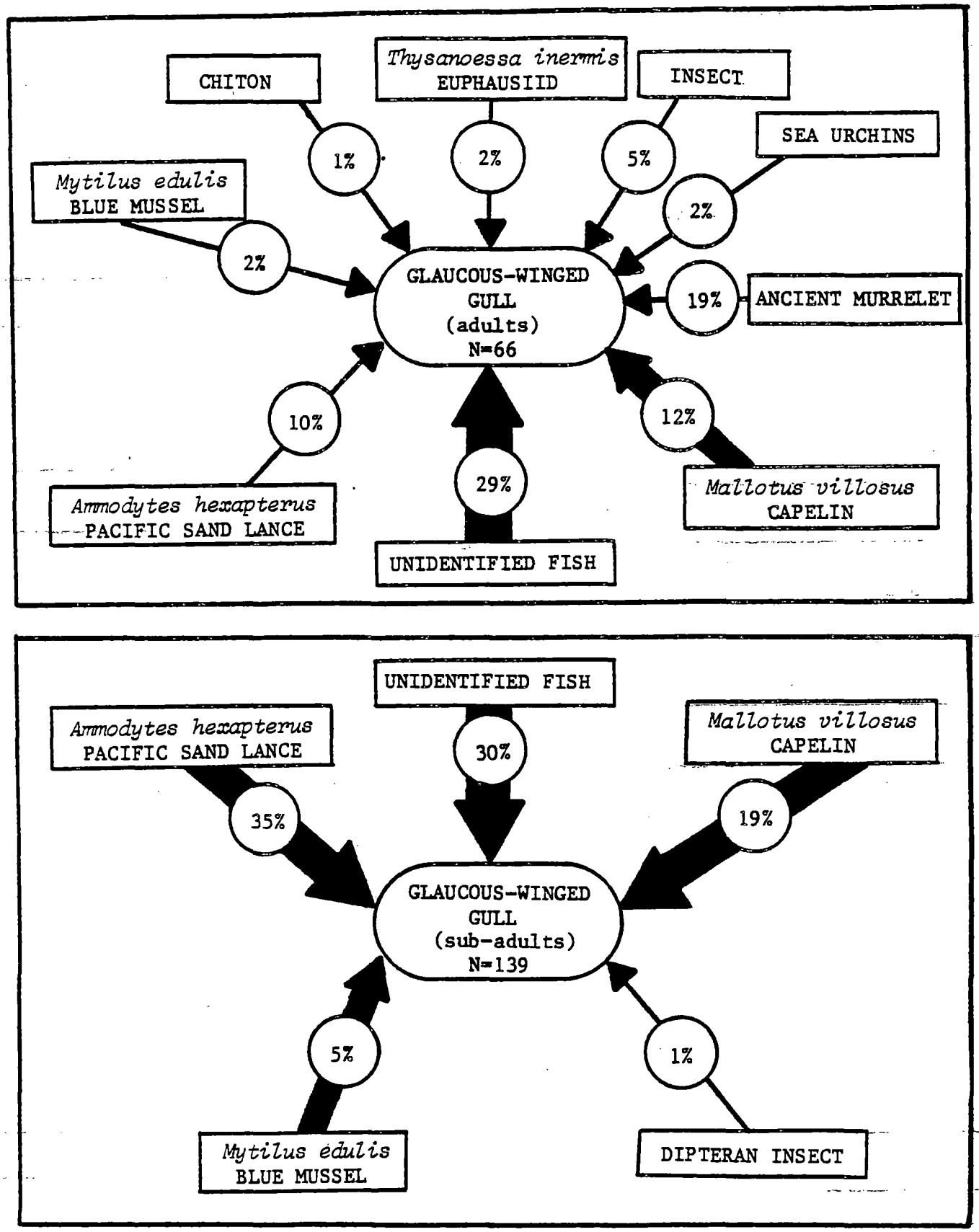


Figure 15. Food webs for adult (top) and sub-adult (bottom) glaucous-winged gulls, showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

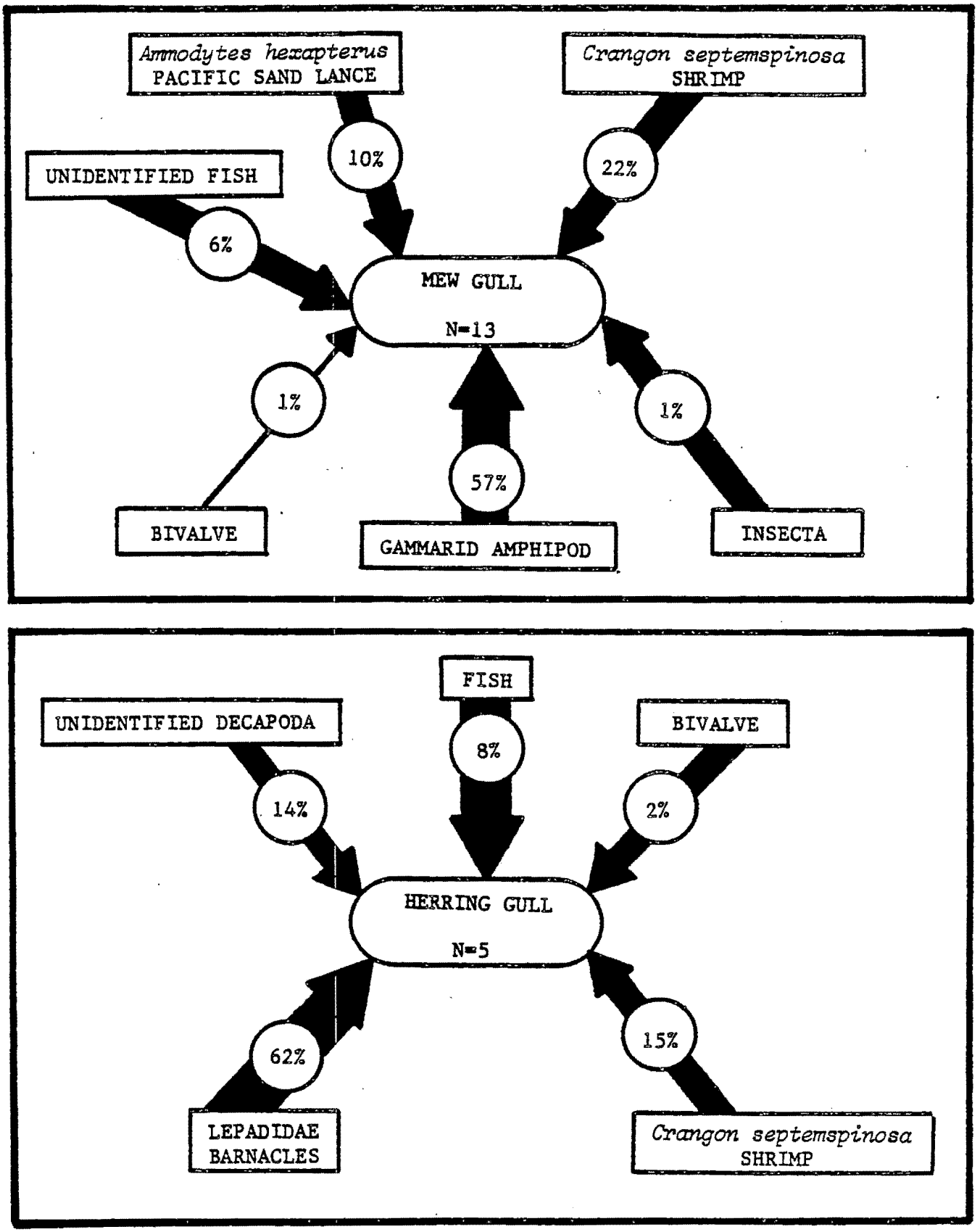


Figure 16. Food web for mew (top) and herring gulls (bottom), showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

Table 3. Comparative importance of prey to the larger Larus gulls, based on data pooled from food samples from birds in Alaskan waters. Importance levels of prey based on their IRI values: 0-9 = trace(tr); 10-99 = 1; 100-999 = 2; 1,000+ = 3.

PREY NAME	Importance of Prey to Gull Species				
	Glaucous	Glaucous-winged		Herring	Mew
		adult	sub-ad.		
	N = 7	N = 68	N = 157	N = 5	N = 13
POLYCHAETA					
Opheliidae	-	-	tr	-	-
Nereidae	-	tr	-	-	-
Unidentified	-	-	-	-	tr
GASTROPODS					
Acmaeidae (Limpet)	-	-	tr	-	-
Colisella pelta Limpet	-	tr	-	-	-
Littorina sitkana Sitka Periwinkle	-	tr	-	-	-
Buccinum baeri Baer's Buccinum	-	tr	-	-	-
Unidentified	-	-	tr	-	1
CHITONS					
Katharina tunicata Black Katy Chiton	-	tr	tr	-	-
Unidentified	-	1	tr	-	-
BIVALVES					
Mytilus edulis Blue Mussel	-	1	2	-	-
Siliqua sp. Razor Clam	-	-	tr	-	-
Hiatella arctica Arctic Saxicave	-	-	tr	-	-
Clinocardium sp. Cockle	-	tr	-	-	-
Unidentified	-	tr	tr	2	1
CRUSTACEANS					
Barnacles					
Lepadidae	-	-	-	3	-
Balanidae	-	tr	-	-	-
Amphipods					
Unident. Gammaridea	-	-	tr	-	3
Unident. Gammaridae	2	-	-	-	-
Valviferan Isopod	-	tr	-	-	-
Euphausiids					
Thysanoessa inermis	-	1	-	-	-
T. raschii	-	tr	-	-	-

Table 3. Comparative Importance of prey to Larus gulls, page 2 of 2

PREY NAME	Importance of Prey to Gull Species				
	Glaucous	Glaucous-winged adults	Glaucous-winged sub-ad.	Herring	Mew
Shrimps					
Crangon septemspinosa	-	tr	-	2	2
Pandalus borealis Pink Shrimp	-	tr	-	-	-
Crabs					
Telmessus cheiragonus Helmet Crab	-	tr	tr	-	-
INSECTS					
Dipteran Flies	2	tr	1	-	tr
Tipulid Flies	-	-	-	-	tr
Unidentified	-	1	-	-	2
ECHINODERMS					
Leptasterias hexactis Brooding Sea Star	-	-	tr	-	-
Amphipolis pugetana Brittle Star	-	-	tr	-	-
Strongelocentrotus droebachiensis Green Sea Urchin	-	1	tr	-	-
FISHES					
Salmonidae	2	-	-	-	-
Mallotus villosus Capelin	-	2	3	-	-
Hypomesus pretiosus Surf Smelt	-	tr	-	-	-
Theragra chalcogramma Walleye Pollock	-	-	tr	-	-
Gadidae, Unidentified	-	-	tr	-	tr
Hexagrammidae	-	tr	-	-	-
Trichodon trichodon Pacific Sandfish	-	-	tr	-	-
Pholidae (Gunnel)	-	-	tr	-	-
Ammodytes hexapterus Pacific Sand Lance	-	1	3	-	2
BIRDS					
Synthliboramphus antiquus Ancient Murrelet	-	1	-	-	-
Cepphus columba Pigeon Guillemot	-	-	tr	-	-
MAMMAL, Unidentified	2	-	-	-	-

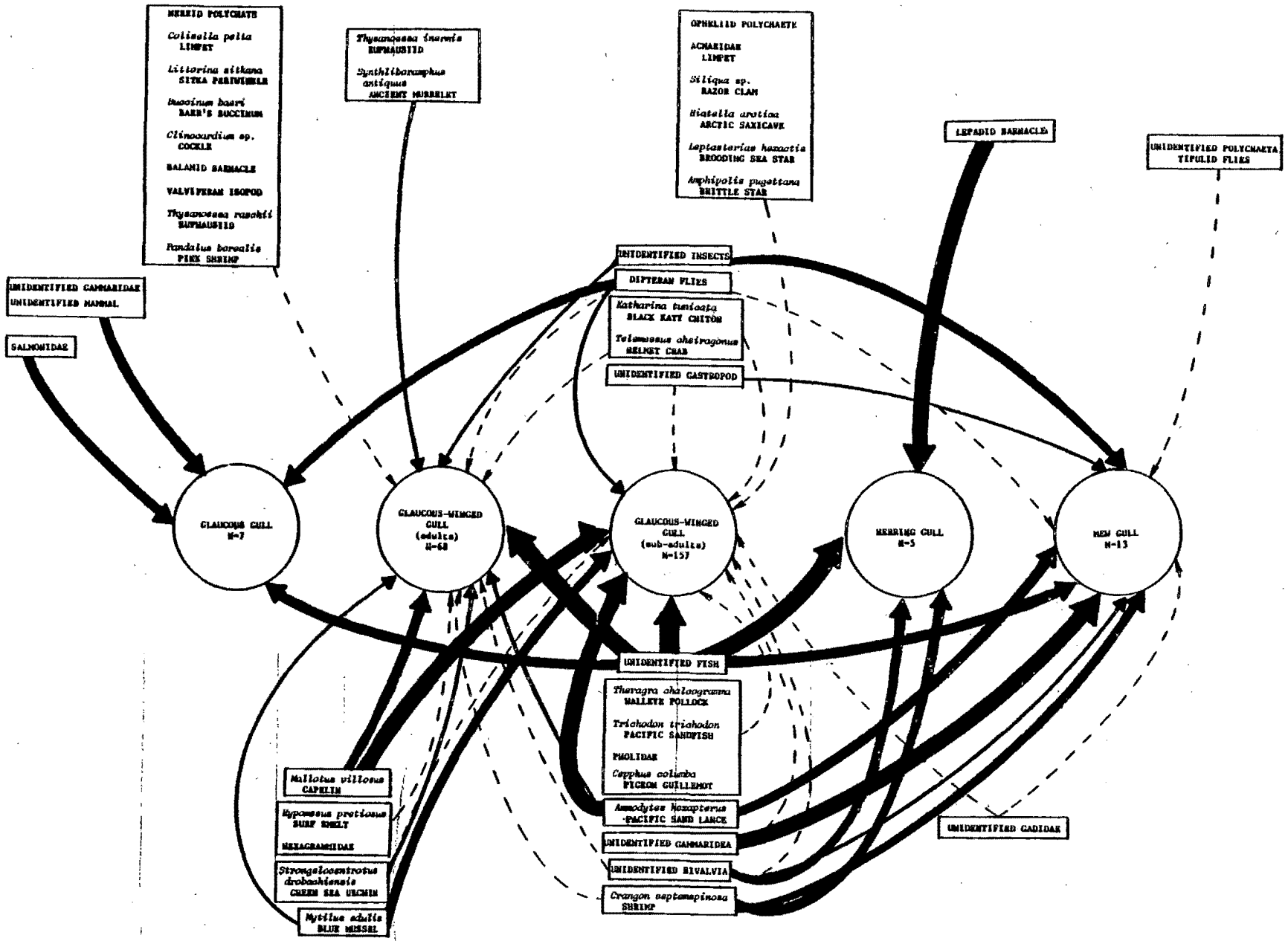


Figure 17. Food web relationships among the larger Larus gulls, based on data pooled from all years, seasons and regions. See Fig. 4 caption.

fish, and they were usually in the stomachs of only one or two gull species. Exceptions were gammarid amphipods and dipteran flies, which were eaten by all species except herring gulls, and the shrimp Crangon septemspinosa, which was eaten by all species except glaucous gulls.

Bonaparte's Gull. Four Bonaparte's gulls had food in their stomachs; all were collected at Nelson Lagoon, located near Port Moller on the north side of the Alaska Peninsula. Only two kinds of prey were in their stomachs: the shrimp Crangon septemspinosa and unidentified gammarid amphipods (Appendix Table 21). In view of the abundance of the gammarid amphipod Anisogammarus pugettensis at Nelson Lagoon (Petersen 1980), those in the gulls likely included this species.

Black-legged Kittiwake. Birds collected for feeding studies included 328 adults; 273 (83%) of these had food in their stomachs, which included a minimum of 23 species of prey. Fish was the most important general category of prey, accounting for 88% of the volume, 32% of the numbers of all prey, and had an IRI of 4,274 (Appendix Table 23). Crustaceans were of moderate importance overall (IRI = 406), and other groups of prey were of only minor or trace importance.

Capelin was decidedly the most important species of prey; it comprised 15% of the numbers, 51% of the volume, and occured in 36% of all adult birds with food in their stomachs. Together, these values resulted in an IRI of 2,354 (Appendix Table 23). Other prey species were relatively less important, but the most important of these were Pacific sand lance (IRI 329, vol 17%), and the the euphausiid Thysanoessa inermis (IRI 313, vol 5%) (Figure 18, Appendix Table 23). Walleye pollock also made up 5% of the volume, but low numbers (1%) and frequency of occurence (5%) resulted in a low IRI value of 32.

Minor and trace prey included pelagic polychaetes, pteropods, chitons, blue mussels, unidentified cephalopods, barnacles, copepods, gammarid and hyperiid amphipods, shrimp, crabs, Pacific cod and Pacific sand fish (Figure 18, Appendix Table 23).

Food samples from sub-adult birds totaled 215, and included 129 regurgitations from nestlings and stomach contents from 86 flying young. Fifty-five (64%) of the latter had empty stomachs (Appendix Table 24). Data from all of these samples are pooled here. The same general dietary trends observed for adult birds were repeated, with the notable exception that Pacific sand lance and capelin were both major prey of the sub-adults (Figure 18). Sand lance had an IRI of 4,127, accounted for 44% of numbers, 39% of volume and occured in 50% of all sub-adult food samples (Appendix Table 24). Respective data for capelin are IRI 2,697, numbers 32%, volume 36% and frequency of occurence 40%. All other prey were of only minor or trace importance.

Red-legged Kittiwake. Three birds were collected, two from the southeastern Bering Sea, and the third a few miles south of Adak Island (Aleutians) in the North Pacific Ocean. All had food in their stomachs. Unidentified fish comprised 74% of the combined volume of stomach contents, and Pacific ambereye shrimp and unidentified decapods (probably shrimp) each accounted for 12.5% of the volume. Unidentified cephalopod

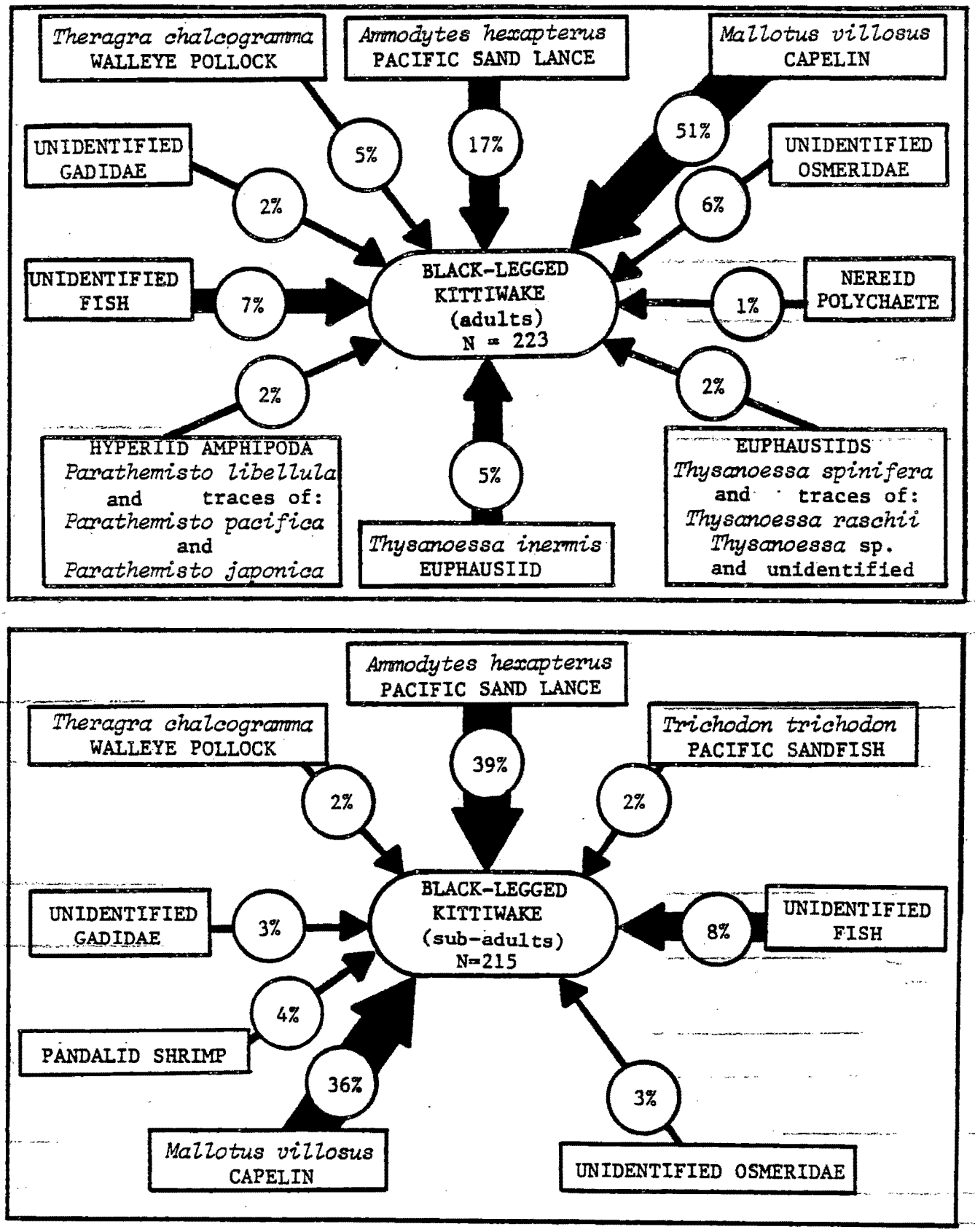


Figure 18. Food web for adult (top) and sub-adult (bottom) black-legged kittiwakes, showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

beaks and the euphausiid Thysanoessa inermis were present in small amounts (Figure 19, Appendix Table 25). Walleye pollock and lantern fishes (myctophids), common in the diet of birds from near the Pribilof Islands (Hunt et al. 1981), were not present in these birds.

Food Web Relationships Among Kittiwakes. The importance of different prey species to adult and sub-adult black-legged kittiwakes, and to red-legged kittiwakes are compared in Table 4 and Figure 20. The small sample size for red-legs (N = 3) makes such a comparison quite tentative, however. Also, two of the red-legs were from the southeastern Bering Sea, while most of the black-legs were from the Gulf of Alaska.

The euphausiid Thysanoessa inermis was the only prey eaten by both age groups of black-legged kittiwakes, and by red-legged kittiwakes. In general, fish was the most important kind of prey to kittiwakes. Capelin, walleye pollock and sand lance were important to adult and sub-adult black-legged kittiwakes, but were not present in the stomachs of the three red-legs. However, pollock was very important in the diet of nestling red-legged kittiwakes in the Pribilof Islands (Hunt et al. 1981).

Sabine's Gull. One adult bird collected in the southeastern Bering Sea had pieces of avian egg shell in its stomach.

Laridae (Terns, Subfamily Sterninae)

Terns exist in a variety of marine habitats in Alaska in spring and summer, but they occur mostly in nearshore and protected waters close to their breeding colonies (Gould et al. 1981). Terns feed mostly by plunging beneath the water's surface after they have spotted prey while flying or hovering above the water (Ashmole 1971). We have data on the feeding habits of adult and subadult arctic terns (Sterna paradisea) and Aleutian terns (S. aleutica). Most food samples were collected in the vicinity of Kodiak Island.

Arctic Tern. Of 36 adult birds collected, 34 (94%) had food in their stomachs, which included a minimum of eight prey species. Crustaceans, primarily euphausiids, were the most important prey group; they comprised 98% of the numbers and 82% of the volume of all prey, and had an IRI of 9,511 (Appendix Table 26).

The euphausiid Thysanoessa inermis was decidedly the most important prey species to adult arctic terns. It comprised 93% of prey numbers, 82% of the volume, and occured in 53% of the stomachs, which resulted in an IRI of 8,930 (Figure 21, Appendix Table 26). T. spinifera was of moderate importance (IRI 211). Fish in the terns' diet included capelin (IRI 130) and Pacific sand lance (IRI 126). Prey of minor or trace importance included T. raschii, the hyperiid amphipod Parathemisto libellula (from birds from the Bering sea), unidentified decapod crustaceans and nereid polychaetes.

Thirty-two food samples from sub-adult birds included 20 regurgitations from nestlings at Kodiak Island and 12 stomachs samples from flying birds; 11 (91.7%) of the latter had food in their stomachs. In marked

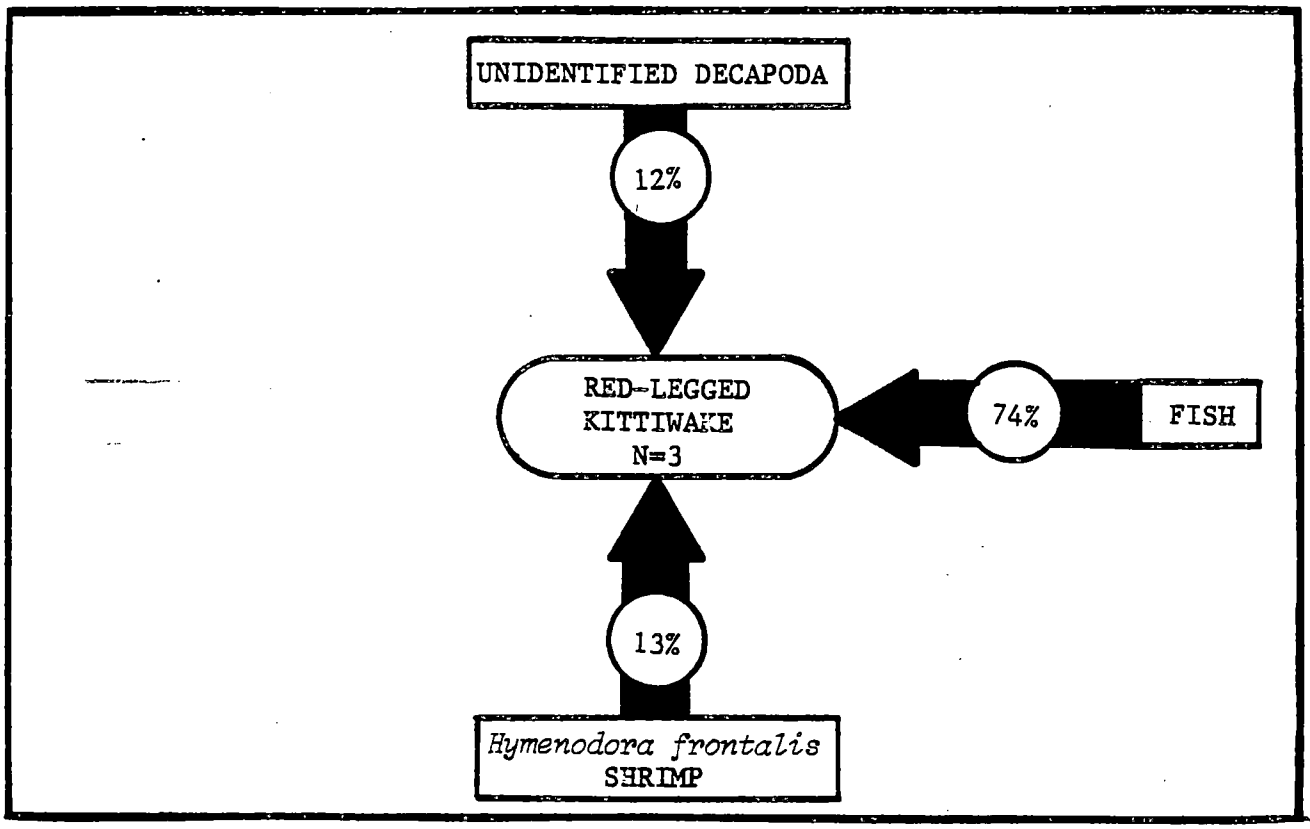


Figure 19. Food web for red-legged kittiwakes, showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

Table 4. Comparative importance of prey to kittiwakes, based on data pooled from food samples from birds in Alaskan waters. Importance levels of prey based on their IRI values: 0-9 = trace(tr); 10-99 = 1; 100-999 = 2; 1,000+ = 3.

PREY NAME	Importance of Prey to Bird Species		
	Black-legged Kittiwake (adults) N = 273	Black-legged Kittiwake (sub-adults) N = 184	Red-legged Kittiwake (adults) N = 3
POLYCHAETES, Nereidae	1	-	-
PTEROPOD, *Limacina helicina*	tr	-	-
CHITON, *Katharina tunicata*	tr	tr	-
MUSSEL, *Mytilus edulis*	tr	-	-
CEPHALOPOD, Unidentified	tr	-	2
CRUSTACEANS			
Calanoid Copepod	tr	-	-
Ligia pallasi	-	tr	-
Paracallisoma alberti Gammaridean Amphipod	1	-	-
Hyperiid Amphipods			
Parathemisto libellula	1	-	-
P. pacifica	tr	-	-
P. japonica	tr	-	-
Decapods			
Hymenodora frontalis Pacific Ambereye Shrimp	-	tr	3
Pandalus borealis Pink Shrimp	-	tr	-
Pandalopsis dispar Sidestripe Shrimp	tr	tr	-
Cancer sp. (Crab)	tr	-	-
Unidentified Cancrid Crab	-	tr	-
Euphausiids			
Thysanoessa inermis	2	tr	2
T. raschii	tr	-	-
T. spinifera	1	-	-
Barnacle	tr	-	-
INSECT, Dipteran Fly	-	tr	-

Table 4. Comparative importance of prey to kittiwakes, page 2 of 2

PREY NAME	Importance of Prey to Bird Species: Black-legged Kittiwake (adults) N = 273	Black-legged Kittiwake (sub-adults) N = 184	Red-legged Kittiwake (adults) N = 3
FISH			
Clupea harengus Pacific Herring	tr	-	-
Onchorhynchus gorbuscha Pink Salmon	-	tr	-
O. nerka Red Salmon	-	tr	-
Mallotus villosus Capelin	3	3	-
Gadus macrocephalus Pacific Cod	tr	tr	-
Theragra chalcogramma Walleye Pollock	1	1	-
Microgadus proximus Pacific Tomcod	-	tr	-
Trichodon trichodon Pacific Sandfish	tr	1	-
Ammodytes hexapterus Pacific Sand Lance	2	3	-
Unidentified	2	2	3

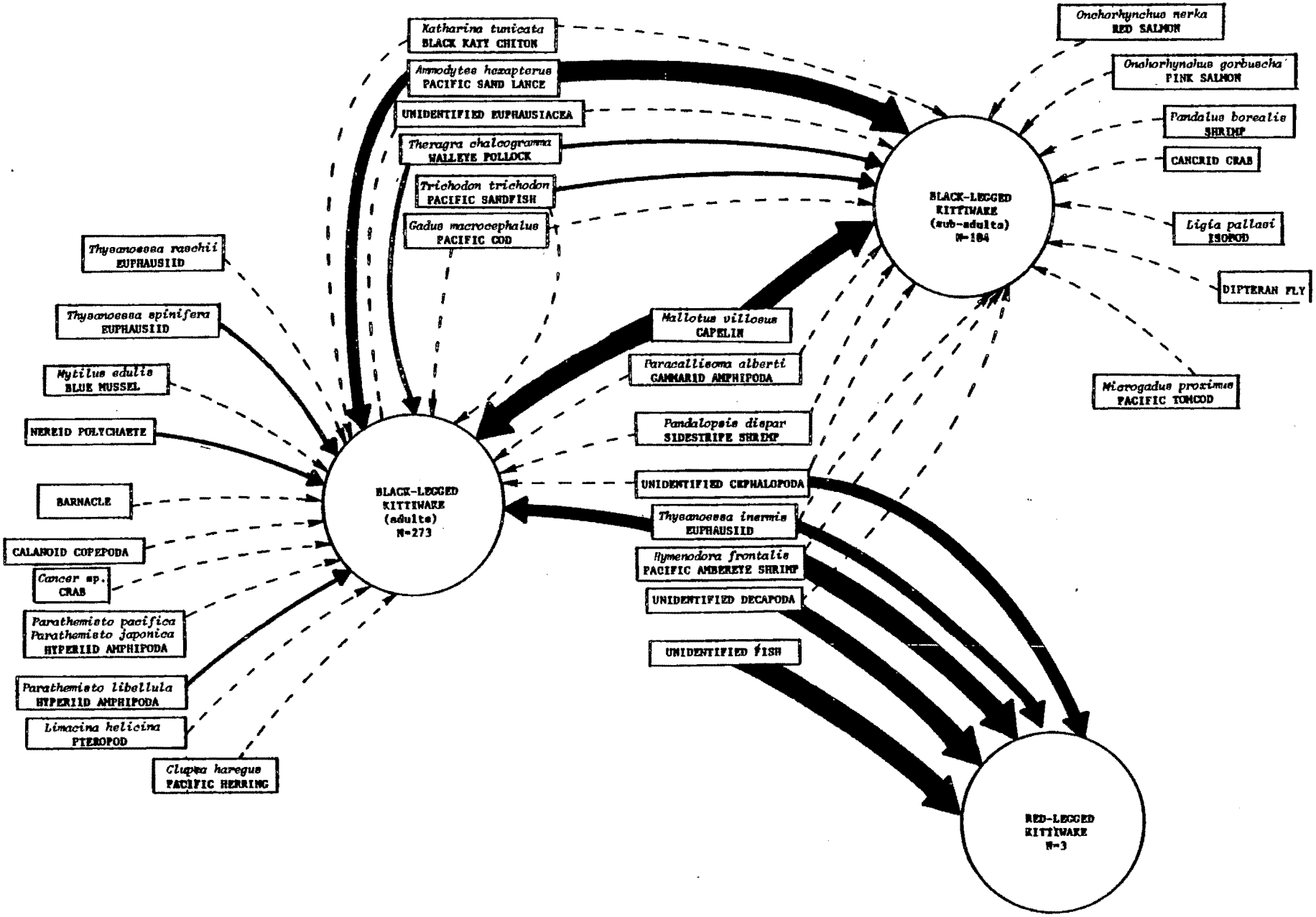


Figure 20. Food web relationships among adult and sub-adult black-legged kittiwakes, and red-legged kittiwakes, based on data pooled from all years, seasons, and regions. See Fig. 4 caption.

contrast to the adults, the diet of sub-adults was exclusively fish (Figure 21, Appendix Table 27). At least six species were included in the diet, and of these, capelin was the most important. It accounted for 50% of prey numbers, 40% of their volume, and it occured in 48% of the samples, for an IRI of 4,368. Sand lance was also important to nestling arctic terns, and had an IRI of 1,745. The other fish, all of minor importance, included rock and white-spotted greenlings, Pacific sandfish, and prowfish.

Aleutian Tern. At least eight prey species had been eaten by the 13 adults (93% of 14 collected) with food in their stomachs. As with adult arctic terns, crustaceans were the most important major prey taxon. Their IRI was 3,590, and crustaceans comprised 89% of prey numbers, and 66% of the volume (Appendix Table 28). Fish were relatively more important than they were to adult arctics, however, and had an IRI of 1,186.

The euphausiid Thysanoessa inermis was the most important prey species; it accounted for 88% of the numbers, 55% of the volume and it occured in 23% of the stomachs. Sand lance (IRI 521), capelin (IRI 137) and unidentified fish (IRI 157) were relatively less important (Figure 22, Appendix Table 28). The isopod crustacean Pentidotea sp. (IRI 87) comprised 10% of the volume. Other prey, all of minor or trace importance, included nereid polychaetes, the isopod Synidotea sp., and, unidentified insects and gadid fishes.

Forty-eight food samples were collected from sub-adult birds. These included 43 nestling regurgitations from Kodiak Island, and stomachs from five flying birds; four of the latter had food in their stomachs. Subadults had eaten at least eight species of prey (Figure 22, Appendix Table 29). Except for traces of Thysanoessa euphausiids and unidentified insects, the diet of nestling Aleutian terns was exclusively fish, which accounted for 97% of prey volume and 99% of the numbers, and had an IRI of 2,273. Unidentified fish had an IRI of 1,524, and sand lance, the most important prey species, had an IRI of 335. Other fish in the diet included rock greenling, Atka mackeral, silverspotted sculpin and Pacific sandfish.

In addition to the samples described above, 11 bill loads that were intended for nestlings (Appendix Table 30) had been dropped by adult birds at a nesting colony at Kodiak Island that was utilized by both species. In addition to the prey noted above for both tern species, these samples included juvenile silver salmon, surf smelt, unidentified pricklebacks, and juvenile Pacific halibut.

Food Web Relationships Between Terns. Together, the terns ate at least 22 prey species, including at least seven crustaceans, 13 fish, and one each nereid polychaete, cheliferate arthropod, and insect (Table 5, Figure 23). There was, however, relatively little overlap among the prey of terns in our samples. The euphausiid Thysanoessa inermis was quite important to adults of both tern species, while capelin and sand lance were more heavily utilized by subadults of both species than by adult terns. The rock greenling and Pacific sandfish were both of low or trace importance to sub-adults of both species. Otherwise, there was little overlap among the prey of terns in our samples.

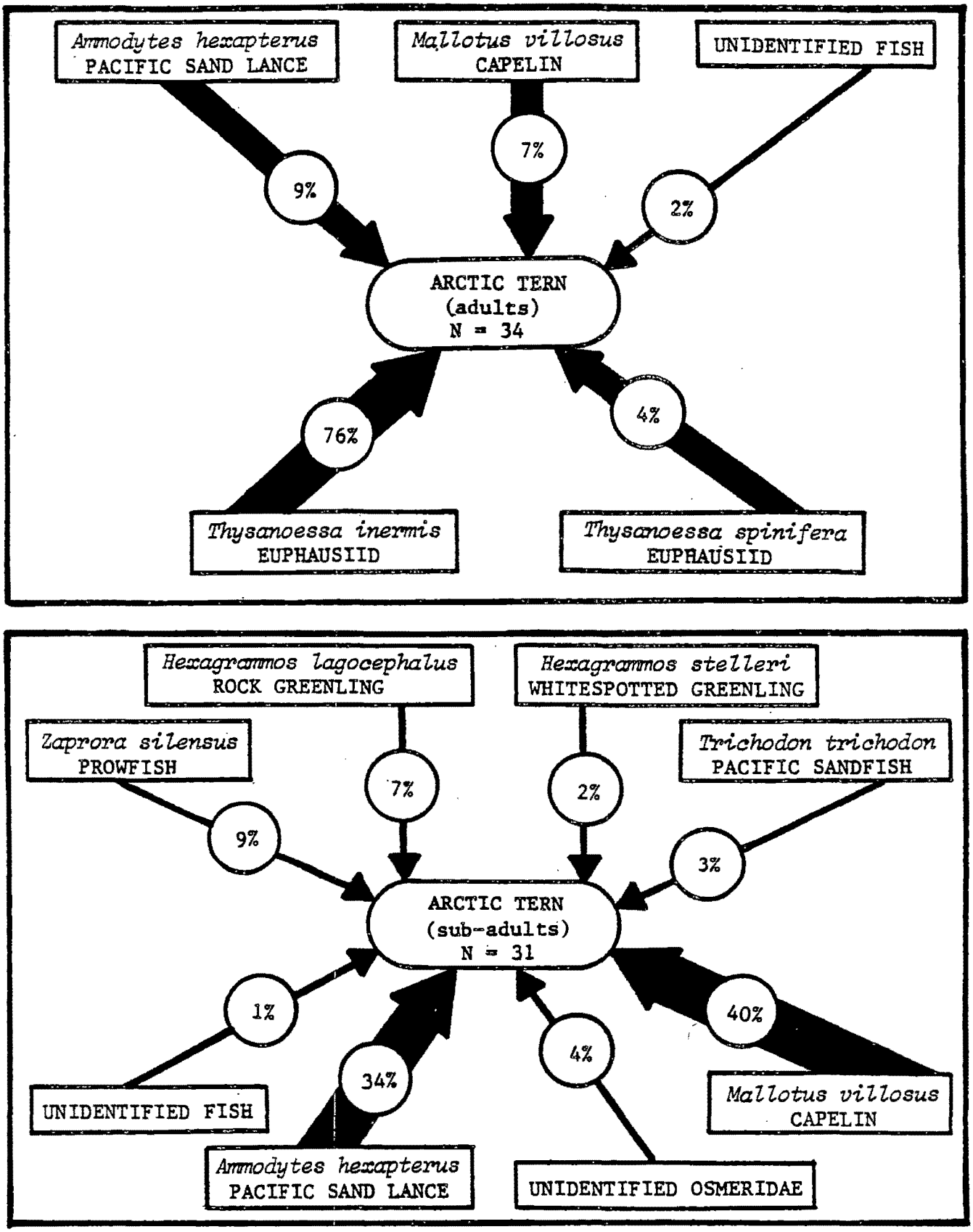


Figure 21. Food webs for adult (top) and sub-adult (bottom) arctic terns, showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

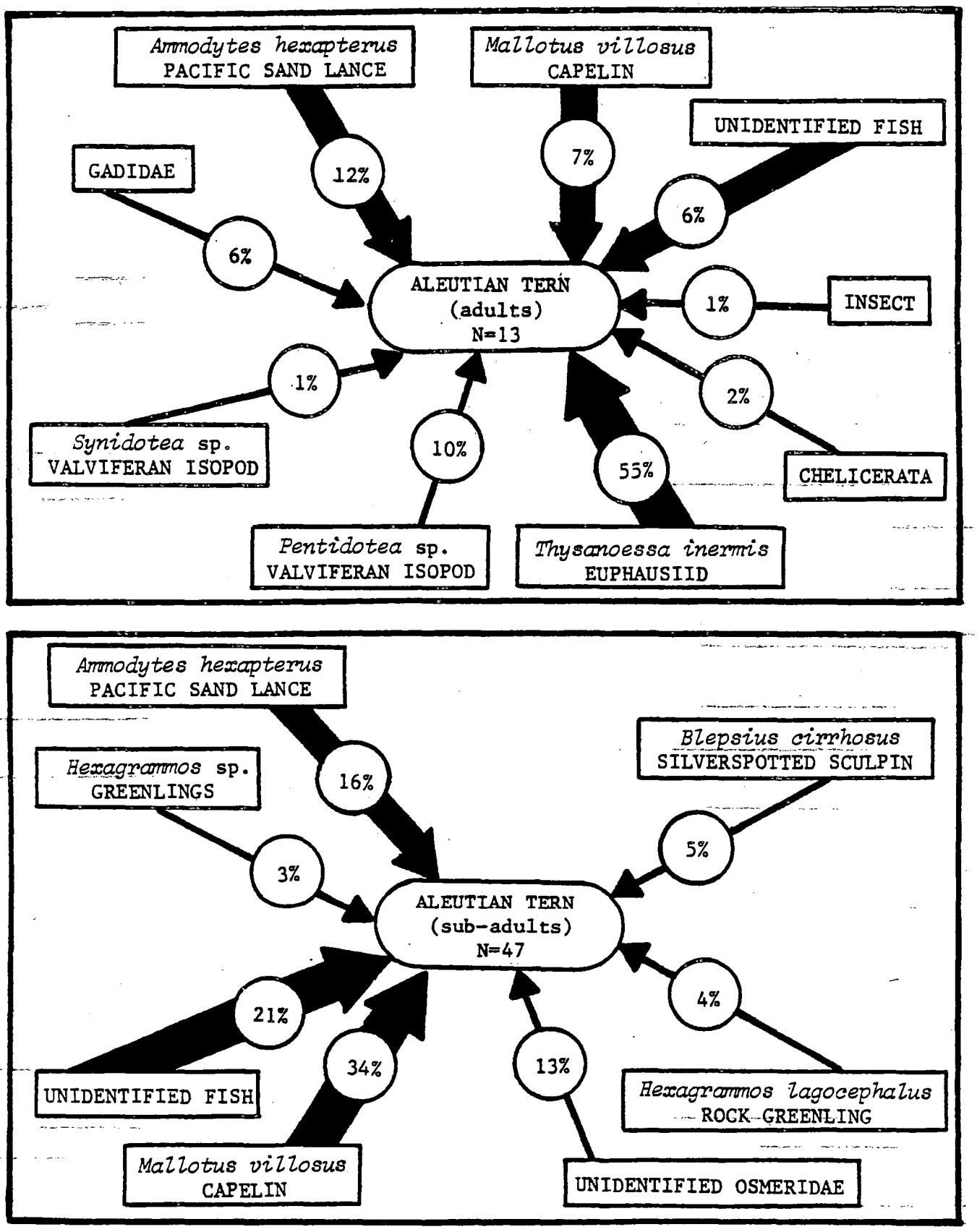


Figure 22. Food webs for adult (top) and sub-adult (bottom) Aleutian terns, showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

Table 5. Comparative importance of prey to arctic and Aleutian terns, based on data pooled from food samples from birds in Alaskan waters. Importance levels based on IRI values: 0-9 = trace(tr); 10-99 = 1; 100-999 = 2; 1,000+ = 3.

PREY NAME	Importance of Prey to Tern Species				
	Arctic		Aleutian		Either/or
	adults N = 34	sub-ad. N = 31	adults N = 13	sub-ad. N = 47	nestlings N = 11
POLYCHAETES, Nereidae	tr	-	tr	-	-
CHELICERATE ARTHROPOD	-	-	1	-	-
CRUSTACEA					
Isopods					
Synidotea sp.	-	-	1	-	-
Pentidotea sp.	-	-	1	-	-
Unidentified Decapod	tr	-	-	-	-
Parathemisto libellula Hypereiid Amphipod	tr	-	-	-	-
Euphausiids					
Thysanoessa inermis	3	-	3	-	-
T. raschii	tr	-	-	-	-
T. spinifera	2	-	-	-	-
T. sp.	-	-	-	tr	-
INSECT, Unidentified	-	-	1	tr	-
FISH					
Onchorhynchus kisutch Silver Salmon	-	-	-	-	2
Hypomesus pretiosus Surf Smelt	-	-	-	-	2
Mallotus villosus Capelin	2	3	2	3	2
Hexagrammos lagocephalus Rock Greenling	-	1	-	1	2
Hexagrammos stelleri Whitespotted Greenling	-	1	-	-	-
Pleurogrammus stelleri Atka Mackeral	-	-	-	tr	-
Blepsius cirrhosus Silverspotted Sculpin	-	-	-	1	1
Stichaeidae (Pricklebacks)	-	-	-	-	1
Trichodon trichodon Pacific Sandfish	-	1	-	tr	-
Zaprora silensus Prowfish	-	1	-	-	-
Gadidae	-	-	1	-	-
Ammodytes hexapterus Pacific Sand Lance	2	3	2	2	3
Hippoglossus stenolepis Pacific Halibut	-	-	-	-	2

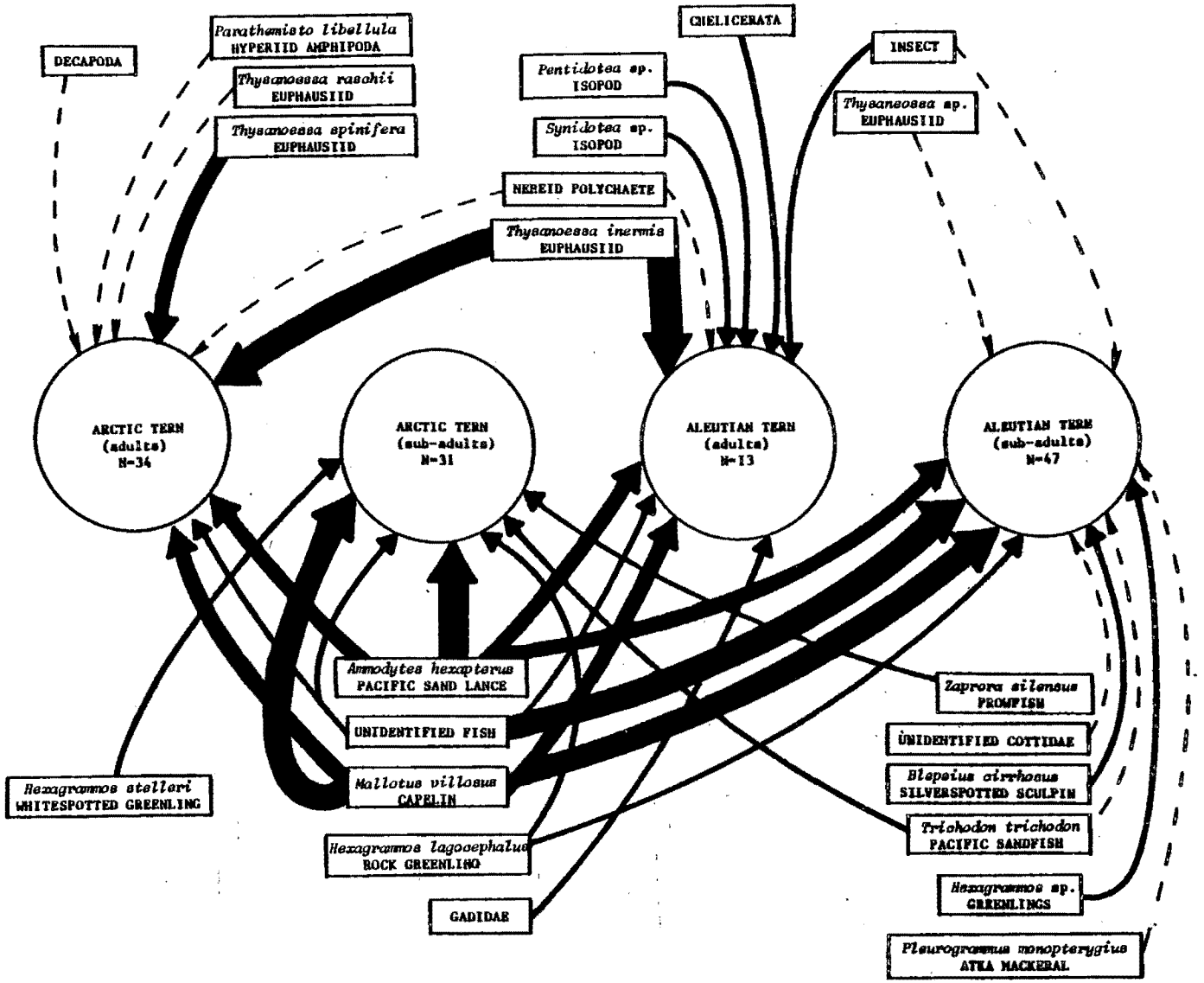


Figure 23. Food web relationships among adult and sub-adult arctic and Aleutian terns, based on data pooled from all years, seasons, and regions. See Fig. 4 caption.

Alcidae (Murres, Murrelets, Auklets, and Puffins)

The alcids are a large, diverse group of pelagic seabirds with 16 species nesting in Alaska. Members of the family forage and occur mostly over the continental shelf relatively close to land, particularly during the spring-summer nesting season (Gould et al. 1982). In winter, however, some species such as the tufted puffin (Fratercula cirrhata) range hundreds of km into the oceanic environment, far from land (Shuntov 1972; Gould et al. 1982).

Alcids range in size from the 90 g least auklet (Aethia pusilla) to the common (Uria aalge) and thick-billed murre (U. lomvia) of a kg or more. All alcids feed by pursuit diving (Ashmole 1971), and depending on species and water depth, they apparently feed throughout the water column, at depths ranging down to at least 40 m for some auklets (Bedard 1969) and to 125 m for the common murre (Gould et al. 1982). Diets indicate that some species feed on or very near the bottom (see below).

We have data on the feeding habits of the 13 following species: Common murre, thick-billed murre, pigeon guillemot (Cepphus columba), marbled murrelet (Brachyramphus marmoratus), Kittlitz's murrelet (B. brevirostris), ancient murrelet (Synthliboramphus antiquus), Cassin's auklet (Ptychoramphus aleuticus), parakeet auklet (Cyclorrhynchus psittacula), crested auklet (Aethia cristatella), least auklet, rhinoceros auklet (Cerorhinca monocerata), horned puffin (Fratercula corniculata), and tufted puffin.

Common Murre. Of 251 birds sampled, 166 (66.1%) had food in their stomachs; common murres ate at least 23 species of prey (Appendix Table 31). Overall, fish was the most important major taxon of prey; they comprised 81% of the volume and had an IRI of 2,995. Crustaceans were relatively less important (IRI 474), and polychaetes, cephalopods, insects and echinoderms were all of trace importance only.

Capelin (vol 30%, IRI 1,003) was the most important prey species, followed by Pacific sand lance (IRI 607), walleye pollock (IRI 297) and the mysid Neomysis rayii (IRI 162) (Figure 24, Appendix Table 31). The next most important prey was the euphausiid Thysanoessa inermis (IRI 41), and all other prey were of minor or trace importance only. Pandalid shrimp, including pink shrimp (Pandalus borealis), humpy shrimp (P. goniuris) and unidentified Pandalus sp., together accounted for 4% of overall diet volume.

Thick-billed Murre. Sixty-four stomach samples from thick-billed murres were obtained, and 38 (59%) of these contained food. At least 14 species of prey were present. Cephalopods were the dominant major taxon, and accounted for 47% of the numbers, 26% of the volume, and they occured in 51% of the stomachs with food, for an IRI of 3,765 (Appendix Table 32). In comparison, fish comprised 44% of the volume (IRI 1,181) and crustaceans 30% of the volume (IRI 678).

One or more species of cephalopods certainly would have been the most important species of prey of Thick-billed Murres, if they had been identifiable. The hyperiid amphipod Parathemisto libellula, however, was the

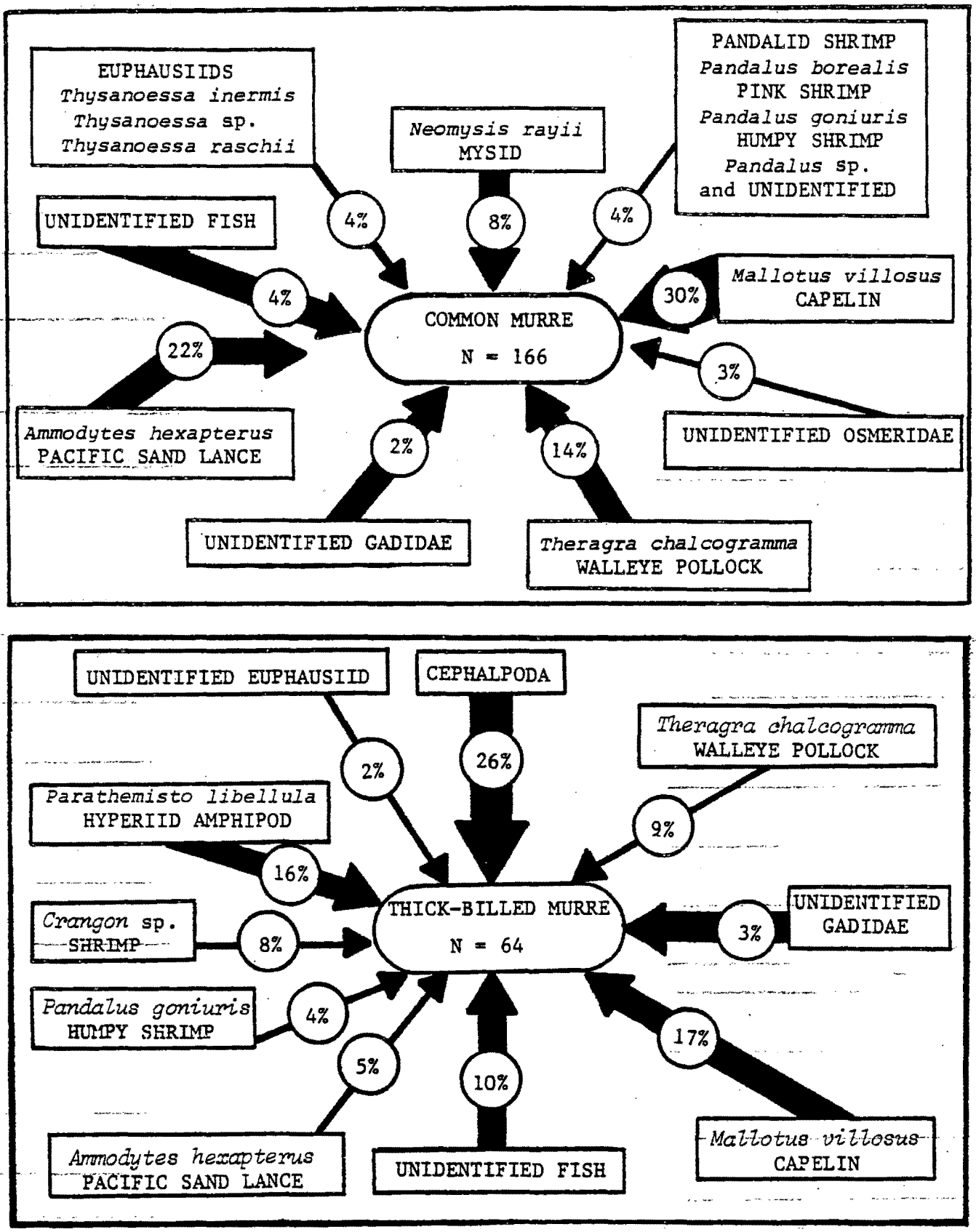


Figure 24. Food webs for common (top) and thick-billed murres (bottom), showing main prey items as indicated by data pooled from all years, seasons and regions; see Fig. 2 caption.

most important species of identifiable prey (volume 16%, IRI 438). Capelin (volume 17%, IRI 156) and gadid fishes as a group (volume 13%, IRI 176) were the next most important prey (Figure 24, Appendix Table 32).

Food Web Relationships Between the Murres. A comparison of the importance of different prey to the two murres (Table 6) may reflect geographic and seasonal differences as much as interspecific ones. It is seen, however, that capelin, Pacific sand lance and walleye pollock were the only prey that were of more than trace or minor importance to both species. In general, fish were most important to common murres, and cephalopods, fish and crustaceans were important to thick-billed murres.

Pigeon Guillemot. Sixty-four guillemots were collected, and 58 (91%) had food in their stomachs; they had eaten at least 29 species of prey. Major prey taxa were dominated by fishes (numbers 24%, volume 60%, IRI 3,176) and crustaceans (numbers 67%, volume 37%, IRI 2,336) (Appendix Table 33).

The diet of guillemots was characterized by a variety of prey species, none of which were dominant (Figure 25, Appendix Table 33). The red rock crab (Cancer oregonensis) had the highest IRI value (516); it comprised 17% of prey numbers, but only 6% of the volume. Capelin made up 19% of the prey volume, but only 4% of the numbers (IRI 277), and Pacific sandfish accounted for 12% of the volume and 3% of the numbers (IRI 102). Shrimps ($\leq$ 10 spp.) accounted for 20% of the prey volume (IRI 282) and total crabs ($\leq$ 5 spp.) made up 11% of the volume (IRI 788). Shrimps occured in only 5% of the stomachs with food, however, but crabs were found in 22% of the stomachs. Other prey, all of minor or trace importance, included nereid polychaetes, the gastropod Lacuna vincta, venerid and Musculus sp. bivalves, mysids, gammarid amphipods, and at least five species of fish in addition to capelin and Pacific sandfish.

Marbled Murrelet. Of 158 birds collected, 129 (82%) had food in their stomachs. The murrelets ate a minimum of 16 prey species, including seven crustaceans and four fishes (Appendix Table 34). Fish accounted for 50% of the prey numbers, 76% of their volume, and they were eaten by 26% of the birds with food in their stomachs, for an IRI of 3,337. In contrast, crustaceans accounted for 49% of prey numbers, 23% of the volume, and they occured in only 8% of the stomachs, for an IRI of 617. Other major taxa of prey were relatively unimportant.

Capelin, which accounted for 38% of prey numbers and 27% of their volume (IRI 1,692), was by far the most important prey species (Figure 26, Appendix Table 34). The next most important prey and their IRI's were sand lance (741), the mysid Acanthomysis sp. (327), and the euphausiid Thysanoessa inermis (132). Other prey were of minor or trace importance, none having an IRI higher than 22.

Kittlitz's Murrelet. Sixteen Kittlitz's murrelets were collected and 15 had food in their stomachs. As with marbled murrelets, crustaceans and fish were the major kinds of prey (Appendix Table 35). Unidentified fish and four species of identifiable fishes made up 65% of prey numbers and 70% of the volume, for an IRI of 5,404, while three species of crustaceans comprised 35% of prey numbers and 30% of their volume, for an IRI of 1,730.

Table 6. Comparative importance of prey to murres, based on data pooled from stomach samples collected in Alaskan waters. Importance levels based on IRI values, as follows: trace (tr) = 0 - 9; 1 = 10 - 99; 2 = 100 - 999; 3 = 1,000+

PREY NAME	Importance of Prey to Bird Species	
	Common Murre N = 166	Thick-billed Murre N = 38
POLYCHAETE, Nereidae	tr	tr
GASTROPOD, Unidentified	-	tr
CEPHALOPODA,		
Unidentified/Unidentified Squid/ Unidentified Gonatid Squid	tr	3
CRUSTACEA		
Calanoid Copepod	-	tr
Leucon sp. (Cumacean)	tr	-
Neomysis rayii (Mysid)	2	-
Gammarid Amphipods		
Protomedeia sp.	tr	-
Anonyx sp.	tr	-
Unidentified	tr	tr
Hyperiid Amphipods		
Parathemisto libellula	-	2
P. pacifica	-	tr
Euphausiids		
Thysanoessa inermis	1	tr
T. raschii	tr	-
T. sp./Unidentified	1	1
Decapods		
Eualus stimpsoni (Shrimp)	tr	-
Pandalus borealis (Pink Shrimp)	1	-
P. goniuris (Humpy Shrimp)	tr	1
Crangon franciscorum (Bay Crangon Shrimp)	tr	-
C. sp. (Crangon Shrimp)	-	1
INSECT, Unidentified	tr	-
ECHINODERM		
Amphipodia sp. (Brittle Star)	tr	-
FISH		
Clupea harengus (Pacific Herring)	tr	-
Mallotus villosus (Capelin)	3	2
Gadus macrocephalus (Pacific Cod)	tr	-
Boreogadus saida (Arctic Cod)	-	tr
Microgadus proximus (Pacific Tomcod)	tr	-
Theragra chalcogramma (Walleye Pollock)	2	1
Trichodon trichodon (Pacific Sandfish)	tr	-
Lumpenus maculatus (Daubed Shanny)	tr	-
L. saggita (Snake Prickleback)	tr	-
Ammodytes hexapterus (Pacific Sand Lance)	2	1

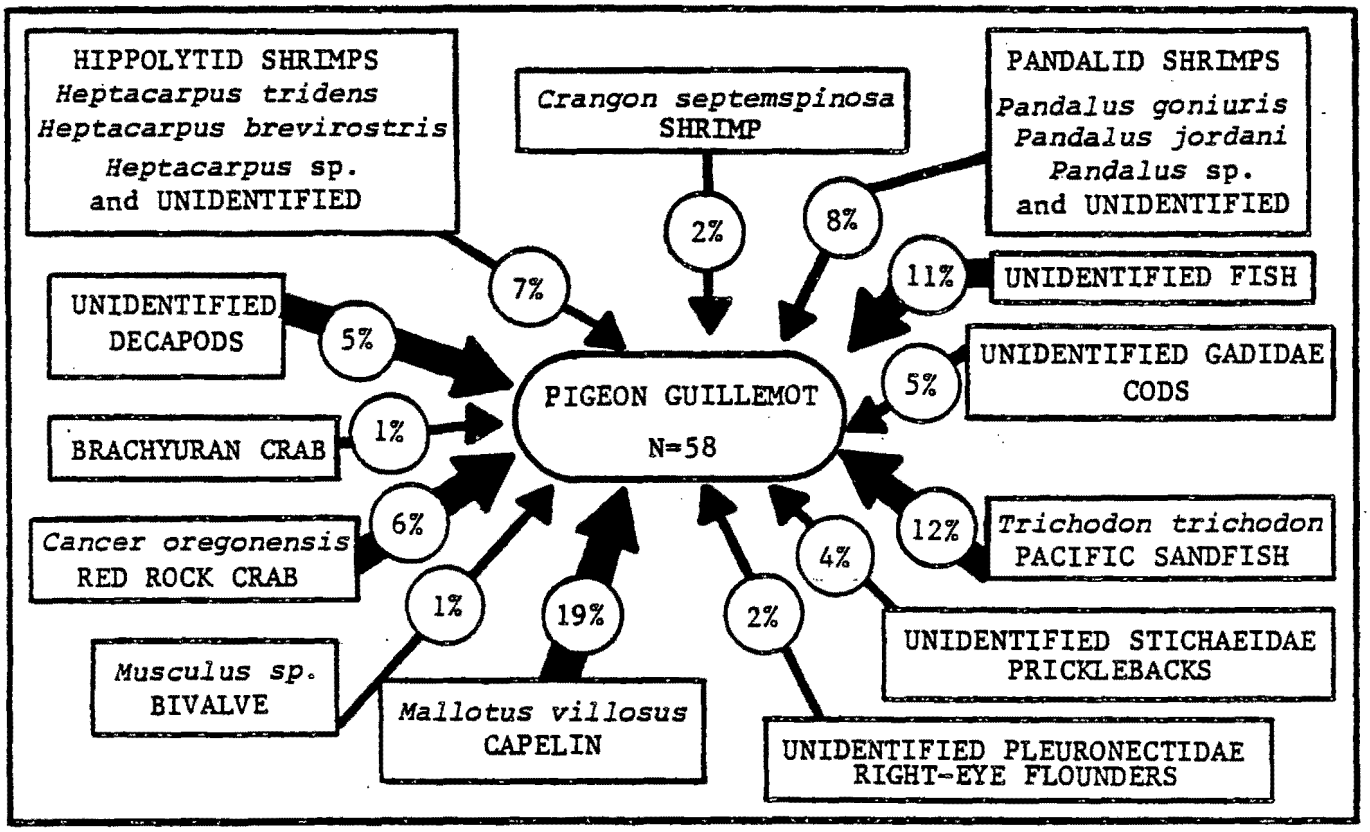


Figure 25. Food web for pigeon guillemots, showing main prey items as indicated by data pooled from all years, seasons and regions. See Fig. 2 caption.

In contrast to marbled murrelets, the most important prey species to Kittlitz's murrelets was a crustacean, the euphausiid Thysanoessa inermis (Figure 26, Appendix Table 35). This species accounted for 25% of the numbers and 14% of the volume of prey, although it occured in only 3 of the 15 birds with food in their stomachs (IRI 788). This information could be misleading, however, because unidentifiable fish comprised 53% of the numbers and 34% of the prey volume. A species of fish could therefore have been more important to the birds than the euphausiid.

Pacific sand lance (IRI 183) was the most important species of identifiable fish, accounting for 7% each of prey numbers and volume. Capelin (IRI 92) and Pacific sandfish (IRI 87) were the next most important fish prey, and accounted for 12% and 11% of the prey volume, respectively (Appendix Table 35). Each of these species, however, occured in only one stomach. The euphausiid Thysanoessa spinifera occured in two birds, and accounted for 6% each of prey numbers and volume and had an IRI of 152.

Ancient Murrelet. Fifteen (83%) of the 18 murrelets collected had food in their stomachs, which included at least five prey species. Crustaceans were the most important major taxon of food; they occured in 33% of the stomachs and accounted for 56% and 57%, respectively, of the prey numbers and volume, for an IRI of 3,786. Fish also occured in 33% of the stomachs, but in contrast to crustaceans, they respectively accounted for only 43% of prey numbers and 42% of the volume, for an IRI of 2,817 (Appendix Table 36).

Thysanoessa inermis was the most important species of prey to ancient murrelets, respectively accounting for 52% and 49% of of prey numbers and volume, which contributed to an IRI of 3,353. Unidentified gadid fishes (IRI 437) made up 18% of the volume, and unidentified fish (IRI 460) accounted for 11% of the volume. No other prey had an IRI higher then 56 (Figure 27, Appendix Table 36).

Cassin's Auklet. Eight Cassin's auklets all had food in their stomachs. Crustaceans (IRI 8,780) dominated the diet, but fish (IRI 408) and squid (IRI 101) were also present (Appendix Table 37). At least six species of prey were found in the stomachs.

Calanoid copepods dominated both prey numbers (78%) and volume (59%), and they occured in four (50%) of the birds, for an IRI of 6,870. Unidentifiable decapods (crabs and shrimp) had an IRI of 1,250, a result of their occuring in 50% of the stomachs and accounting for 16% of the prey numbers and 9% of their volume. Unidentified fish (IRI 408), the euphausiid Thysanoessa spinifera (IRI 315), and unidentifiable squid (IRI 101) rounded out the prey, plus one gammarid amphipod was found in one bird.

Food Web Relationships Among Three Murrelets and Cassin's Auklet. Specimens of the preceeding four species were all collected in the Gulf of Alaska, so major geographic differences in their diet are eliminated. A direct comparison of the main components of their diets (Table 7, Figure 28) shows that, in general, fish and planktonic crustaceans were the main prey of all four species. Mysids of the genera Acanthomysis and Neomysis were of low to moderate importance to marbled and ancient murrelets, but were absent from the diets of the other species.

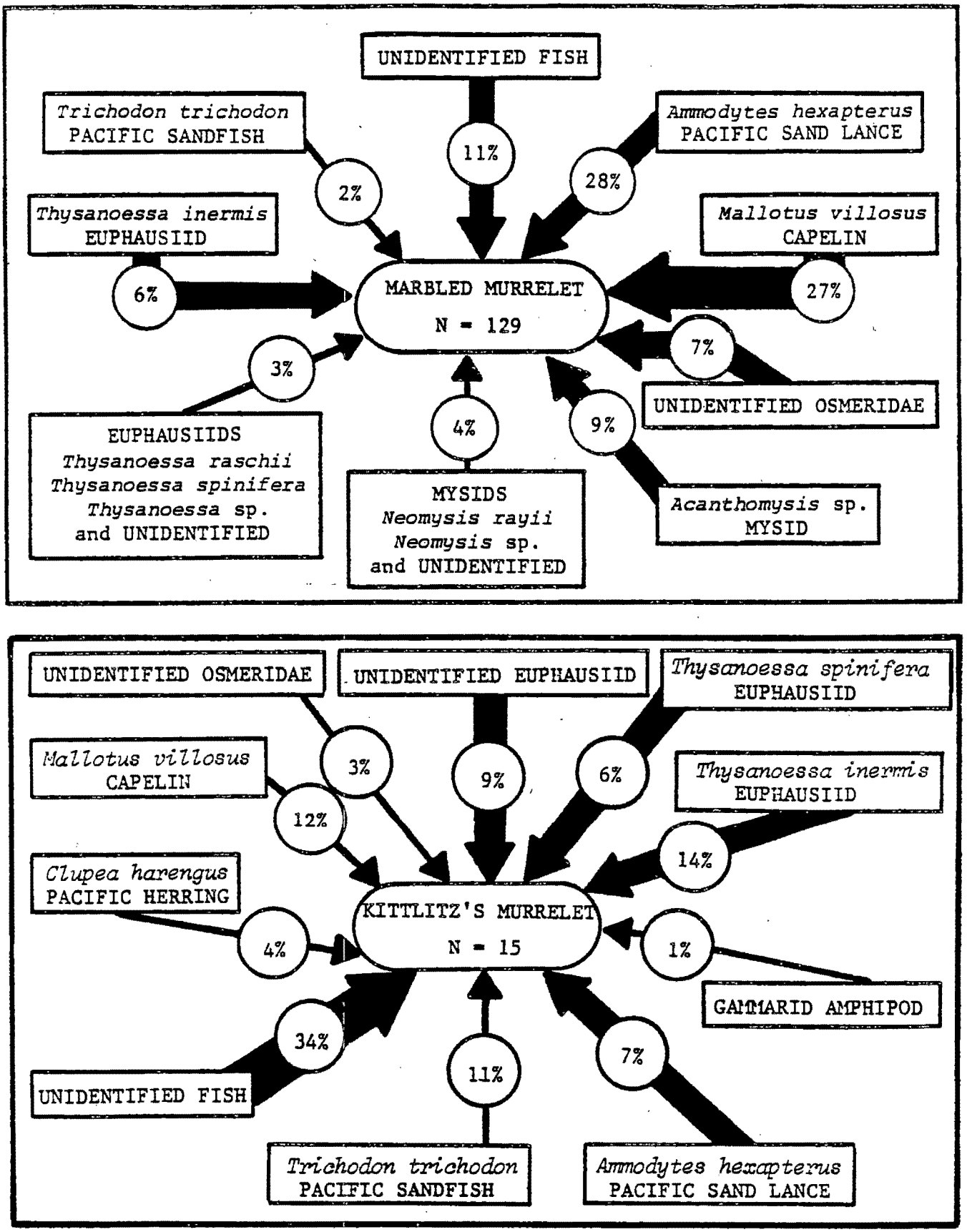


Figure 26. Food webs for marbled (top) and Kittlitz's murrelets (bottom), showing main prey items as indicated by data pooled from all years, seasons and regions. See Fig. 2 caption.

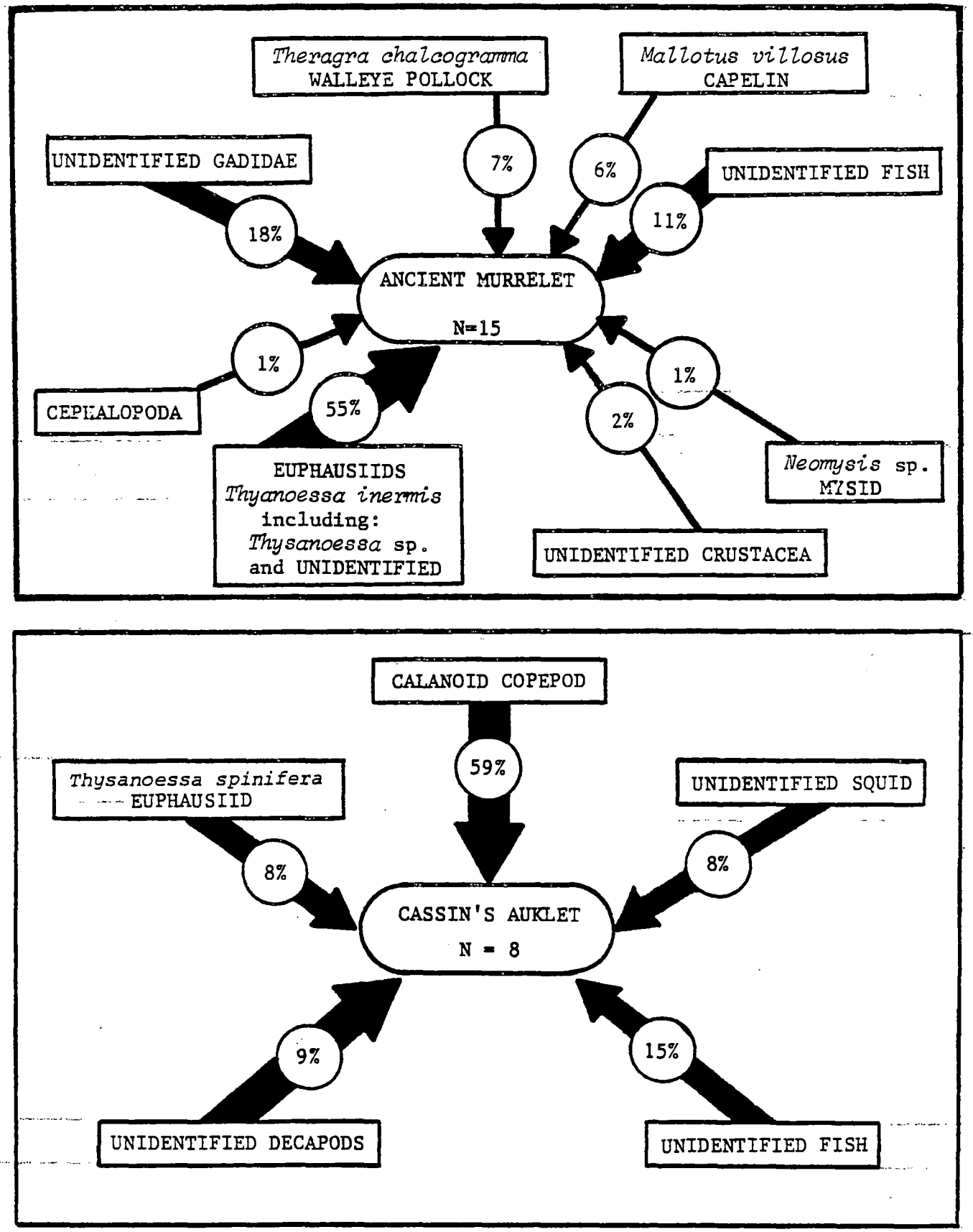


Figure 27. Food webs for ancient murrelets (top) and Cassin's auklets (bottom), showing main prey items as indicated by data pooled from all years, seasons and regions. See Fig. 2 caption.

Table 7. Comparative importance of prey to murrelets and the Cassin's Auklet, based on data pooled from birds collected in the Gulf of Alaska. Importance levels of prey based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000+ = 3

PREY NAME	Importance of Prey to Bird Species			
	Marbled Murrelet N = 129	Kittlitz's Murrelet N = 15	Ancient Murrelet N = 15	Cassin's Auklet N = 8
POLYCHAETA, Nereidae	tr	-	-	-
GASTROPOD, *Littorina sitkana* Sitka Periwinkle				
BIVALVE, *Mytilus edulis* Blue Mussel	tr	-	-	-
CEPHALOPODA, Squid & Unident.	tr	-	1	2
CRUSTACEA				
Calanoid Copepod	-	-	-	3
Gammarid Amphipod	tr	1	-	tr
Mysida				
Acanthomysis sp.	2	-	-	-
Neomysis rayii	tr	-	-	-
N. sp.	1	-	1	-
Euphausiids				
Thysanoessa inermis	2	2	3	-
T. raschii	1	-	-	-
T. spinifera	tr	2	-	2
T. sp./Unidentified	1	2	2	-
Pink Shrimp				
Pandalus borealis	tr	-	-	-
CHAETOGNATHA, Arrow Worms	tr	-	-	-
FISH				
Clupea harengus Pacific Herring	-	1	-	-
Mallotus villosus Capelin	3	1	1	-
Unidentified Osmeridae	2	1	-	-
Theragra chalcogramma Walleye Pollock	tr	-	1	-
Unidentified Gadidae	tr	-	2	-
Trichodon trichodon Pacific Sandfish	1	1	-	-
Ammodytes hexapterus Pacific Sand Lance	2	2	-	-
Unidentified	2	3	2	2

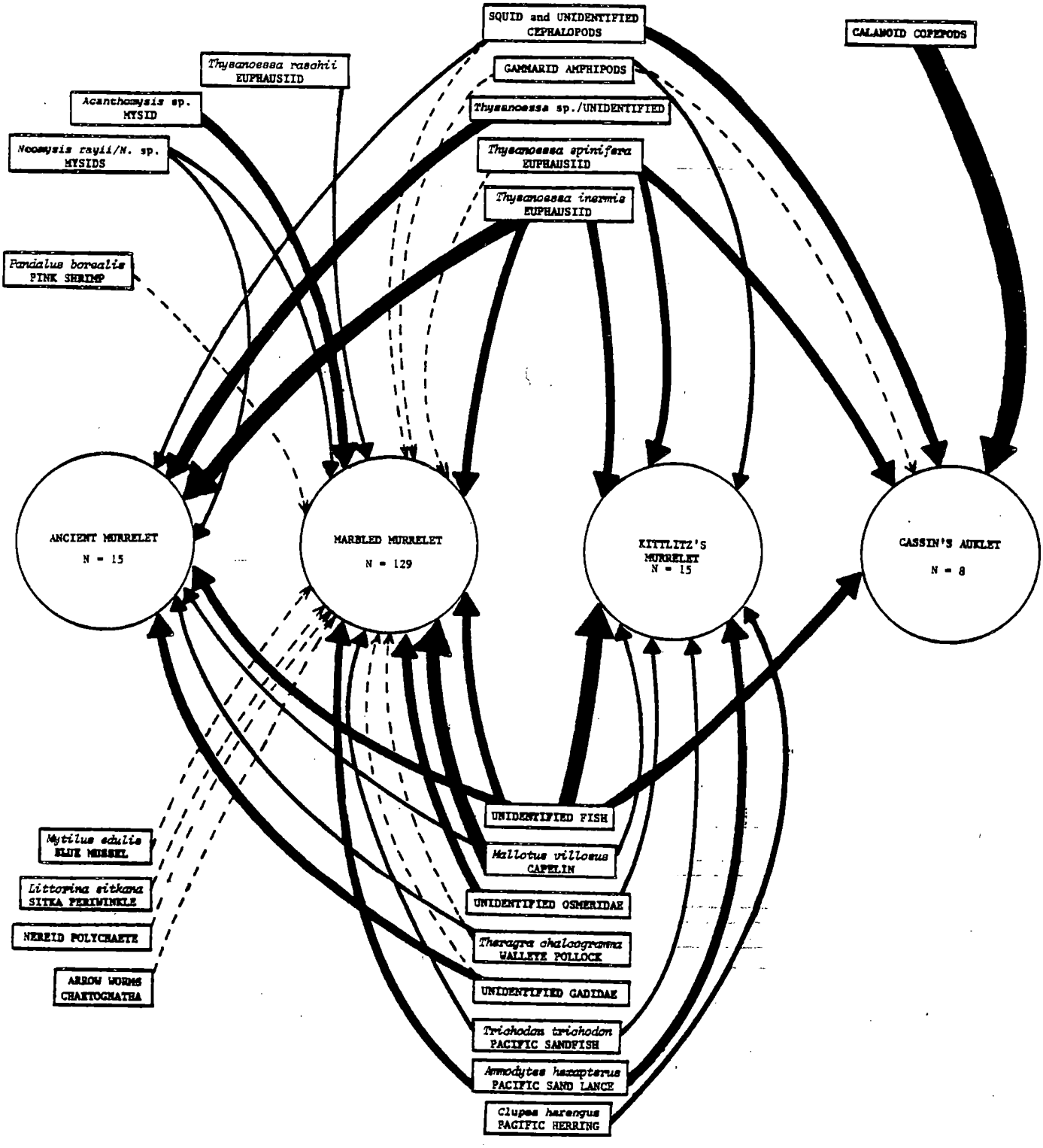


Figure 28. Food web relationships among ancient, marbled and Kittlitz's murrelets, and Cassin's auklets, based on data pooled from all years, seasons, and regions. See Fig. 4 caption.

Euphausiids of the genus Thysanoessa were of moderate or high importance to all four alcids; T. inermis was of moderate or high importance to all species except the Cassin's auklet, and T. spinifera was of moderate importance to Kittlitz's murrelets and Cassin's auklets. Calanoid copepods were heavily eaten by Cassin's auklets, but were not eaten by the other species.

No one species of fish was eaten by all four of these alcids, although unidentified fish had importance levels of two or three for all four birds. Capelin were of high importance to marbled murrelets, and low importance to Kittlitz's and Ancient murrelets. Sand lance were moderately important to marbled and Kittlitz's murelets, but they were not eaten by Ancient murrelets nor Cassin's auklets. Pacific sandfish were eaten by both marbled and Kittlitz's murrelets, but were of low importance to each. None of the fish remains in the Cassin's auklets were identifieble.

Parakeet Auklet. Thirteen birds were collected, but only five (38%) had food in their stomachs. They had eaten at least three species of prey, including two crustaceans and unidentified fish. Euphausiids of the genus Thysanoessa made up 93% of total prey numbers and 17% of the volume, but they were found in only one of the five stomachs. Unidentified fish accounted for 6% of prey numbers, 51% of the volume and occured in two birds. Unidentified decapods (shrimps and crabs) equaled 16% of the prey volume, but they occured in only one stomach (Figure 29, Appendix Table 38).

Least Auklet. Three Least Auklets were collected, and all had food in their stomachs. At least four kinds of prey were found, but none were identifiable to species. Calanoid copepods accounted for 55% of prey numbers and 18% of their volume, gammarid amphpods made up 12% and 7%, respectively of numbers and volume, and equivalent figures for chaetognaths (arrow worms) were 28% and 31%. Unidentified decapods made up 11% of the volume, but only 3% of the numbers (Figure 29, Appendix Table 39).

Crested Auklet. At least three kinds of crustaceans were found in 13 birds with food in their stomachs out of 25 collected. The mysid Acanthomysis accounted for 80% of prey numbers and 43% of the volume, but was found in only two (15%) of the stomachs, and the euphausiid Thysanoessa inermis made up 15% of the numbers, 25% of the volume, and it was found in four of 13 birds (31%) with food. Unidentified hyperiid amphipods made up the remainder of prey (Figure 30, Appendix Table 39).

Food Web Relationships Among the Auklets. Unidentifid decapods were found in both Parakeet and Least Auklets, and Thysanoessa euphausiids had been eaten by Parakeet and Crested Auklets, but there was otherwise no overlap in the kinds of prey eaten by birds in our samples (Table 8, Figure 31) Diets of these three species in the Bering Sea (e.g., Bedard 1969; Hunt et al. 1981) show a fair degree of overlap in prey species. Thus, the small amount of overlap observed here may be a result of the small sample sizes, and the locations of the collections. The three Least Auklets all came from the Bering Sea, but collections of the other two species were from scattered locations in the Gulf of Alaska, as well as the Bering Sea.

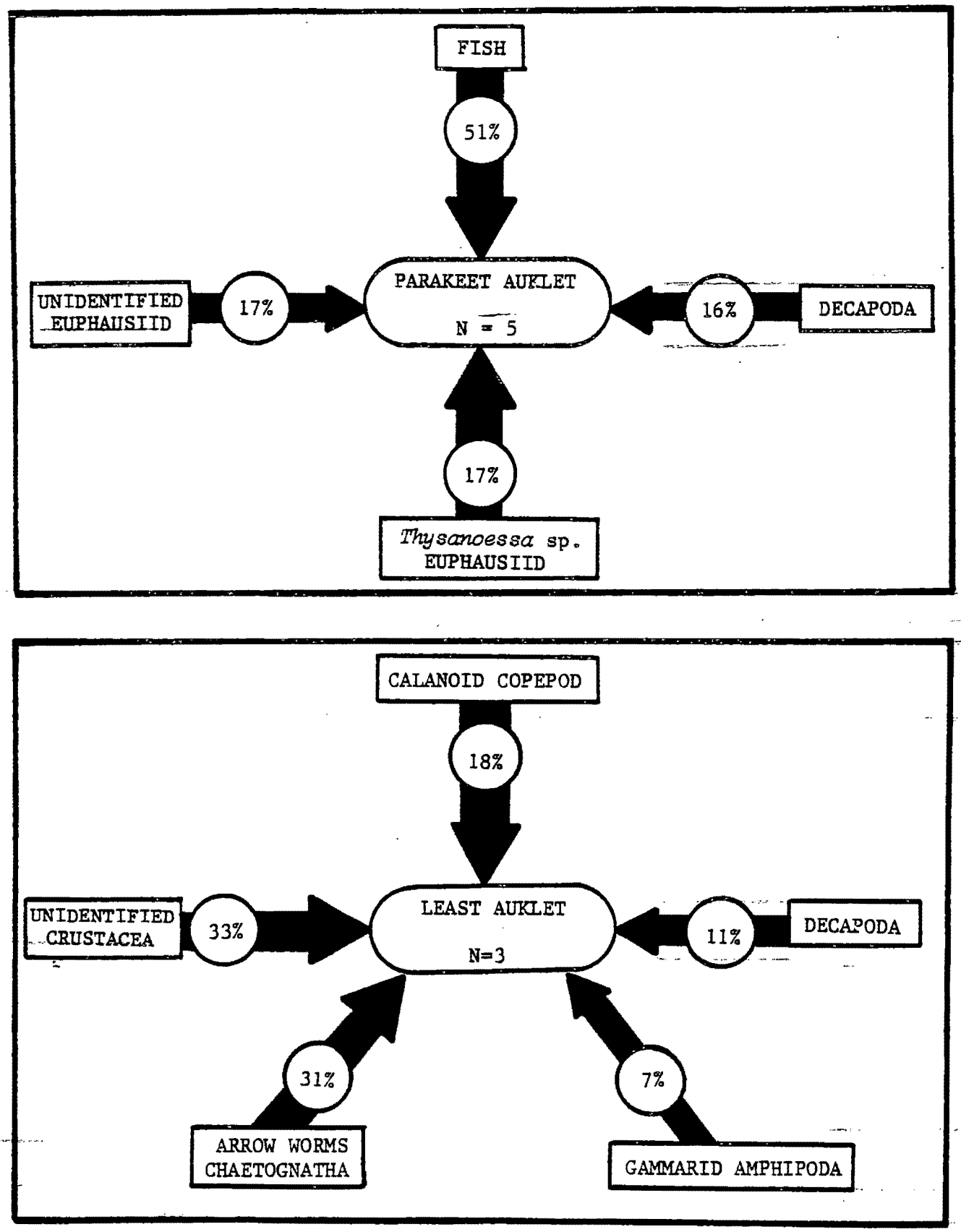


Figure 29. Food webs for parakeet (top) and least (auklets), showing main prey items as indicated by data pooled from all years, seasons and regions. See Fig. 2 caption.

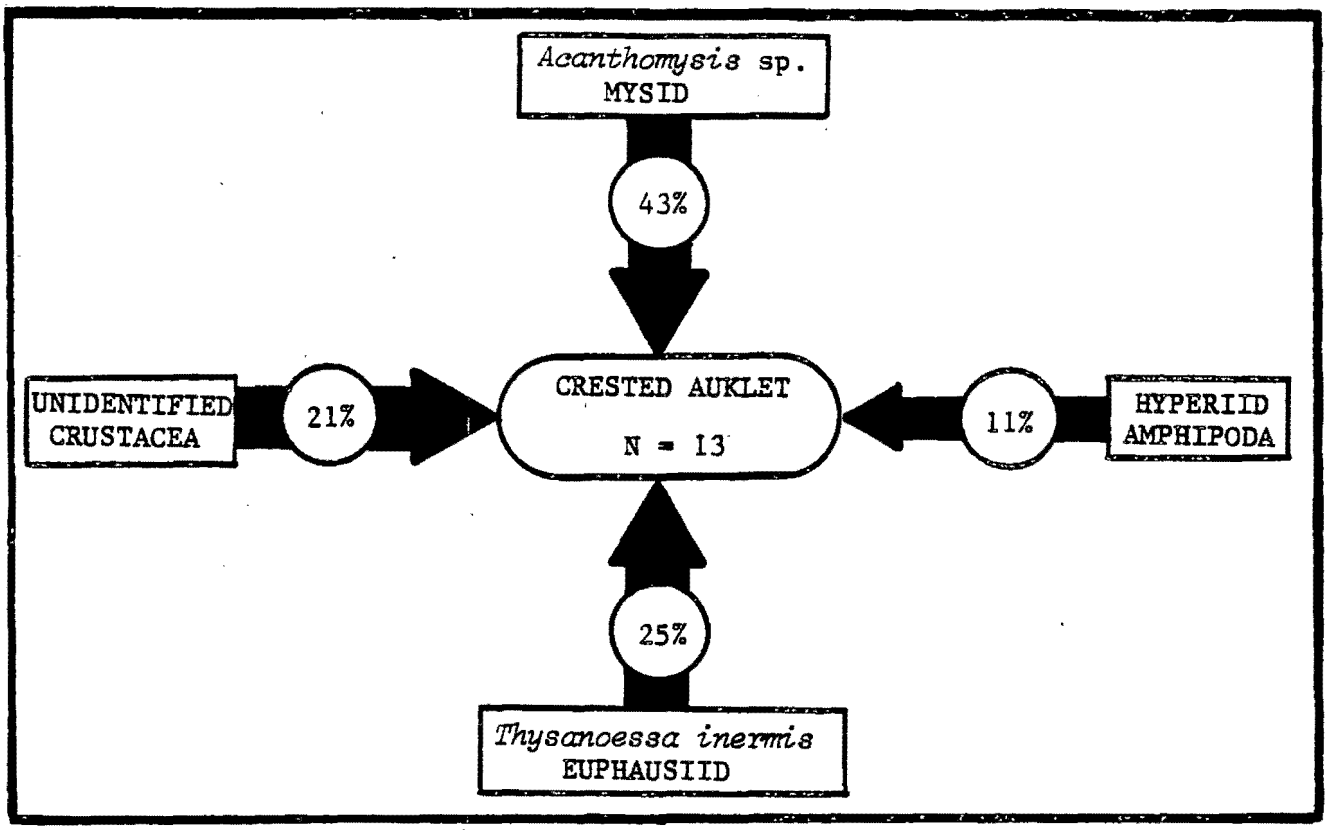


Figure 30. Food web for crested auklets, showing main prey items as indicated by data pooled from all years, seasons and regions. See Fig. 2 caption.

Table 8. Comparative importance of prey to Parakeet, Least, and Crested Auklets, based on data pooled from food samples from birds collected in Alaskan waters. Importance levels of prey based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000+ = 3

PREY NAME	Importance of Prey to Bird Species		
	Parakeet Auklet N = 13	Least Auklet N = 3	Crested Auklet N = 5
CRUSTACEA			
Calanoid Copepoda	-	3	-
Gammarid Amphipoda	-	2	-
Hyperiid Amphipoda	-	-	2
Acanthomysis sp. Mysid	-	-	3
Thysanoessa inermis Euphausiid	-	-	3
Thysanoessa sp. Euphausiid	3	-	-
Decapoda Shrimps and Crabs	2	2	-
FISH, Unidentified	3	-	-
CHAETOGNATHA Arrow Worms	-	3	-

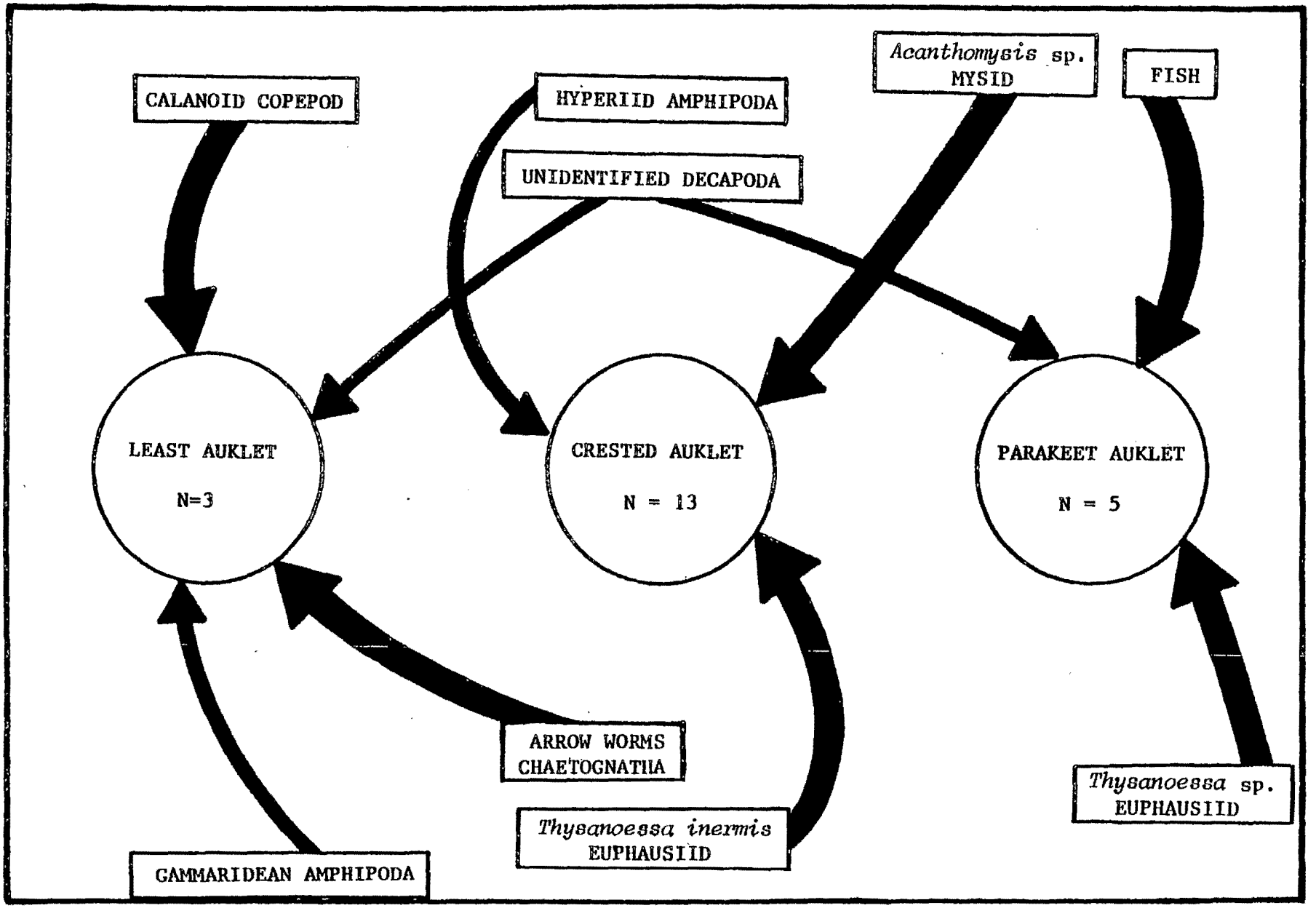


Figure 31. Food web relationships among least, crested, and parakeet auklets based on data pooled from all years, seasons, and regions. See Fig. 2 caption.

Rhinoceros Auklet. Twenty-one adult rhinoceros auklets were collected, and 16 (76%) had food in their stomachs. At least five species of prey were present, including four fishes and unidentified cephalopods (Appendix Table 40). Capelin (IRI 1,061) was the most important identifiable species of prey, and it accounted for 24% and 61%, respectively, of their numbers and volume. The next most important prey, Pacific sand lance, made up 12% of the prey volume, and had an IRI of 372. Other identifiable fish in the diet included rockfish (Sebastes sp.) (IRI 152) and Pacific saury (IRI 58, volume 6%). Unidentifiable fish had an IRI of 2,114, but accounted for only 10% of the volume (Figure 32, Appendix Table 40).

Twenty-five regurgitation samples from nestlings revealed a minimum of nine species of prey, all of them fish (Appendix Table 41). Pacific herring and Pacific sand lance were by far the most important species. Each occured in 44% of the samples, and they respectively accounted for 37% and 33% of the volume, and 67% and 23% of the prey numbers. Herring had an IRI of 2,439, and sand lance, 4,578 (Figure 32, Appendix Table 41). Rockfish (Sebastes sp.) had an IRI of 101, and values for all other fish were below 84. Species included were saury, rock and kelp greenlings, sablefish, and pollock. Capelin, which were quite important to adult rhinoceros auklets, as well as many other species of seabirds, comprised only 7% of the prey volume of the nestling rhinos, 1% of their numbers, and it occured in only one sample (4%), for an IRI of 32. This may have been because all samples were from Forrester Island near the Canadian border, where capelin may not be as abundant as in areas farther north such as Kodiak (Hart 1973).

Horned Puffin. Of 54 adult horned puffins collected, 40 (74%) had food in their stomachs and they had eaten at least 13 species of prey. Fish was the most important major taxon of prey (IRI 9,141), and crustaceans, squid, polychaetes and chitons were all of relatively minor importance (Appendix Table 42).

Capelin was the most important prey of adult horned puffins. This forage fish made up 51% of all prey numbers, 50% of their volume, and it occured in 28% of the samples, for an IRI of 2,793 (Figure 33, Appendix Table 42). Sand lance was the next most important prey, accounting for 27% of the overall prey volume, and having an IRI of 736. The remaining 11 species were of minor or trace importance in the diet, although gonatid squid (in one stomach only) accounted for 10% of the volume. Four bill load samples from parent birds, intended for nestlings, included three species of fish: Pacific herring, kelp greenling and sand Lance (Figure 33, Appendix Table 43).

Tufted Puffin. Four-hundred-forty adult birds were collected, and 364 (83%) had food in their stomachs, including a minimum of 22 prey species. Six major taxa of prey were found, and fish (IRI 4,844), crustaceans (IRI 604) and cephalopods (IRI 362) had the highest IRI values (Appendix Table 44).

Despite the large number of prey species, only three had IRI values over 100: Capelin (3,464), the euphausiid Thysanoessa inermis (497), and Pacific Sand Lance (254) (Appendix Table 44). Indeed, no other prey had an

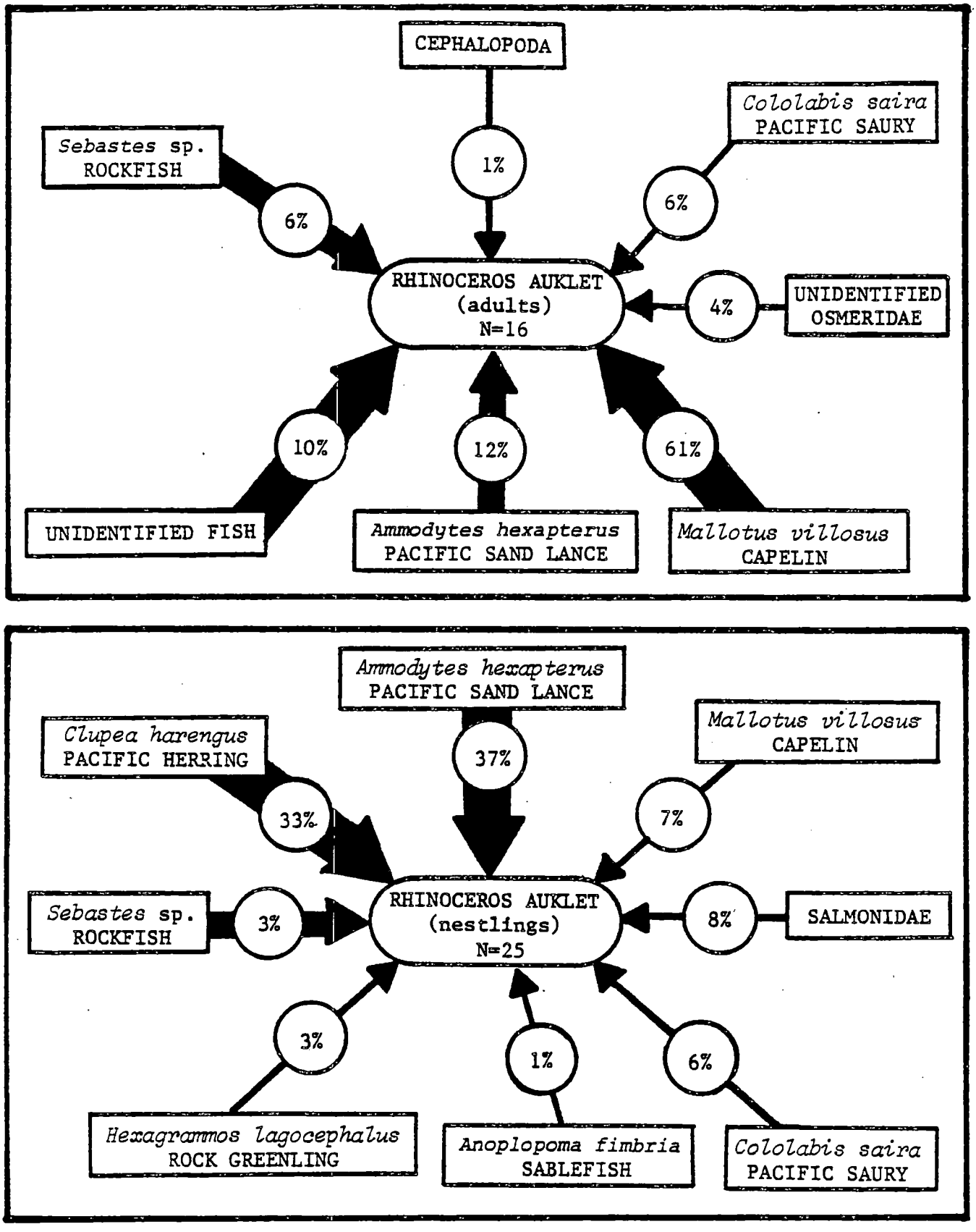


Figure 32. Food webs for adult (top) and nestling (bottom) rhinoceros auklets, showing main prey items as indicated by data pooled from all years, seasons and regions. See Fig. 2 caption.

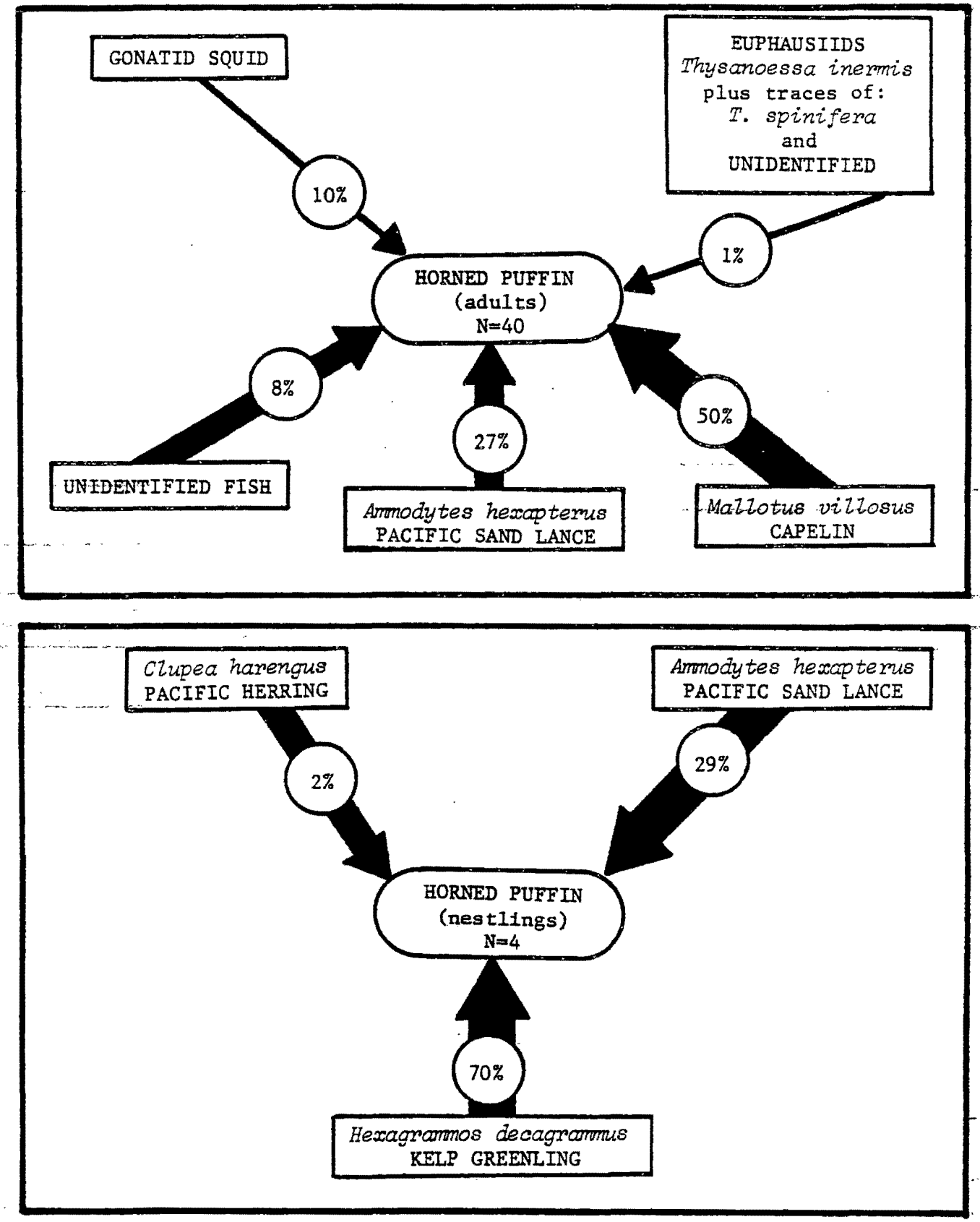


Figure 33. Food webs for adult (top) and nestling (bottom) horned puffins, showing main prey items as indicated by data pooled from all years, seasons and regions. See Fig. 2 caption.

IRI higher than 29 (walleye pollock). Capelin accounted for 61% of the total prey volume, and 17% of the numbers, Thysanoessa inermis 8% and 39% of the same units respectively, and Pacific sand lance 15% and 5%. Walleye pollock made up 4% of the volume, but only 2% of the numbers, and it occured in 5% of the samples (Figure 34, Appendix Table 44). Unidentified cephalopods accounted for 22% of the numbers and 3% of the volume.

The diet of subadult Tufted Puffins was dominated by capelin (IRI 5,850) and Pacific sand lance (IRI 2,998) (Appendix Table 45). Fifty-three percent of the volume of the 60 samples with food was capelin, and 35% was sand lance. These two species accounted for 42% and 40%, respectively, of prey numbers, and they respectively occured in 62% and 40% of the samples (Figure 34, Appendix Table 45). Nereid polychaetes accounted for 10% of the numbers, and had an IRI of 17; no other prey had an IRI higher than 7.

Food Web Relationships Among Puffins. Together, the rhinoceros auklets (a puffin; cf. Storer 1945), and horned and tufted puffins in our samples had eaten a minimum of 29 species of prey, nearly half (14) of them fish. Of these 29 species, however, only three were eaten by all three puffins: Capelin, walleye pollock and Pacific sand lance (Table 9, Figure 35). Unidentified squids were found in all three birds. In general, capelin appeared to be relatively more important in the diets of adult birds than they were to nestlings and subadults, while the opposite was observed with sand lance.

Except for euphausiids, crustaceans occured in the diets of the puffins in trace amounts only. Euphausiids of the genus Thysanoessa were of low to moderate importance to adult horned and tufted puffins, but were absent from the diets of juveniles of all three birds, and from adult rhinoceros auklets.

Pacific herring were of moderate or high importance to subadult rhinoceros auklets and horned puffins (N = 4). Pacific saury were of low importance to both adult and nestling rhinoceros auklets, and Sebastes sp. rockfish were of moderate importance to both age groups (Table 9). Neither species of fish was found in the diets of the other two puffins, however.

DIETS, REGIONAL/SEASONAL DATA

Eleven species of birds with the most comprehensive regional and seasonal data in our data base are discussed in this section. Tables summarize and compare data on the relative importance of prey for each bird species, utilizing prey "importance levels" that are based on exponential increments of the prey's Index of Relative Importance (IRI; see preceeding sections of report); i.e., 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; etc. Sample sizes are often small even when pooled from several years, although there are exceptions, particularly for the Kodiak region. As a general rule, only data sets with a sample size of at least three are included in the tables. In a few cases, however, samples of one or two are included when they provide continuity in comparisons.

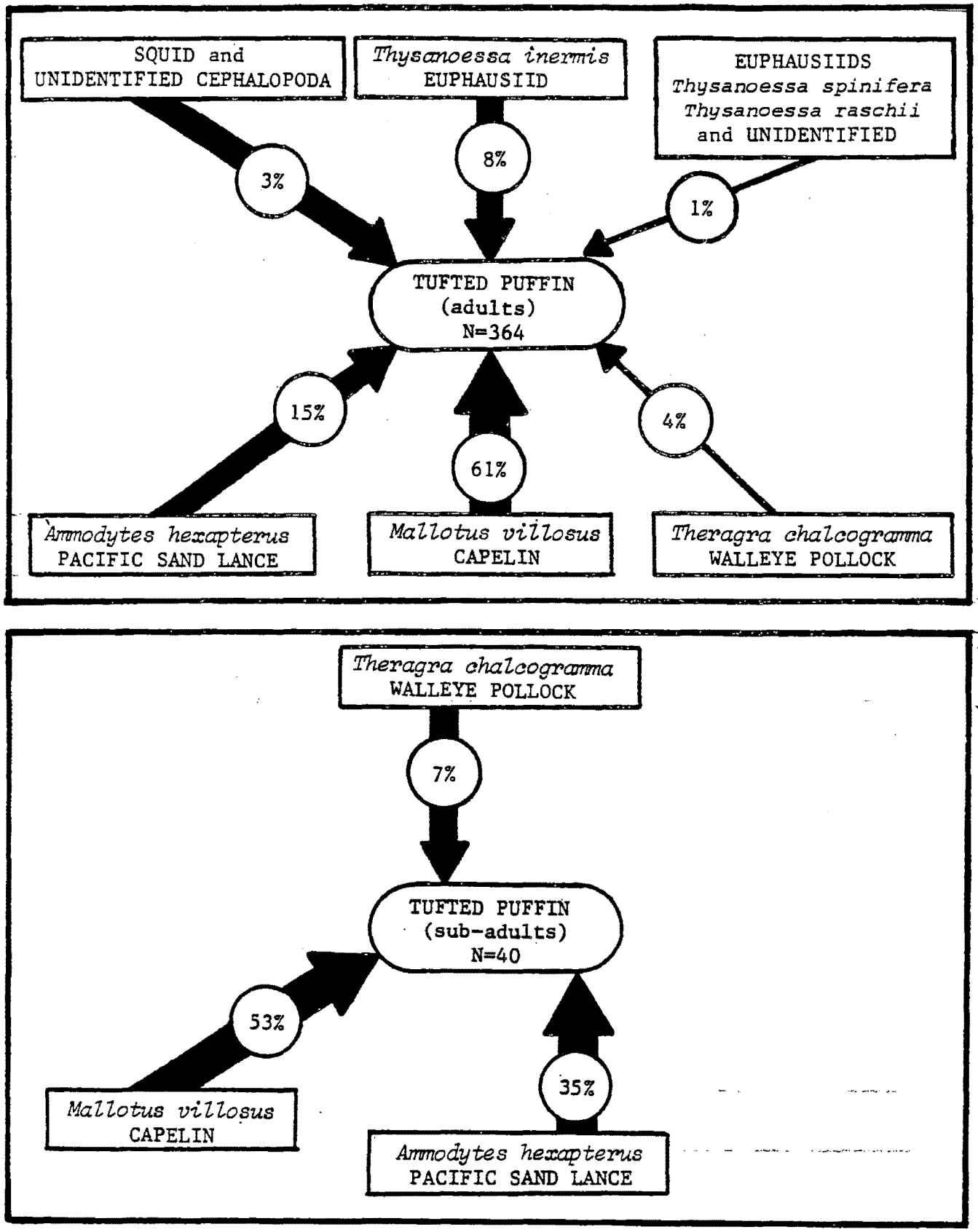


Figure 34. Food webs for adult (top) and sub-adult (bottom) tufted puffins, showing main prey items as indicated by data pooled from all years, seasons and regions. See Fig. 2 caption.

Table 9. Comparative importance of prey to adult and sub-adult puffins, based on data pooled from food samples from birds in Alaskan waters. Importance levels of prey based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000+ = 3

	Importance of Prey to Bird Species					
	Rhinoceros Auklets		Horned Puffins		Tufted Puffin	
	Adults	Nestlings	Adults	Nestlings	Adults	Sub-Ads.
PREY NAME	N = 16	N = 25	N = 40	N = 4	N = 364	N = 60
POLYCHAETA, Nereidae	-	-	1	-	tr	1
PTEROPODA						
Limacina helicina	-	-	-	-	tr	-
POLYPLACOPHORA, Chiton	-	-	tr	-	-	-
ACARINA, Unident. Mite	-	-	-	-	tr	-
CEPHALOPODA						
Squid & Unidentified	1	-	1	-	2	tr
Gonatid Squid	-	-	1	-	-	-
Unidentified Octopi	-	-	-	-	-	tr
CRUSTACEA						
Calanoid Copepod	-	-	-	-	tr	-
Anisogammarus pugettensis Gammarid Amphipod	-	-	tr	-	-	-
Unident. Gammarid	-	-	-	-	tr	-
Parathemisto libellula Hyperiid Amphipod	-	-	-	-	tr	-
Acanthomysis sp. Mysid	-	-	tr	-	-	-
Euphausiids						
Thysanoessa inermis	-	-	1	-	2	-
T. spinifera	-	-	tr	-	1	-
T. raschii	-	-	-	-	tr	-
T. sp.	-	-	-	-	1	-
Unidentified	-	-	tr	-	tr	-
Decapods						
Pandalus montagui Pandalid Shrimp	-	-	tr	-	-	-
P. sp.	-	-	-	-	tr	-
Pagurid Crab	-	-	-	-	tr	-

Table 9. Comparative importance of prey to puffins, page 2 of 2

PREY NAME	Importance of Prey to Bird Species					
	Rhinoceros Auklets		Horned Puffins		Tufted Puffin	
	Adults N = 16	Nestlngs N = 25	Adults N = 40	Nestlings N = 4	Adults N = 364	Sub-Ads. N = 60
FISH						
Clupea harengus Pacific Herring	-	3	-	2	-	-
Onchorhynchus nerka Red Salmon	-	-	-	-	tr	-
Unident. Salmonid	-	1	-	-	-	-
Mallotus villosus Capelin	3	1	3	-	3	3
Unident. Osmerid	1	-	-	-	tr	-
Microgadus proximus Pacific Tomcod	-	-	-	-	tr	-
Theragra chalcogramma Walleye Pollock	-	tr	tr	-	1	2
Cololabis saira Pacific Saury	1	1	-	-	-	-
Gasterosteus aculeatus Threespine Stickleback	-	-	tr	-	-	-
Trichodon trichodon Pacific Sandfish	-	-	-	-	tr	tr
Sebastes sp. Rockfish	2	2	-	-	-	-
Anoplopoma fimbria Sablefish	-	1	-	-	-	-
Hexagrammos decagrammus Kelp Greenling	-	tr	-	3	-	-
H. lagocephalus Rock Greenling	-	1	-	-	-	-
Unident. Cyclopterid Snailfish	-	-	-	-	tr	-
Ammodytes hexapterus Pacific Sand Lance	2	3	2	3	2	3
Unidentified	3	tr	2	-	-	-

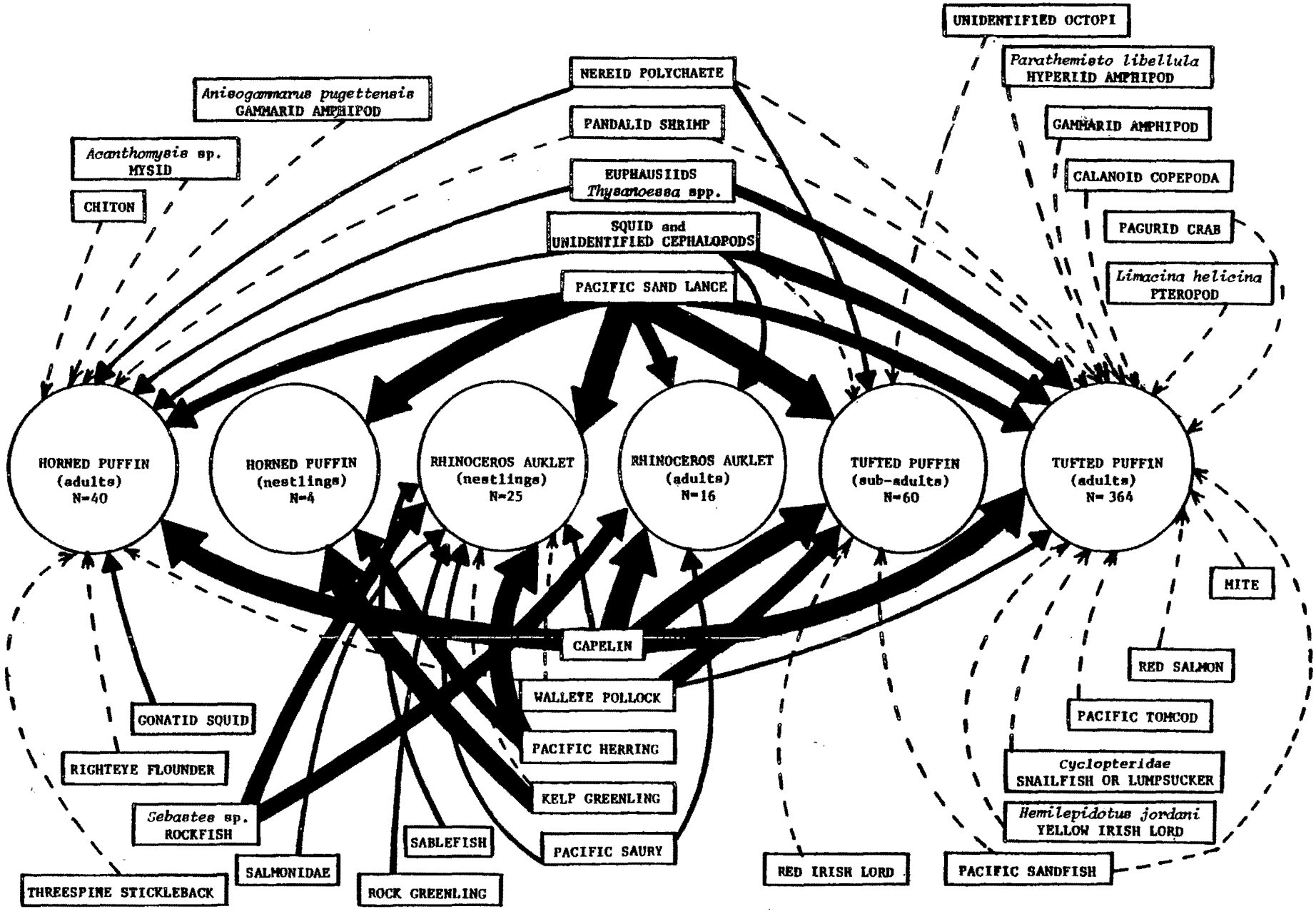


Figure 35. Food web relationships among adults and sub-adults of the three species of North Pacific puffins, based on data pooled from all years, seasons, and regions. See Fig. 4 caption.

Prey are listed as "present" in these cases, rather than by numerical importance level.

Complete, computer-generated listings of percent numbers, volume and frequency of occurence of the prey of all bird species for each set of regional/seasonal data are on file at the U.S. Fish and Wildlife Service, Research-Migratory Birds, 1011 E. Tudor Rd, Anchorage, AK 99503.

Northern Fulmar

Food samples from fulmars were restricted to the Kodiak and Northeast Gulf of Alaska (NEGOA) regions, and the spring, summer, and fall seasons (Table 10). In general, cephalopods (including gonatid squid and "unidentified") were important foods eaten in both regions.

Euphausiids had been eaten by birds in the Kodiak region in summer and fall. Other crustaceans eaten in the region included calanoid copepods and amphipods. In contrast, crustaceans had been less heavily utilized by 15 birds sampled in the NEGOA. Capelin and unidentified gadid fishes were eaten by birds from Kodiak, while walleye pollock had been eaten by birds from NEGOA.

Sooty Shearwater

Sooties were sampled in the Aleutian, Western Gulf of Alaska (WGOA), Kodiak, and NEGOA regions, and during the spring, summer and fall seasons (Table 11). Cephalopods, including unidentified squid, were consistently important in the diet of birds from all four regions and all three seasons sampled.

Fish had been eaten by birds collected in WGOA, Kodiak and NEGOA. In particular, capelin were important to birds from Kodiak and NEGOA in summer, and Kodiak in fall. A lanternfish (Myctophidae), Stenobrachius nannochir, occured in the diet of birds from WGOA in spring.

Crustaceans appeared to be utilized by Sooty Shearwaters less heavily than other prey, although the gammarid amphipod Paracallisoma alberti was important to birds from the Aleutian and WGOA regions, and euphausiids were of moderate importance in the diet of birds from the Kodiak and NEGOA regions in summer.

Short-tailed Shearwater

Samples of Short-tailed Shearwaters for comparative purposes are available only from the Bering Sea and Kodiak regions, and the spring, summer and fall seasons (Table 12).

Cephalopods were present in the diet of birds sampled in both regions, during all seasons sampled. Crustaceans were relatively important to birds in both areas and all three seasons sampled. The large (20-60 mm) hyperiid amphipod Parathemisto libellula was utilized by birds from the Bering Sea in fall, and euphausiids of the genus Thysanoessa had been eaten by birds from both areas. T. inermis was especially important to birds from the Kodiak Region.

Table 10. Comparison of the importance of the main prey species of northern fulmars in Alaskan waters by major geographic region and season. Prey Importance levels based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000 - 9,999 = 3; 10,000 and up = 4.
Seasons: Sp = Spring; Su = summer; F = fall.

	Kodiak			Northeastern Gulf of Alaska	
	Sp	Su	F	Su	F
Sample Size =	4	5	3	3	12
PREY NAME					
Nereid Polychaete.....	-	-	-	-	1
Unidentified Bivalve.....	-	-	-	-	2
Gonatid Squid.....	4	-	-	-	-
Unidentified Cephalopod.....	-	3	4	-	4
Calanoid Copepod.....	-	2	-	-	-
Parathemisto pacifica..... Hyperiid Amphipod	-	1	-	-	-
Gammarid Amphipod.....	-	-	-	2	-
Thysanoessa inermis.....	-	2	-	-	-
Unidentified Euphausiid.....	-	-	3	-	-
Unidentified Crustacean.....	-	-	-	-	1
Capelin.....	-	2	-	-	-
Walleye Pollock.....	-	-	-	3	-
Unidentified Gadid Fish.....	-	-	2	-	1
Unidentified Fish.....	-	-	2	2	1

Table 11. Comparison of the importance of the main prey species of sooty shearwaters in Alaskan waters by major geographic region and season. Prey Importance levels based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000 - 9,999 = 3; 10,000 and up = 4.

	Aleutians	Western Gulf of Alaska	Kodiak		Northeastern Gulf of Alaska
	Su	Sp	Su	F	Su
Sample Size =	3	3	133	19	16
PREY NAME					
Nereid Polychaete.....	-	-	tr	tr	-
Onychoteuthis sp..... Squid	-	-	-	-	tr
Gonatid Squid.....	-	-	-	-	2
Un. Squid/Cephalopod..	3	2	3	3	3
Calanoid Copepod.....	-	-	tr	-	-
Paracallisoma alberti. Gammarid Amphipod	2	3	-	-	-
Parathemisto pacifica. Hyperiid Amphipod	3	-	-	-	-
Un. Hyperiid Amphipod.	-	-	tr	-	-
Thysanoessa inermis...	-	-	2	-	tr
T. raschii.....	-	-	-	-	tr
T. spinifera.....	-	-	tr	-	-
T. sp./Un. Euphausiid.	-	-	-	-	2
Capelin.....	-	-	3	4	3
Stenobrachius..... nannochir (Mytophid)	-	3	-	-	-
Pacific Tomcod.....	-	-	tr	-	-
Pacific Sandfish.....	-	-	tr	-	-
Pacific Sand Lance....	-	-	2	-	-
Unidentified Fish.....	-	3	2	1	tr

Table 12. Comparison of the importance of the main prey species of short-tailed shearwaters in Alaskan waters, by major geographic region and season. Prey Importance levels based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000 - 9,999 = 3; 10,000 and up = 4. Seasons: Sp = spring; Su = summer; F = fall.

	Bering Sea		Kodiak		
	Su	F	Sp	Su	F
Sample Size =	24	6	3	141	21
PREY NAME					
Nereid Polychaete.....	-	-	-	tr	tr
Unident. Gastropod....	-	-	-	tr	-
Gonatid Squid.....	-	1	-	-	-
Un. Squid/Cephalopod..	2	2	2	1	1
Parathemisto libellula Hyperiid Amphipod	-	3	-	-	-
P. pacifica..... Hyperiid Amphipod	-	tr	-	-	-
Gammarid Amphipod	-	-	-	-	tr
Thysanoessa inermis...	tr	-	3	2	tr
T. raschii.....	2	-	-	1	1
T. spinifera.....	-	-	-	1	tr
T. sp./Un. Euphausiid.	3	-	-	3	2
Telmessus chieragonus. Crab	-	-	-	tr	-
Unident. Decapod.....	-	-	-	tr	-
Unident. Crustacean...	-	-	3	-	tr
Capelin.....	-	-	-	2	3
Walleye Pollock.....	-	2	-	-	-
Pacific Sand Lance....	tr	-	-	1	tr
Unidentified Fish.....	-	1	2	1	2

Fish were utilized more sporadically by the birds sampled than were cephalopods or crustaceans. In the Bering Sea, walleye pollock had been eaten by birds collected in the fall, and in the Kodiak region, capelin were important in the diet of birds collected in summer and fall. Pacific sand lance were present in the diets of birds from both areas, but were of low importance compared to other foods.

Pelagic Cormorant

Food samples from this species were obtained from five birds collected in the spring in the Kodiak region, and from four birds each in summer in Kodiak and the NEGOA regions (Table 13). Except for sea urchins and unidentified decapods (shrimps and crabs), the diet of birds collected consisted of fish. Capelin and pollock were important to birds from the Kodiak region, and Pacific sand lance were important dietary components to birds from both regions.

Black-legged Kittiwake

Comparative samples were available from the summer and fall seasons, and from the Bering, WGOA, Kodiak, lower Cook Inlet (LCI), and NEGOA regions (Table 14). Over this broad geographical range, kittiwakes ate a wide variety of crustaceans, fish, and other prey, although they ate many of these in trace amounts only.

In general, amphipods appeared to be important foods of kittiwakes in all areas. The gammarid amphipod Paracallisoma alberti was eaten by birds from the WGOA and NEGOA in fall, while the hyperiid amphipod Parathemisto libellula was important to birds from the Bering and LCI regions in fall. The occurence of P. libellula in birds from LCI is noteworthy, since it provides records of this crustacean at the sea surface in an area between its previously-known disjunct distribution over shelf waters of the Bering Sea (the apparant center of its distribution) and southeastern Alaska (Wing 1976). Similarly, the occurence of a specimen of Parathemisto japonica in a summer bird from the Kodiak region represents an eastward extension from its previously-known eastern range limit near Unimak Pass (Fukuchi 1970).

Euphausiids assumed moderate to low importance to birds from the Kodiak and NEGOA regions, but they were absent from the diet of 10 birds from the Bering region. Thysanoessa inermis was common in the diet of summer birds from Kodiak and NEGOA, while T. spinifera was moderately important to fall birds from Kodiak and to summer birds from the NEGOA region.

Capelin were prominent in the diet of birds from the Kodiak region, especially in summer. Walleye pollock had been eaten by birds from all regions, but appeared to be most important in the Bering region. Pacific sand lance were consistently present in the diet of birds from the Kodiak, LCI and NEGOA regions. Four birds from the LCI region in fall had eaten Pacific herring, but this species was otherwise absent from the diet of birds from other areas.

Table 13. Comparison of the importance of the main prey species of adult pelagic cormorants in Alaskan waters, by major geographic region and season. Prey Importance levels based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000 - 9,999 = 3; 10,000 and up = 4. Seasons: Sp = spring; Su = summer.

	Kodiak		Northeastern Gulf of Alaska
	Sp	Su	Su
Sample Size =	5	4	4
PREY NAME			
Echinoid (Sea.Urchin).	_	2	-
Unident. Decapod.....	1	-	-
Capelin.....	-	3	-
Walleye Pollock.....	2	-	-
Unident. Cottid Fish..	-	-	3
Pacific Sand Lance....	4	3	3

Table 14. Comparison of the importance of the main prey species of black-legged kittiwakes in Alaskan waters, by major geographic region and season. Prey Importance levels based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000 - 9,999 = 3. Seasons: Su = summer; F = fall.

	Bering Sea		W Gulf of Ak.	Kodiak		Lower Cook Inlet	NE Gulf of AK	
	Su	F	F	Su	F	F	Su	F
Sample Size =	4	6	5	201	28	4	16	3
PREY NAME								
Nereid Polychaete.....	2	-	-	2	tr	-	2	-
Unident. Cephalopod...	-	1	-	-	-	-	1	-
Katharina tunicata....	-	-	-	tr	-	-	-	-
Chiton								
Limacina helicina.....	-	-	-	-	-	-	2	-
Pteropod								
Blue Mussel.....	-	-	-	tr	-	-	tr	-
Calanoid Copepod.....	-	-	-	tr	-	-	-	-
Gooseneck Barnacle....	-	-	-	tr	-	-	-	-
Amphipods								
Paracallisoma alberti.	-	-	3	-	-	-	-	3
Unidentified Gammarid.	-	-	-	tr	tr	-	-	-
Parathemisto libellula	-	3	-	-	-	3	-	-
P. pacifica.....	-	-	2	-	-	-	-	-
P. japonica.....	-	-	-	tr	-	-	-	-
Euphausiids								
Thysanoessa inermis...	-	-	-	2	tr	-	2	-
T. raschii.....	-	-	-	tr	-	-	-	-
T. spinifera.....	-	-	-	tr	2	-	2	-
Decapods								
Hymenodora frontalis..	-	-	-	-	-	-	-	-
Pac. Ambereye Shrimp								
Pandalopsis dispar....	-	-	-	-	1	-	-	-
Sidestripe Shrimp								
Unident. Pandalid.....	-	-	-	-	1	-	-	-
Cancer sp. (Crab).....	-	-	-	-	-	2	-	-
Unidentified.....	-	-	2	-	-	-	-	-
Fish								
Pacific Herring.....	-	-	-	-	-	3	-	-
Capelin.....	-	-	-	3	2	-	-	-
Unident. Osmerid.....	-	-	-	1	-	-	2	3
Pacific Cod.....	-	1	-	-	-	-	-	-
Walleye Pollock.....	2	3	2	tr	1	2	1	-
Unidentified Gadid....	-	-	3	tr	1	-	-	2
Pacific Sandfish.....	-	-	-	tr	-	-	-	-
Pacific Sand Lance....	-	-	-	2	3	3	3	-
Unidentified.....	3	-	2	2	2	2	2	3

Common Murre

Compared with other species, sample sizes from murres were distributed fairly evenly among all seasons in the Bering, LCI, NEGOA, and particularly in the Kodiak regions (Table 15). The overall diet of common murres was dominated by fish, but they had eaten some crustaceans.

Mysids were important foods of birds collected in winter in Kodiak (Acanthomysis sp.) and LCI (Neomysis rayii). Euphausiids were of moderate importance to birds collected in summer in the Bering Sea (Thysanoessa raschii) and Kodiak (T. inermis). Shrimps had low to moderate importance for birds collected in winter in Kodiak (unidentified pandalids), and LCI (pink and humpy shrimp; Eualus sp.), and in LCI in spring (pink shrimp and Crangon franciscorum).

The kittiwakes collected had eaten at least 10 species of fish from the four regions sampled, but three species stood out as important foods: Capelin, walleye pollock, and Pacific sand lance. Capelin had been eaten by birds in the Bering region in summer, in the Kodiak region during all seasons, in the LCI region in winter, spring and fall, and in the NEGOA region in summer. Pollock was an important food of Kodiak birds in winter and spring, but less so in summer and fall. In the LCI region, pollock were of low or moderate importance in winter and spring. Pacific sand lance were present in the diet of birds from the Bering region in summer, and they were present in Kodiak birds during all four seasons (lowest importance in winter, intermediate in spring and summer, and highest in the fall). In the LCI region in winter sand lance were a trace item in the murres' diet, but in the NEGOA region in summer they were an important food in the diet of nine birds collected.

Thick-billed Murre

Thick-bills were collected in the Bering, Aleutian, WGOA and Kodiak regions (Table 16). Unidentified cephalopods were the only prey of murres collected in winter in the Aleutian and WGOA regions, and they were also prominent in the diet of Aleutian birds in summer. Parathemisto libellula was an important food of birds from the Bering region in summer and fall, and euphausiids were similarly important to Aleutian birds in summer; Thysanoessa inermis was a component in samples from the Kodiak region in summer.

Capelin were important to summer birds from Kodiak, but they were otherwise absent from the diet of thick-billed murres. Arctic Cod, a species not found south of the Bering Sea, was of moderate importance there to birds collected in summer, while pollock had been eaten by birds taken from both the Bering and Kodiak regions in summer, but not elsewhere. The "unidentified gadids" important to birds from the Bering region in fall were likely walleye pollock (cf. notes on prey identity in a preceeding section). Pacific sand lance were found only in thick-bills collected in summer in the Bering and Kodiak regions.

Marbled Murrelet

Marbled murrelets were collected in all four regions of the Gulf of Alaska: WGOA, Kodiak, LCI, and NEGOA (Table 17). Fish were generally the

Table 15. Comparison of the importance of the main prey species of common murres in Alaskan waters, by major geographic region and season. Prey Importance levels based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000 - 9,999 = 3; 10,000 and up = 4; x = present. Seasons: W = winter; Sp = spring; Su = summer; F = fall.

	Bering Sea			Kodiak				Lower Cook Inlet			NE Gulf of AK	
	W	Su	F	W	Sp	Su	F	W	Sp	F	W	Su
Sample Size =	1	6	1	11	11	81	8	23	9	5	2	9
PREY NAME												
Nereid Polychaete.....	-	-	-	tr	-	-	-	tr	-	-	-	-
Unidentified Squid....	-	-	-	-	-	tr	-	-	-	-	-	-
Acanthomysis sp.....	-	-	-	2	-	-	-	-	-	-	-	-
Neomysis rayii.....	-	-	-	-	-	-	-	3	-	-	-	-
Anonyx sp.(gamm. amph)	-	-	-	-	-	-	-	-	-	-	x	-
Gammarid Amphipod.....	-	-	-	1	-	-	-	-	-	-	-	-
Euphausiids												
Thysanoessa inermis...	-	-	-	tr	-	2	-	-	-	-	-	-
T. raschii.....	-	2	-	-	-	tr	-	-	-	-	-	-
T. sp./Un. Euphausiid.	-	-	-	-	-	2	-	-	-	-	-	-
Shrimp												
Eualus sp.....	-	-	-	-	-	-	-	tr	-	-	-	-
Pink Shrimp.....	-	-	-	tr	-	-	-	2	3	-	-	-
Humpy Shrimp.....	-	-	-	-	-	-	-	tr	-	-	-	-
Unidentified Pandalid.	-	-	-	2	-	-	-	1	-	-	-	-
Crangon franciscorum..	-	-	-	-	-	-	-	1	2	-	-	-
Unidentified Shrimp...	-	-	-	-	-	-	-	1	2	-	-	-
Unidentified Insect...	-	-	-	-	-	-	-	-	-	-	x	-
Fish												
Pacific Herring.....	-	-	-	-	-	-	-	1	-	-	-	-
Capelin.....	-	3	-	2	2	3	3	1	2	3	-	1
Pacific Cod.....	-	-	-	-	-	tr	-	-	-	-	-	-
Pacific Tom Cod.....	-	-	-	-	-	tr	-	-	1	-	-	-
Walleye Pollock.....	-	-	x	3	3	1	1	1	2	-	-	-
Unidentified Gadid....	x	2	-	2	3	1	-	tr	2	-	-	-
Pacific Sandfish.....	-	-	-	tr	-	1	-	-	-	-	-	-
Daubed Shanny.....	-	-	-	1	-	-	-	-	2	-	-	-
Snake Prickleback.....	-	-	-	-	-	-	-	-	-	-	-	2
Pacific Sand Lance....	-	2	-	1	2	2	3	tr	-	-	-	3
Pleuronectid flounder.	-	-	-	-	-	tr	-	-	-	-	-	-
Unidentified Fish.....	-	3	-	-	1	2	1	1	2	3	-	2

Table 16. Comparison of the importance of the main prey species of thick-billed murres in Alaskan waters, by major geographic region and season. Prey Importance levels based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000 - 9,999 = 3; 10,000 and up = 4; x = present
Seasons: W = winter; Sp = spring; Su = summer; F = fall.

	Bering Sea			Aleutians			W Gulf of AK	Kodiak
	Sp	Su	F	W	Sp	Su	W	Su
Sample Size =	1	5	3	4	2	4	4	9
PREY NAME								
Nereid Polychaete.....	-	-	2	-	-	-	-	-
Unident. Gastropod....	-	-	-	-	-	-	-	1
Unident. Cephalopod...	-	-	-	4	x	3	4	1
Calanoid Copepod.....	-	-	-	-	-	1	-	-
Gammarid Amphipod.....	-	-	-	-	-	1	-	-
Parathemisto libellula	-	3	3	-	-	-	-	-
P. pacifica.....	-	-	-	-	x	-	-	-
Thysanoessa inermis...	-	-	-	-	-	-	-	1
Unident. Euphausiid...	-	-	-	-	-	3	-	-
Unident. Decapod.....	-	-	-	-	-	-	-	1
Crangon sp. (shrimp)..	-	2	-	-	-	-	-	-
Unidentified Crustacea	-	-	2	-	-	-	-	-
Capelin.....	-	-	-	-	-	-	-	3
Arctic Cod.....	-	2	-	-	-	-	-	-
Walleye Pollock.....	-	1	-	-	-	-	-	2
Unidentified Gadid....	x	1	3	-	-	-	-	2
Pacific Sand Lance....	-	2	-	-	-	-	-	2
Unidentified Fish.....	-	2	3	-	-	3	-	2

Table 17. Comparison of the importance of the main prey species of marbled murrelets in Alaskan waters, by major geographic region and season. Prey Importance levels based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000 - 9,999 = 3; 10,000 and up = 4; x = present. Seasons: W = winter; Sp = spring; Su = summer; F = fall.

	W Gulf of AK	Kodiak			Lower Cook Inlet			NE Gulf of AK	
	Su	W	Sp	Su	W	Sp	F	Su	F
Sample Size =	5	31	11	45	13	6	2	15	1
PREY NAME									
Nereid Polychaete.....	-	tr	-	-	-	-	-	-	-
L. sitkana(Periwinkle)	-	-	-	1	-	-	-	-	-
Unident. Gastropod....	-	-	-	tr	-	-	-	-	-
Blue Mussel.....	-	-	-	tr	-	-	-	-	-
Cephalopoda.....	-	-	-	tr	-	-		-	-
Acanthomysis sp.....	-	3	-	-	-	-	-	-	-
Neomysis rayii.....	-	1	-	-	-	-	x	-	-
N. sp./Un. Mysid.....	-	2	-	-	2	-	-	-	-
Gammarid Amphipod.....	-	tr	-	-	1	-	-	-	-
Euphausiids									
Thysanoessa inermis...	-	2	2	1	1	-	-	3	-
T. raschii.....	-	tr	1	-	2	3	-	-	-
T. spinifera.....	-	tr	-	-	1	-	-	1	-
T. sp./Un. Euphausiid.	2	1	-	tr	2	2	-	1	-
Pandalus borealis.....	-	tr	-	-	-	-	-	-	-
Unident. Decapod.....	-	-	-	tr	-	-	-	-	-
Arrow Worm (Chaetog.).	-	tr	-	-	-	-	-	-	-
Fish									
Capelin.....	-	2	3	3	3	3	-	1	x
Unidentified Osmerid..	2	2	1	-	tr	2	-	-	-
Walleye Pollock.....	-	tr	-	-	tr	-	-	-	-
Unidentified Gadid....	-	-	-	tr	tr	-	-	-	-
Pacific Sandfish.....	2	-	-	1	-	-	-	2	-
Pacific Sand Lance....	2	-	2	3	2	-	x	3	x
Unidentified Fish.....	3	1	1	3	2	-	-	2	-

most important kinds of prey, but crustaceans were also sometimes heavily utilized. In addition, birds from the Kodiak region had eaten small amounts of nereid polychaetes, periwinkle "snails," blue mussels, cephalopods and arrow worms (Chaetognatha). The periwinkles and mussels indicate that the murrelets collected had foraged on the bottom.

Capelin were prominent in the diet of birds taken in the Kodiak region during winter, spring and summer, and in the LCI region during winter and spring. Small amounts of capelin were found in the stomachs of birds from the NEGOA region in summer. Pacific sand lance had been eaten by birds in all regions: In WGOA, Kodiak, and NEGOA in summer; in Kodiak in spring; and, in LCI in winter. Pacific sandfish were of moderate importance in the summer diets of birds from the WGOA and NEGOA regions, but of low importance to summer birds from Kodiak. Walleye pollock and unidentified gadids occured in trace amounts during winter in the stomachs of murrelets from the Kodiak and LCI regions, and during summer in Kodiak birds.

During summer in the WGOA region, unidentified euphausiids were the only prey besides fish. Mysids were important winter foods of birds from the Kodiak and LCI regions, and euphausiids of the genus Thysanoessa figured heavily in the winter and spring diets of birds collected in both the Kodiak and LCI regions. T. inermis had a low importance to summer birds from Kodiak, but in the NEGOA region in summer it was relatively more important.

Kittlitz's Murrelet

This little-known species was collected in the Bering region in spring, and in the Kodiak and NEGOA regions in summer (Table 18). The diet of murrelets from the Bering region was solely crustaceans (the euphausiid T. spinifera) and unidentified gammarid amphipods), while in the Gulf of Alaska regions, the birds' diets consisted of both crustaceans and fish.

In the Kodiak region, T. inermis, capelin and Pacific sand lance were equally important in the diet of birds collected, while in the NEGOA region Kittlitz's murrelets had eaten euphausiids (T. spinifera and unidentified), Pacific herring, unidentified osmerids, and Pacific sandfish.

Horned Puffin

Horned puffins were collected during summer in the Aleutian, WGOA, Kodiak, LCI and NEGOA regions, and during fall and winter in the Kodiak region (Table 19). In the Aleutian region, gonatid squid and unidentified cephalopods and unidentified fish were the main prey of three birds collected, and they had eaten nereid polychaetes as well.

Although capelin was the main prey of summer birds from the WGOA region, this was the only region where crustaceans made up a substantial portion of the diet as well. The euphausiid Thysanoessa inermis and the shrimp Pandalus montagui assumed moderate importance there, along with unidentified euphausiids and Pacific sand lance.

In the Kodiak region Pacific sand lance and pleuronectid flatfish

Table 18. Comparison of the importance of the main prey species of Kittlitz's murrelets in Alaskan waters, by major geographic region and season. Prey Importance levels based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000 - 9,999 = 3; 10,000 and up = 4; x = present Seasons: Sp = spring; Su = summer.

	Bering Sea	Kodiak	NE Gulf of AK
	Sp	Su	Su
Sample Size =	3	7	4
PREY NAME			
Gammarid Amphipods....	2	-	-
Thysanoessa inermis...	-	2	-
T. spinifera.....	3	-	2
Unident. Euphausiids..	3	-	3
Pacific Herring.....	-	-	2
Capelin.....	-	2	-
Unidentified Osmerid..	-	-	2
Pacific Sandfish.....	-	-	3
Pacific Sand Lance....	-	2	-
Unidentified Fish.....	-	3	3

Table 19. Comparison of the importance of the main prey species of horned puffins in Alaskan waters, by major geographic region and season. Prey Importance levels based on their IRI values, as follows: 0 - 9 = trace (tr); 10 - 99 = 1; 100 - 999 = 2; 1,000 - 9,999 = 3; 10,000 and up = 4; x = present. Seasons: W = winter; Su = summer; F = fall.

	Aleutians	W Gulf of AK	Kodiak			L Cook Inlet	NE Gulf of AK
	Su	Su	W	Su	F	Su	Su
Sample Size =	3	6	1	15	8	3	2
PREY NAME							
Nereid Polychaete.....	2	-	-	1	-	-	-
Unidentified Chiton...	-	-	-	1	-	-	-
Gonatid Squid.....	3	-	-	-	-	-	-
Unident. Cephalopod...	3	-	-	-	-	-	-
Anisogammarus pugettensis (Gam. Amphipod)	-	-	-	1	-	-	-
Acanthomysis (Mysid)..	-	-	x	-	-	-	-
Thysanoessa inermis...	-	2	x	-	-	-	-
T. spinifera.....	-	-	x	-	-	-	-
Unident. Euphausiid...	-	2	-	-	-	-	-
Pandalus montagui.....	-	2	-	1	-	-	-
Pacific Herring.....	-	-	-	-	-	-	-
Capelin.....	-	3	x	1	4	-	-
Unidentified Osmerid..	-	-	-	-	-	-	-
Walleye Pollock.....	-	-	-	-	1	-	-
Unident. Gadidae.....	-	-	-	-	1	-	-
Three-spine Stickleback	-	-	-	-	1	-	-
Kelp Greenling.....	-	-	-	-	-	-	-
Pacific Sand Lance....	-	2	-	3	2	-	x
Pleuronectid Flounder.	-	-	-	2	-	-	-
Unidentified Fish.....	3	3	x	3	-	4	-

were the most important summer prey, but the 15 birds collected had also eaten lesser amounts of capelin, P. montagui, a gammarid amphipod (Anisogammarus pugettensis), nereid polychaetes, and chitons. The fall diet, however, was dominated by capelin, with lesser amounts of Pacific sand lance present, and small amounts of pollock and three-spined sticklebacks. Mysids, euphausiids, and capelin were present in the stomach of the lone bird collected in winter.

Unidentified fish was the only prey found in summer birds from the LCI region, and Pacific sand lance was the only prey in two birds from the NEGOA region in summer.

Tufted Puffin

The tufted puffin had the distinction of being the only species sampled extensively enough to compare among all six geographic regions. Only the summer season was represented in all regions, however, and other seasons had sporadic regional sampling (Table 20). Nineteen kinds of prey occurred in the samples, although six of them were present in trace quantities only, in birds sampled during summer in the Kodiak region (n = 282).

Unidentified cephalopods and squid had been eaten in all regions except LCI, and they had an importance level of 4 (IRI $\geq$ 10,000) for birds sampled during both winter and summer in the Aleutian region, and during winter in the WGOA region. Cephalopopds and squid were of relatively low importance to summer puffins from the Kodiak region, however.

The hyperiid amphipod Parathemisto libellula was present in winter and fall birds from the Bering region, but not elsewhere. Unidentified euphausiids were present in summer birds from the Aleutian region, and euphausiids of the genus Thysanoessa had been eaten by birds collected during summer in the WGOA region, and during spring and summer in the Kodiak region. T. inermis was the most important prey of birds collected in the WGOA region, and in the Kodiak region in spring; it assumed lesser importance to Kodiak birds in summer, however, and was not present in nine birds collected there during fall. T. spinifera was moderately important to Kodiak birds in spring, but decreased to trace presence in birds collected there during summer. Pandalid shrimp were of only trace importance in summer birds from Kodiak.

Among fish eaten by tufted puffins, capelin was by far the most important to birds from the Kodiak region in summer and fall, and least important there in spring. Capelin were of intermediate importance in the stomachs of birds collected during summer in the Bering, WGOA, and NEGOA regions, but capelin were not found in birds collected in the Aleutian or LCI regions. Walleye pollock, in contrast, was the most important fish prey to birds from the Bering region in summer and fall, and least important to Kodiak birds during spring and summer, and to NEGOA birds in summer.

Unidentified gadids were important to birds sampled during winter in the Aleutian region. Pacific sand lance were of moderate importance to birds collected in the Kodiak region in summer and fall, they were of

Table 20. Comparison of the importance of the main prey of tufted puffins in Alaskan waters, by major geographic region and season. Prey Importance levels based on IRI values: 0-9 = trace (tr); 10-99 = 1; 100-999 = 2; 1,000-9,999 = 3; 10,000 and up = 4; x = present Seasons: W = winter; Sp = spring; Su = summer; F = fall.

	Bering Sea			Aleutians		W Gulf of AK			Kodiak			Lower Cook Inlet		NE Gulf of AK
	W	Su	F	W	Su	W	Sp	Su	Sp	Su	F	Sp	Su	Su
Sample Size =	1	8	3	4	4	3	2	8	14	282	9	2	2	22
PREY NAME														
Nereid Polychaete.....	-	-	2	-	1	-	-	-	1	tr	-	-	-	-
Limacina helicina.....	-	-	-	-	-	-	-	-	-	tr	-	-	-	-
Pteropod Cephalopods/Squid.....	-	1	-	4	4	4	x	2	tr	2	1	-	-	3
Calanoid Copepods.....	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Gammarid Amphipods.....	-	-	-	-	-	-	-	-	tr	-	-	-	-	-
Parathemisto libellula	x	-	3	-	-	-	-	-	-	-	-	-	-	-
Thysanoessa inermis...	-	-	-	-	-	-	-	3	4	2	-	-	-	-
T. raschii.....	-	-	-	-	-	-	-	-	-	tr	-	-	-	-
T. spinifera.....	-	-	-	-	-	-	-	-	2	tr	-	-	-	-
Unident. Euphausiids..	-	-	-	-	2	-	-	-	2	tr	-	x	-	-
Pandalid Shrimp.....	-	-	-	-	-	-	-	-	-	tr	-	-	-	-
Pagurid Crab.....	-	-	-	-	-	-	-	-	-	tr	-	-	-	-
Unident. Decapods.....	-	-	-	-	-	-	-	1	-	tr	1	-	-	-
Unident. Crustacea....	-	1	-	-	-	-	-	-	-	tr	-	-	-	tr
Red Salmon.....	-	-	-	-	-	-	-	-	-	tr	-	-	-	-
Capelin.....	-	2	-	-	-	-	-	2	1	3	3	-	-	2
Pacific Tom Cod.....	-	2	-	-	-	-	-	-	-	tr	-	-	-	-
Walleye Pollock.....	-	3	3	-	-	-	-	2	tr	1	-	-	-	1
Unidentfied Gadid.....	-	-	3	3	-	-	-	2	-	tr	-	-	-	1
Irish Lord.....	-	-	-	-	-	-	-	-	-	tr	-	-	-	-
Unidentified Cottid...	-	-	-	-	-	-	-	-	-	tr	-	-	-	-
Snailfish/Lumpsucker..	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Pacific Sandfish.....	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Pacific Sand Lance....	-	1	-	-	-	-	-	-	-	2	2	-	-	3
Unidentified Fish.....	-	3	-	1	-	2	x	2	1	1	2	x	x	2

high importance to summer birds from the NEGOA, low importance to summer birds from the Bering region, and they were absent from the stomachs of birds collected in all other seasons and regions.

DISCUSSION

It is evident from the lengthy lists of prey in the appendices that the 33 species of pelagic seabirds discussed in this report collectively eat a wide variety of fishes, crustaceans, cephalopods, and other prey. The minimum number of prey species eaten by a single species of pelagic bird range up to 29 (pigeon guillemot), and a few other species have lists of prey numbering in the 20's (glaucous-winged gull, black-legged kittiwake and common murre, 23 each; tufted puffin, 22).

Only a relatively few species of prey, however, stand out as having general importance to the entire community of pelagic birds studied. As determined by either the total number of species eating a prey, or by the cumulative IRI of the prey for all species eating it, or both (Table 21), two fishes stand out clearly as the most important species of prey to the plagic bird community as a whole: Pacific Sand Lance and Capelin. Sand lance were eaten by 17 species of birds, in which its cumulative IRI was 41,655, and capelin were eaten by 21 species of birds, in which its cumulative IRI was 30,973. Cephalopods (unknown number of species) were eaten by 12 bird species, and had a cumulative IRI of 20,208. The euphausiid Thysanoessa inermis was the third most important food species in general, and the most important crustacean to pelagic birds, being eaten by 16 species, and having a cumulative IRI of 19,496.

Although the cumulative importance of other prey to pelagic birds drops off considerably beyond these three species and total cephalopods, temporal and geographic influences on the apparent overall importance of other species of prey need to be considered. For example, epitoke (breeding) stages of nereid polychaetes, which swarm in dense concentrations at the water's surface (Meglitsch 1972), occured in 16 species of pelagic birds, and had a cumulative IRI of 8,239. Most of this value, however, was accounted for by the presence of nereids in seven red-necked phalaropes in which their IRI was 8,068. IRI values for the other 15 bird species ranged from less than one (five species) to 79 (Black-legged kittiwake). Nereids are extremely soft bodied and swarm at the surface at night (Meglitsch 1972). Their remains in the birds, which were collected from a few to several hours after dawn, usually consisted of only chitinous jaws. Had the birds been collected at night, however, the volume of nereids in their stomachs would have been much larger, resulting in correspondingly higher IRI values. Thus, these data probably underestimate the general importance of nereids to pelagic seabirds.

Similarly, few birds (about 6% of the total) were collected in the eastern Bering Sea where Walleye Pollock and the hyperiid amphipod Parathemisto libellula are major prey species of the bird community (Hunt et al. 1981). Pollock were eaten by 14 species of birds we studied (Table 21), but their cumulative IRI was relatively low (722), as was that of P. libellula (457). For the constrasting reason that about 74% of the samples were from the Kodiak region, the importance of Capelin to

Table 21. Summary of the overall utilization of the main and/or commercially-important prey of pelagic seabirds, as indicated by cumulative IRI of prey for all bird species eating it, and by the number of bird species eating it.

Kind or Species of Prey	Number of Bird Spp. Eating Prey	Cumulative IRI
Pacific Sand Lance	17	41,655
Capelin	21	30,973
Cephalopods	12	20,208
Thysanoessa inermis	16	19,496
Nereid Polychaetes	16	8,239
Pacific Herring	5	2,654
Mysids (*Acanthomysis* plus *Neomysis rayii*)	6	2,537
Thysanoessa spinifera	10	1,492
Walleye Pollock	14	722
Salmon spp.	4	585
Parathemisto libellula	5	457
Pandalid Shrimp	9	136
Pacific Halibut	1	112
Razor Clam	1	108
Sablefish	1	61
Pacific Cod	2	trace

Alaskan marine birds in general may not be as great as suggested by these data at face value. Capelin are apparently abundant around Kodiak (I. Warner, pers. commun.), but their relative abundance elsewhere in Alaskan waters is unknown.

Our data for the foods of marine waterfowl are relatively sketchy, although they are fairly well known for a few species in winter in Kachemak Bay (Sanger and Jones in press) and at Kodiak Island (Krasnow and Sanger 1982). In general, however, blue mussels (Mytilus edulis) and the clams Protothaca staminea, Spisula polynyma, Macoma spp., and Mya spp. should be considered important foods of marine waterfowl in the Gulf of Alaska. Interestingly, capelin were eaten by oldsquaws and Pacific sand lance were eaten by both oldsquaws and white-winged scoters, further indicating the importance of these two fishes to the marine bird community.

UTILIZATION OF COMMERCIALLY-IMPORTANT PREY BY SEABIRDS

Walleye pollock support a world-class fishery in the eastern Bering Sea (Frost and Lowry 1981), and their heavy use by seabirds and other vertebrates there has been well documented (Frost and Lowry loc. cit.; Hunt et al. 1981). The results of the present study, however, suggest far less dependence by birds on currently harvested species of fish and shellfish in the Gulf of Alaska. Commercially valuable species eaten by the birds we studied include Pacific herring, pollock, Pacific cod, salmon, sablefish, razor clams, and pandalid shrimps, but their cumulative IRI values are generally low (Table 21). However, no attempt was made to sample birds at times and in areas known to harbor concentrations of commercial species that were potentially of sizes eaten by the birds (Krasnow and Sanger 1982; Sanger, unpublished data). The scarcity of juvenile salmon and herring in the diets of the birds is particularly curious, because they would seem to be ideal sizes to be eaten by seabirds, and salmon smolts generally migrate to sea during late spring and summer, the seasons for which our seabird feeding habits data are most complete.

At present, the eastern subarctic Pacific Ocean is the only major geographic region in the northern hemisphere without a commercial fishery for Capelin (Jangaard 1974). There is little information available on the size of capelin stocks in Alaskan waters, but in addition to the species' heavy utilization by seabirds and by pinnepeds (Pitcher 1980; Kajimura, personal communication), capelin have been caught in abundance with shrimp trawls during surveys in Kodiak Island waters (Irving Warner, pers. communication). Consequently, the development of fisheries for capelin or sand lance could have far more serious consequences to seabirds than existing fisheries do; this is a situation that warrants continued close observation.

POTENTIAL EFFECTS OF PETROLEUM DEVELOPMENT

The negative effects of direct oiling to seabirds has already been dealt with extensively (e.g., Vermeer and Vermeer 1974). Indirect effects of petroleum pollution to seabirds are suspected to be adverse, but

they are relatively unknown (Krasnow and Sanger 1982). On the basis this study, however, any pollution event that would substantially affect populations of the main prey discussed above would presumably have serious negative consequences to marine birds and their ecosystems.

NEEDS FOR FURTHER STUDY

Data discussed in this report are largely pooled from food samples collected over extensive geographic regions and during several years and seasons. This allows fairly broad, generalized conclusions to be made about the kinds of foods seabirds eat and how they relate trophically, but this information needs to be viewed very cautiously when applied to the dynamic ecosystems of which seabirds are a part. The ocean is constantly changing, both physically and biologically; some of these changes are fairly predictable, but some are not.

To further our understanding of how seabirds relate to their oceanic environment, future studies must emphasize replicate collections of seabird food samples and their prey in nature during all seasons and within welldefined geographic/oceanographic frames. Petroleum pollution or other negative environmental perturbations take place on well-defined geographic and time scales, and it could be misleading to the detriment of seabird populations to assume that the information in this report would be adequate to address information needs from a particular pollution event.

The diets of nestlings and the feeding ecology of marine birds as related to their productivity in the Gulf of Alaska is discussed in some detail by Baird (1983), but relationships between seabird productivity, the proximity of nesting colonies to foraging areas at sea, and the distribution and availability of prey populations remain essentially unknown. Similarly, information and ideas about the nature of trophic relationships between primary productivity and seabirds appear to be scanty. Enough information appears to be available from OCSEAP studies in other disiplines and the literature, however, to at least begin to form hypotheses about these relationships.

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Appendix Table 1. Data on Indices of Relative Importance (IRI) for prey of northern fulmars, pooled from birds collected in Alaskan waters.

Species: Northern Fulmar (Fulmarus glacialis) Minimum # Prey Species = 10

N = 46 No. Empty = 3(6.5%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereidae	1.3	<.1	2.3	3
CLAMS, Unidentified	3.0	<.1	2.3	7
CEPHALOPODA				
Gonatid Squid	12.6	2.5	11.6	175
Unidentified Squid	58.9	60.1	81.4	9,687
Total Squid	71.5	62.6	81.4	10,916
CRUSTACEA				
Unidentified	<.1	<.1	4.6	2
Calanoid Copepod	8.2	1.0	2.3	21
Amphipoda				
Paracallisoma alberti	<.1	<.1	2.3	<1
Parathemisto pacifica	<.1	<.1	2.3	<1
Unidentified	1.7	2.3	9.3	37
Total Amphipoda	1.7	2.3	9.3	37
Euphausiacea				
Thysanoessa inermis	4.7	1.4	2.3	14
Unidentified	1.7	<.1	2.3	4
Total Euphausiacea	6.4	1.4	2.3	17
Total Crustacea	16.3	1.4	2.3	195
FISHES				
Mallotus villosus	<.1	2.3	2.3	6
Unidentified Gadidae	1.2	6.1	7.0	51
Theragra chalcogramma	1.2	2.8	2.3	9
Unidentified	3.0	15.4	11.6	213
Total Osteichthyes	5.4	26.6	7.0	224
BIRDS				
Oceanodroma furcata Fork-tailed Storm Petrel	<.1	5.1	2.3	12

Appendix Table 2. Data on Indices of Relative Importance (IRI) for prey of sooty shearwaters, pooled from birds collected in Alaskan waters.

Species: Sooty Shearwater (*Puffinus griseus*) Min. # Prey Species = 14

N = 187 No. Empty = 9(4.8%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereidae	0.2	<.1	1.1	<1
CEPHALOPODA				
Unidentified Squid	7.7	1.0	28.4	247
Gonatidae	1.9	0.1	2.3	4
Onychoteuthis borealijaponicus	0.0	0.0	0.6	<1
Unidentified	38.1	1.0	40.9	1,599
Total Squid	40.7	1.1	40.9	1,710
Total Cephalopoda	47.7	2.1	40.9	2,037
CRUSTACEA				
Calanoid Copepod	0.1	0.0	0.6	<1
Amphipoda				
Paracallisoma alberti	0.2	0.0	1.1	<1
Parathemisto pacifica	1.1	0.1	0.6	<1
Unidentified Hyperiidea	0.0	0.0	0.6	<1
Total Amphipoda	1.3	0.1	1.1	2
Euphausiacea				
Thysanoessa inermis	19.2	2.5	5.1	111
Thysanoessa raschii	0.1	0.0	0.6	<1
Thysanoessa spinifera	0.0	0.1	0.6	<1
Thysanoessa sp.	0.5	0.0	0.6	<1
Unidentified	0.1	0.0	0.6	<1
Total Euphausiacea	19.9	2.7	5.1	115
Total Crustacea	21.3	2.8	5.1	123
FISHES				
Mallotus villosus Capelin	22.7	83.1	50.0	5,290
Unidentified Osmerid	0.3	0.4	3.4	2
Stenobrachius nannochir Lanternfish	0.0	0.6	0.6	<1
Microgadus proximus Pacific Tomcod	0.0	0.2	0.6	<1
Trichodon trichodon Pacific Sandfish	0.1	0.2	1.1	<1
Ammodytes hexapterus Pacific Sandlance	6.0	6.5	8.0	100
Unidentified	1.8	4.1	18.8	112
Total Fish	30.9	95.1	50.0	6,300

Appendix Table 3. Data on Indices of Relative Importance (IRI) for prey of short-tailed shearwaters, pooled from birds collected in Alaskan waters.

Species: Short-tailed Shearwater (*Puffinus tenuirostris*) Minimum # Prey Species = 14

N = 228 No. Empty = 27(11.8%)

PREY SPECIES	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereidae	0.1	<.1	2.5	<1
GASTROPODA, Unidentified	<.1	<.1	1.0	<1
CEPHALOPODA				
Unidentified	0.6	1.5	36.8	77
Squid				
Gonatidae, Unidentified	<.1	<.1	0.5	<1
Unidentified	<.1	<.1	0.5	<1
Total Cephalopoda	0.6	1.5	36.8	77
CRUSTACEA				
Unidentified	0.3	0.5	2.0	2
Calanoid Copepod	<.1	<.1	0.5	<1
Amphipods				
Gammaridea, Unidentified	<.1	<.1	0.5	<1
Parathemisto libellula	1.7	1.3	1.5	4
Parathemisto pacifica	<.1	<.1	0.5	<1
Total Amphipods	1.7	1.3	1.5	4
Euphausiids				
Thysanoessa inermis	12.8	9.1	13.9	305
T. raschii	2.6	1.8	9.0	40
T. spinifera	3.5	2.3	9.0	52
Thysanoessa sp.	74.4	32.0	22.4	2,383
Euphausiidae, Unidentified	1.3	0.4	2.0	3
Unidentified	0.6	0.4	6.0	6
Total Euphausiids	95.2	46.0	22.4	3,163
Decapod, Unidentified	0.1	<.1	1.5	<1
Telmesus cheiragonus	<.1	<.1	0.5	<1
Total Crustacea	97.3	47.8	22.4	3,250
FISHES				
Unidentified	0.1	1.9	11.9	24
Mallotus villosus	1.3	41.0	19.9	841
Osmeridae, Unidentified	0.2	4.9	7.5	38
Theragra chalcogramma	<.1	0.7	0.5	<1
Ammodytes hexapterus	0.3	2.2	4.0	10
Total Fishes	1.9	50.7	19.9	1,047

Appendix Table 4. Data on Indices of Relative Importance (IRI) for prey of Fork-tailed Storm Petrels, pooled from birds collected in Alaskan waters.

Species: Fork-tailed Storm Petrel (*Oceanodrama furcata*) Min. # Prey Species = 6

N = 14 No. With Food = 8(57.1%)

PREY SPECIES	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA				
Unidentified Nereid	1.6	2.8	12.5	55
CEPHALOPODA				
Unidentified Squid	3.2	42.8	25.0	1,150
Unidentified	6.3	15.7	37.5	826
Total Cephalopoda	9.5	58.5	37.5	2,550
CRUSTACEA				
Calanoid Copepod	11.1	2.7	12.5	173
Paracallisoma alberti Gammaridean Amphipod	3.2	5.7	12.5	111
Euphausiacea				
Thysanoessa spinifera	47.6	11.3	12.5	737
Thysanoessa sp.	12.7	3.1	12.5	197
Total Euphausiacea	60.3	14.4	12.5	934
Unidentified Decapoda	1.6	8.6	12.5	127
Total Crustacea	76.2	31.4	12.5	1,345
FISHES				
Theragra chalcogramma Walleye Pollock	1.6	4.3	12.5	73
Unidentified	11.1	2.9	12.5	175
Total Fishes	12.7	7.2	12.5	249

Appendix Table 5. Data on Indices of Relative Importance (IRI) for prey of nestling double-crested cormorants from food samples collected in Alaskan waters.

Species: Double-crested Cormorant, N = 2 (Phalacrocorax auritus) Min. # Prey Species = 2

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
CRUSTACEA				
Crangon septemspinosa	25.0	2.8	50.0	1,390
FISH				
Unidentified	75.0	97.2	100.0	17,220

Appendix Table 6. Data on Indices of Relative Importance (IRI) for prey of adult pelagic cormorants, pooled from birds collected in Alaskan waters.

Species: Pelagic Cormorant, N = 16 (none empty) (Phalacrocorax pelagicus) Min. # Prey Species = 9

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
ECHINODERMATA				
Echinoida (Sea Urchins)	0.5	0.1	6.3	4
CRUSTACEA				
Mysida (Opposum Shrimps)	0.5	<.1	6.3	3
Gammaridean Amphipoda	3.0	0.1	6.3	19
Unidentified Decapoda	1.5	0.4	18.8	35
FISHES				
Mallotus villosus	4.0	8.8	12.5	160
Theragra chalcogramma	0.5	7.8	6.3	52
Unidentified Gadidae	7.0	1.3	6.3	52
Ammodytes hexapterus	73.1	45.7	62.5	7,424
Unidentified Cottidae	0.5	12.3	6.3	80
Unidentified	9.5	23.4	25.0	822

Appendix Table 7. Data on Indices of Relative Importance (IRI) for prey of nestling pelagic cormorants, pooled from food samples collected in Alaskan waters.

Species: Pelagic Cormorant (nestlings), N = 15 (Phalacrocorax pelagicus) Min. # of Prey Species = 5

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA				
Unidentified	1.7	<.1	6.7	11
INSECTA				
Diptera	22.0	0.2	26.7	593
CRUSTACEA				
Crab	1.7	1.0	6.7	18
FISH				
Ammodytes hexapterus	44.1	72.7	33.3	3,889
Gadidae	1.7	1.0	6.7	18
Unidentified	28.8	25.1	66.7	3,595

Appendix Table 8. Data on Indices of Relative Importance (IRI) for prey of adult red-faced cormorants, pooled from birds collected in Alaskan waters.

Species: Red-faced Cormorant (adults) (*Phalacrocorax urile*) Min. # of Prey Species = 6

N = 2 (neither empty)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA				
Unidentified Nereidae	1.3	0.8	50.0	105
CRUSTACEA				
Valviferan Isopod	1.3	0.8	50.0	105
Shrimp				
Lebbeus polaris	32.0	11.8	50.0	2,188
Pandalus jordani	2.7	3.0	50.0	281
FISH				
Unidentified	10.7	6.4	50.0	856
Hemilepidotus jordani	1.3	6.4	50.0	389
Ammodytes hexapterus	50.7	70.9	50.0	6,078

Appendix Table 9. Data on Indices of Relative Importance (IRI) for prey of nestling red-faced cormorants, pooled from food samples collected in Alaskan waters.

Species: Red-faced Cormorant (nestlings) (*Phalacrocorax urile*) Min. # Prey Species = 4

N = 7 (regurgitation samples)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
INSECTA				
Diptera	9.8	0.9	42.9	458
FISH				
Mallotus villosus	14.6	11.1	28.6	735
Unidentified Osmeridae	7.3	1.8	28.6	260
Gadidae	1.2	4.2	14.3	77
Ammodytes hexapterus	64.6	81.3	71.4	10,424
Unidentified	2.4	0.8	14.3	46

Appendix Table 10. Data on Indices of Relative Importance (IRI) for prey of oldsquaws, pooled from birds collected in Alaskan waters.

Species: Oldsquaw (Clangula hyemalis) Minimum # Prey Species = 94
N = 70 No. Empty Stomachs = 0

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
FORAMINIFERA	0.2	0.1	7.1	2
RHYNCHOCOELA, Unidentified	<.1	0.2	1.4	<1
POLYCHAETA				
Unidentified	0.2	2.2	18.6	45
Harmothoe extenuata	<.1	0.1	1.4	<1
Harmothoe sp.	<.1	<.1	1.4	<1
Phloe minuta	0.5	0.1	4.3	3
Anaitides mucosa	<.1	0.1	1.4	<1
Phyllodoce sp.	<.1	<.1	1.4	<1
Eteone longa	<.1	<.1	1.4	<1
Eteone sp.	<.1	0.1	2.9	<1
Phyllodocidae, Unidentified	<.1	<.1	1.4	<1
Syllidae, Unidentified	<.1	<.1	1.4	<1
Nereidae, Unidentified	<.1	0.1	2.9	<1
Glycinde picta	<.1	<.1	1.4	<1
Glycinde sp.	<.1	0.1	1.4	<1
Lumbrinereis sp.	<.1	<.1	1.4	<1
Cirratulidae, Unidentified	<.1	<.1	1.4	<1
Flabelligeridae, Unident.	<.1	<.1	1.4	<1
Travisia sp.	<.1	0.2	1.4	<1
Opheliidae, Unidentified	0.2	<.1	4.3	1
Owenia sp.	0.1	0.3	8.6	3
Pectinaria gouldii	<.1	<.1	1.4	<1
Pectinaria sp.	0.2	0.7	10.0	9
Ampharete sp.	<.1	0.6	1.4	1
Ampharetidae, Unidentified	0.2	0.6	1.4	1
Total Polychaeta	1.4	5.2	18.6	123
GASTROPODA				
Unidentified	0.8	0.8	18.6	30
Acmaeidae, Unidentified	0.1	0.3	1.4	1
Margarites pupillus	0.1	0.1	5.7	1
Margarites sp.	<.1	<.1	1.4	<1
Limpet species	<.1	0.1	2.9	<1
Lacuna variegata	3.2	3.0	28.6	177
Lacuna sp.	<.1	<.1	1.4	<1
Littorina sitkana	2.5	0.1	4.3	11
Alvinia compacta	2.7	0.6	34.3	113
Alvinia sp.	<.1	<.1	1.4	<1
Cingula katherinae	<.1	0.1	1.4	<1
Bittium sp.	<.1	0.1	1.4	<1

Appendix Table 10. Pooled IRI Data - Oldsquaws, page 2 of 4

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
Cerithiopsis sp.	<.1	<.1	1.4	<1
Melanella sp.	<.1	0.1	1.4	<1
Trichotropis insignis	<.1	<.1	1.4	<1
Trichotropus cancellata	0.1	0.1	2.9	1
Natica clausa	0.1	1.1	2.9	3
Natica sp.	<.1	0.1	1.4	<1
Unident. Mesogastropoda	0.1	0.2	1.4	<1
Trophonopsis pacificus	<.1	<.1	1.4	<1
Nucella lima	<.1	0.1	1.4	<1
Mitrella tuberosa	0.2	0.6	1.4	1
Neptunea sp.	<.1	<.1	1.4	<1
Nassarius sp.	<.1	<.1	1.4	<1
Olivella baetica	0.1	<.1	2.9	<1
Admete couthouyi	<.1	0.1	2.9	<1
Mangelia sp.	0.4	0.7	5.7	6
Oenopota sp.	0.9	1.3	8.6	19
Turridae, Unidentified	0.1	0.3	5.7	2
Odostomia sp.	0.3	0.2	17.1	9
Turbonilla sp.	0.1	0.2	1.4	<1
Philine sp.	<.1	<.1	1.4	<1
Aglaja diomedeum	<.1	<.1	2.9	<1
Retusa sp.	0.1	<.1	5.7	1
Onchidoris bilamellata	<.1	0.6	4.3	3
Total Gastropoda	11.9	10.9	34.3	782
BIVALVES				
Unidentified	0.4	2.0	25.7	63
Nucula tenuis	0.5	1.5	14.3	29
Nuculana fossa	0.4	0.6	11.4	12
Glycymeris subobsoleta	11.1	0.8	14.3	171
Glycymeris sp.	<.1	<.1	1.4	<1
Mytilus edulis	4.5	2.8	22.9	167
Musculus vernicosus	0.1	0.1	2.9	<1
Musculus sp.	<.1	<.1	1.4	<1
Mytilidae,Unident.	<.1	<.1	1.4	<1
Axinopsida sp.	<.1	<.1	1.4	<1
Orobitella sp.	<.1	<.1	1.4	<1
Astarte alaskensis	<.1	<.1	1.4	<1
Astarte esquimalti	<.1	<.1	1.4	<1
Clinocardium sp.	<.1	<.1	1.4	<1
Spisula polynyma	5.3	2.3	11.4	87
Macoma balthica	<.1	<.1	1.4	<1
Macoma sp.	2.0	1.5	7.1	25
Saxidomus gigantia	<.1	0.1	4.3	1
Saxidomus sp.	<.1	0.1	1.4	<1
Psephidia lordi	0.3	0.2	8.6	5
Protothaca staminea	0.4	2.0	22.9	56
Mya sp.	0.3	0.2	11.4	6
Total Bivalves	25.3	14.2	25.7	1,015

Appendix Table 10. Pooled IRI Data - Oldsquaws, page 3 of 4

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
SCAPHOPODA	<.1	<.1	1.4	<1
CRUSTACEA				
Harpacticus sp. (Copepod)	<.1	<.1	1.4	<1
Barnacles				
Unidentified	0.1	0.7	10.0	7
Gooseneck, Unidentified	<.1	0.4	7.1	3
Mysida				
Unidentified	24.2	10.3	2.9	99
Acanthomysis sp.	25.9	9.1	7.1	250
Neomysis sp.	<.1	0.1	2.9	1
Total Mysida	50.1	19.5	7.1	494
Cumacea				
Unidentified	1.4	0.5	8.6	16
Lamprops sp.	<.1	0.1	1.4	<1
Tanaidacea				
Unidentified	0.1	<.1	1.4	<1
Isopoda				
Gnorimosphaeroma oregonensis	<.1	<.1	1.4	<1
Amphipoda				
Gammaridea, Unidentified	0.3	5.8	17.1	105
Gammaridae	0.9	2.9	18.6	71
Lysianassidae	<.1	0.1	2.9	<1
Hyperiidea, Unidentified	0.1	0.3	1.4	1
Total Amphipoda	1.3	9.1	18.6	193
Euphausiacea				
Thysanoessa inermis	0.2	0.3	2.9	1
Thysanoessa raschii	1.1	2.0	4.3	13
Thysanoessa sp.	0.3	1.2	4.3	7
Total Euphausiacea	1.6	3.5	4.3	22
Decapoda				
Unidentified	0.1	0.8	5.7	5
Shrimp				
Unidentified	0.2	0.1	1.4	<1
Hymenodora frontalis	0.1	0.6	2.9	2
Spirontocaris spina	<.1	0.4	2.9	1
Eualus pusiolus	<.1	0.3	2.9	1
Pandalidae, Unidentified	0.1	0.6	1.4	1
Pandalus goniuris	0.2	1.6	2.9	5
Crangon septemspinosa	<.1	0.2	2.9	1
Total Shrimp	0.7	4.6	2.9	15
Crabs				
Unidentified	0.1	0.2	2.9	1
Pagurus sp.	<.1	0.1	2.9	<1
Paralithodes camtschatica	<.1	0.7	2.9	2
Brachyuran, Unidentified	<.1	0.2	4.3	1

Appendix Table 10. Pooled IRI Data - Oldsquaws, page 4 of 4

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
Hyas lyratus	0.3	0.9	5.7	7
Cancer sp.	0.1	0.8	4.3	4
Cancer magister	0.1	1.2	5.7	8
Cancer oregonensis	<.1	<.1	1.4	<1
Total Crabs	0.6	4.1	5.7	27
Total Crustacea	55.9	42.5	18.6	1,830
ECHURIA				
Echiurus echiurus	<.1	0.3	1.4	>1
BRYOZOA				
Microporina borealis	<.1	0.2	2.9	1
ECHINODERMATA				
Ophiuroidea (Brittle Stars)				
Unidentified	0.1	3.8	7.1	28
Ophiopholis aculeata	0.7	2.3	2.9	9
Amphipolis pugetana	0.4	1.3	2.9	5
Total Ophiuroids	1.2	7.4	7.1	61
Echinoida (Sea Urchins)				
Unidentified	0.1	1.3	12.9	18
Strongylocentrotus drobachiensis	<.1	0.6	1.4	1
Strongylocentrotus sp.	<.1	<.1	1.4	<1
Strongylocentrotidae	<.1	<.1	1.4	<1
Total Echinoida	0.1	1.9	12.9	26
Total Echinodermata	1.3	9.3	12.9	137
FISH				
Unidentified	2.0	0.3	7.1	16
Mallotus villosus	0.4	1.7	1.4	3
Unidentified Osmeridae	<.1	0.6	1.4	1
Cottidae	<.1	1.0	1.4	1
Stichaeidae	<.1	0.4	1.4	1
Ammodytes hexapterus	0.6	12.2	15.7	202
Total Fish	3.0	16.2	15.7	301

Appendix Table 11. Data on Indices of Relative Importance (IRI) for prey of Harlequin Ducks, pooled from birds collected in Alaskan waters.

Species: Harlequin Duck (Histrionicus histrionicus) Min. # of Prey Species = 2
N = 5 (none empty)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
MOLLUSCA, Unidentified	1.3	10.4	20.0	234
GASTROPODA				
Littorina sitkana				
Sitka Periwinkle	9.1	5.9	40.0	600
Littorina saxatilis				
Rough Periwinkle	83.1	38.1	40.0	4,848
Unidentified	6.5	45.6	60.0	3,126
Total Gastropoda	98.7	89.6	60.0	11,298

Appendix Table 12. Data on Indices of Relative Importance (IRI) for prey of Steller's eiders, pooled from birds collected in Alaskan waters.

Species: Steller's Eider (Polysticta stelleri) Minimum # Prey Species = 38
N = 3 (none empty)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
ANTHOZOA (Sea Anenomes)	0.3	0.8	33.3	37
RHYNCHOCOELA (Ribbon Worms)	1.2	2.4	33.3	121
POLYCHAETA				
Polynoidae	2.8	<.1	33.3	92
Eteone sp.	2.1	<.1	33.3	71
Phyllodocidae	5.2	3.2	66.7	561
Syllidae	0.3	<.1	33.3	10
Nereidae	3.1	0.8	66.7	258
Lumbrinereidae	0.6	<.1	33.3	20
Orbiniidae	7.6	<.1	33.3	255
Cirratulidae	0.3	<.1	33.3	10
Flabelligeridae	0.3	<.1	33.3	10
Opheliidae	3.4	5.6	66.7	600
Pectinaria sp.	0.6	1.7	66.7	154
Ampharetidae	0.3	<.1	33.3	10
Sabellidae	1.8	<.1	33.3	61
Total Polychaeta	28.4	11.3	66.7	2,648

Appendix Table 12. Pooled IRI Table - Steller's Eider, page 2 of 2

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
GASTROPODA				
Acmaeidae	0.3	0.5	33.3	26
Margarites sp.	1.5	0.5	33.3	67
Lacuna sp.	1.5	0.5	33.3	67
Littorina sp.	0.3	0.1	33.3	15
Barleeia sp.	1.8	0.5	33.3	77
Natica clausa	0.6	0.8	33.3	47
Mangelia sp.	0.6	0.8	33.3	47
Odostomia sp.	1.5	0.8	33.3	78
Total Gastropoda	8.1	4.5	33.3	420
Bivalves				
Unidentified	0.6	3.5	66.7	276
Mysella sp.	0.3	0.1	33.3	15
Macoma sp.	0.9	0.5	33.3	47
Protothaca staminea	0.6	1.5	33.3	69
Hiatella	9.2	12.9	66.7	1,473
Total Bivalves	11.6	18.5	66.7	2,008
CRUSTACEA				
Unidentified	0.3	1.7	33.3	67
Lepas sp.	0.6	0.8	33.3	47
Tanais loricatus (Tanaid)	0.3	0.5	33.3	26
Valviferan Isopod	0.9	0.8	33.3	57
Gammaridean Amphipods				
Unidentified	23.2	6.5	100	2,975
Lyssianassidae	0.6	0.8	33.3	47
Pandalidae (Shrimp)	0.3	0.8	33.3	37
Total Crustacea	26.2	11.9	100	3,810
ECHINODERMATA				
Sea Cucumbers				
Cucumaria sp.	23.5	50.0	66.7	4,901
Eupentacta sp.	0.3	0.5	33.3	26

Appendix Table 13. Data on Indices of Relative Importance (IRI) for prey of white-winged scoters, pooled from birds collected in Alaskan waters.

Species: White-winged Scoter (Melanitta deglandi) Min. # Prey Species = 36

N = 46 Number Empty = 2(4.3%)

PREY NAME	% NUMBER	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA				
Halosydna brevisetosa	0.1	0.5	4.5	3
Nephtys sp.	<.1	0.2	2.3	1
MOLLUSCA, Unidentified	<.1	0.1	2.3	<1
GASTROPODA				
Unidentified	0.4	1.7	15.9	33
Margarites pupillus	1.5	0.7	4.5	10
Margarites sp.	0.4	0.5	4.5	4
Lacuna sp.	0.1	2.2	2.3	5
Littorina saxitalis	<.1	<.1	2.3	<1
Littorina sp.	<.1	<.1	2.3	<1
Natica clausa	0.1	3.1	2.3	7
Neptunea lyrata	0.3	2.7	4.5	13
Olivella baetica	0.2	0.4	4.5	3
Admete couthouyi	0.4	0.4	4.5	4
Admete sp.	<.1	<.1	2.3	<1
Oenopota sp.	0.3	0.1	4.5	2
Total Gastropoda	3.7	11.8	15.9	246
BIVALVES				
Unidentified	0.9	13.9	38.6	571
Nucula tenuis	0.2	0.1	2.3	1
Glycymeris subobsoleta	13.7	1.3	4.5	68
Glycymeris sp.	<.1	<.1	2.3	<1
Mytilus edulis	1.9	27.9	20.5	611
Astarte rolandi	9.3	0.1	4.5	43
Spisula polynyma	0.4	3.3	6.8	25
Macoma sp.	0.1	1.0	4.5	5
Tellina nuculoides	1.6	2.6	4.5	19
Humilaria kennerlyi	<.1	<.1	2.3	<1
Protothaca staminea	0.9	28.5	36.4	1,068
Mya sp.	<.1	0.1	2.3	<1
Total Bivalves	29.1	79.8	38.6	4,204

Appendix Table 13. Pooled IRI Data - White-winged Scoters, page 2 of 2

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
CRUSTACEA				
Barnacle, Unidentified	<.1	0.4	2.3	1
Gooseneck Barnacle	<.1	<.1	2.3	<1
Shrimp, Unidentified	<.1	0.1	2.3	<1
Crabs				
Unidentified	0.2	0.4	9.1	5
Pagurus sp.	<.1	<.1	2.3	<1
Brachyura oxyrhyncha	<.1	<.1	2.3	<1
Cancer magister	<.1	0.7	2.3	2
Total Crustacea	0.2	1.6	9.1	16
SIPUNCULA, *Sipunculus* sp.	<.1	0.4	2.3	1
ECHINODERMATA				
Ophiuroidea (Brittle Stars)	0.1	<.1	2.3	<1
Echinoida (Sea Urchins)				
Strongelocentrotidae, Unid.	<.1	<.1	2.3	<1
Strongylocentrotus droebachiensis Green Sea Urchin	<.1	0.6	2.3	1
Unidentified	<.1	<.1	2.3	<1
Holothuroidea (Sea Cucumbers)	<.1	0.4	2.3	1
FISHES				
Ammodytes hexapterus	0.6	4.3	2.3	11
Eggs, unidentified	65.9	0.0	2.3	150

Appendix Table 14. Data on Indices of Relative Importance (IRI) for food of surf scoters, pooled from birds collected in Alaskan waters.

Species: Surf Scoter (*Melanitta perspicillata*) Min. # Food Items = 13
N = 11 No. Empty = 1(9.1%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA				
Nephtys sp.	5.6	14.2	10.0	198
Terebellidae	2.8	0.2	10.0	30
MOLLUSCA, Unidentified	2.8	1.8	10.0	45
GASTROPODS, Turridae	2.8	0.2	10.0	30
BIVALVES				
Unidentified	13.9	40.1	50.0	2,700
Nucula tenuis	8.3	1.0	30.0	279
Mytilus edulis	25.0	15.8	20.0	816
Musculus discors	13.9	9.5	10.0	234
Macoma balthica	2.8	2.1	10.0	49
Saxidomus gigantea	2.8	0.2	10.0	30
Protothaca staminea	5.6	0.2	10.0	58
Mya sp.	2.8	2.2	10.0	50
Total Bivalves	75.1	71.1	50.0	7,310
CRUSTACEA				
Hyas sp. (Crab)	2.8	1.0	10.0	38
Crangon septemspinosa	2.8	0.4	10.0	32
PLANT MATTER	2.8	10.5	10.0	133
ORGANIC MATTER, Unidentified	2.8	0.7	10.0	35

Appendix Table 15. Data on Indices of Relative Importance (IRI) for prey of black scoters, pooled from birds collected in Alaskan waters.

Species: Black Scoter (*Oidemia nigra*) Minimum # Prey Species = 4
N = 7 No. Empty = 1(14.3%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
GASTROPODA				
Margarites pupillus	1.4	0.3	16.7	26
BIVALVES				
Mytilus edulis	94.2	97.9	100	19,210
Protothaca staminea	1.4	0.4	16.7	30
Unidentified	1.4	0.6	16.7	33
CRUSTACEANS, Barnacles	1.4	0.8	16.7	36

Appendix Table 16. Data on Indices of Relative Importance (IRI) for prey of red-necked phalaropes, pooled from birds collected in Alaskan waters.

Species: Red-necked Phalarope (*Phalaropus lobatus*) Minimum # Prey Species = 7
N = 7 (none empty)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereidae	65.7	47.2	71.4	8,068
CEPHALOPODA, Unidentified	7.1	13.1	14.3	289
CRUSTACEA				
Calanoid Copepod	1.4	4.4	14.3	83
Decapod	11.4	4.1	28.6	443
Gammaridean Amphipods				
Gammaridae	1.4	1.5	14.3	41
Unidentified	1.4	1.5	14.3	41
Total Crustacea	14.2	10.0	28.6	692
INSECTA, Unidentified	7.1	8.7	42.9	680
FISH, Unidentified	4.3	19.6	42.9	1,025

Appendix Table 17. Data on Indices of Relative Importance (IRI) for prey of pomerine and parasitic jaegers, each pooled from birds collected in Alaskan waters.

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI

Species: Pomerine Jaeger (*Stercorarius pomarinus*) Minimum # Prey Species = 2
N = 2 (neither empty)				

FISH				
Mallotus villosus	66.7	85.7	50	7,619
Theragra chalcogramma	33.3	14.3	50	2,381

Species: Parasitic Jaeger (*Stercorarius parasiticus*) Minimum # Prey Species = 1
N = 2 (neither empty)				

FISH				
Mallotus villosus	100	100	100	20,000

Appendix Table 18. Data on Indices of Relative Importance (IRI) for prey of glaucous gulls, pooled for birds collected in the Bering Sea.

Species: Glaucous Gull (Larus hyperboreus) Minimum # Prey Species = 5
N = 7 No. Empty = 1(14.3%)

PREY NAME	% NUMBER	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
CRUSTACEA				
Gammarid Amphipod	28.6	0.4	14.3	415
Decapod	14.3	78.3	14.3	1,324
INSECT, Diptera	14.3	0.2	14.3	207
FISHES				
Salmonidae	14.3	2.5	14.3	400
Unidentified	14.3	13.7	14.3	240
MAMMAL, Unidentified	14.3	4.9	14.3	274

Appendix Table 19. Data on Indices of Relative Importance (IRI) for prey of adult glaucous-winged gulls, pooled from birds collected in Alaskan waters.

Species: Glaucous-winged Gull (Larus glaucescens) Minimum # Prey Species = 23
N = 68 No. empty = 2(2.9%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereidae	0.3	0.3	3.0	2
MOLLUSCA				
Unidentified	<.1	0.1	1.5	<1
Gastropoda				
Colisella pelta	<.1	0.2	1.5	<1
Littorina sitkana	0.2	0.6	1.5	1
Buccinum baeri	<.1	0.2	1.5	<1
Total Gastropods	0.2	1.0	1.5	2
Amphineura (Chitons)				
Katharina tunicata	<.1	<.1	1.5	<1
Unidentified	0.1	1.1	10.6	13
Bivalves				
Mytilus edulis	0.2	2.4	9.1	24
Clinocardium sp.	<.1	0.4	1.5	1
Unidentified	0.1	0.3	6.1	2
CRUSTACEA				
Gooseneck Barnacle	<.1	0.5	3.0	2
Acorn Barnacle	<.1	0.3	3.0	1
Valviferan Isopod	<.1	0.1	1.5	<1
Euphausiids				
Thysanoessa inermis	2.1	1.5	4.5	16
T. raschii	<.1	0.1	1.5	<1
Unidentified	1.6	1.5	1.5	5
Total Euphausiids	3.7	3.1	4.5	31
Shrimp				
Pandalus borealis	0.1	2.1	1.5	3
Crangon septemspinosa	<.1	0.2	1.5	<1
Crab				
Telmessus cheiragonus	<.1	0.7	1.5	1
INSECTS				
Diptera	<.1	0.1	1.5	<1
Unidentified	0.3	4.6	3.0	15
ECHINODERMATA				
Echinoida (Sea Urchins)	0.1	2.1	7.6	17
FISHES				
Hypomesus pretiosus	0.1	4.0	1.5	6
Mallotus villosus	0.3	11.8	13.6	165
Gadidae	<.1	0.1	1.5	<1
Hexagrammidae	<.1	5.6	1.5	8
Ammodytes hexapterus	0.5	10.0	7.6	80
Unidentified	93.9	29.4	36.4	4,484
Total Fish	94.8	60.9	36.4	5,667
BIRDS				
Synthliboramphus antiquus	0.1	18.6	1.5	28
Unidentified	<.1	1.2	1.5	2

Appendix Table 20. Data on Indices of Relative Importance (IRI) for prey of sub-adult Glaucous-winged Gulls, pooled from birds and food samples collected in Alaskan waters.

Species: Glaucous-winged Gull (Larus glaucescens) Minimum # Prey Species = 19

Sample Type	N	Number Empty
Nestling Regurgitations	115	-
Flying Sub-adults	42	18 (42.8%)
TOTAL	157	18 (11.4%)

PREY NAME	% NUMBER	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Opheliidae	0.1	0.6	0.7	<1
MOLLUSCA				
Gastropods				
Acmaeidae (Limpets)	0.1	0.1	0.7	<1
Unidentified	0.1	<.1	0.7	<1
Amphineurns (Chitons)				
Katharina tunicata	0.2	0.9	2.9	3
Unidentified	0.2	0.4	2.2	1
Bivalves				
Mytilus edulis	8.5	5.1	7.9	108
Siliqua sp.	0.1	0.8	0.7	1
Hiatella arctica	0.1	<.1	0.7	<1
Unidentified	0.1	0.9	1.4	1
Total Bivalves	8.8	6.8	7.9	123
CRUSTACEANS				
Gammaridean Amphipods	1.9	0.3	1.4	3
Telmessus chieragonus	0.1	0.1	0.7	<1
Unidentified Brachyuran	0.1	0.1	0.7	<1
Unidentified	0.1	0.1	0.7	<1
Total Crustaceans	2.2	0.6	1.4	4
INSECTS, Diptera	11.3	0.7	1.4	17
ECHINODERMS				
Leptasterias hexactis	0.1	0.7	0.7	1
Amphipolis pugetana	0.2	1.0	2.2	3
Strongelocentrotus droebachiensis	0.1	0.5	1.4	1
FISH				
Mallotus villosus	13.7	18.7	33.8	1,096
Unidentified Osmerid	0.6	0.8	2.9	4
Theragra chalcogramma	0.1	0.7	1.4	1
Unidentified Gadidae	0.1	<.1	0.7	<1
Trichodon trichodon	0.6	2.1	2.2	6
Pholidae (Gunnels)	0.1	0.3	0.7	<1
Ammodytes hexapterus	14.6	35.1	29.5	1,466
Unidentified	47.1	29.5	29.5	2,260
Total Fish	76.9	87.2	29.5	4,841
BIRD				
Cepphus columba	0.1	0.5	0.7	<1

Appendix Table 21. Data on IRI's for prey of Herring Herring and Bonaparte's Gulls, each pooled from birds collected in Alaskan waters.

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
Species: Herring Gull (Larus argentatus) N = 5 (none empty)			Minimum # Prey Species = 4	
BIVALVE, Unidentified	16.7	1.5	20.0	364
CRUSTACEA				
Lepadid Barnacle	16.7	61.5	20.0	1,564
Decapod, Unidentified	16.7	13.8	20.0	610
Crangon septemspinosa	16.7	15.2	20.0	638
Total Crustacea	50.1	90.5	20.0	2,812
FISH, Unidentified	33.3	7.8	40.0	1,647
Species: Bonaparte's Gull (Larus philedelphia) N = 4 (none empty)			Minimum # Prey Species = 2	
CRUSTACEA				
Gammaridean Amphipoda	96.2	42.3	50.0	6,923
Crangon septemspinosa	3.8	57.7	50.0	3,077

Appendix Table 22. Data on Indices of Relative Importance (IRI) for prey of mew gulls, pooled from birds collected in Alaskan waters.

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
Species: Mew Gull (Larus canus) N = 13 No. Empty = 2(15.4%)			Minimum # Prey Species = 10	
POLYCHAETA, Unidentified	1.1	0.3	9.1	13
GASTROPODS, Unidentified	1.1	<.1	9.1	10
BIVALVES, Unidentified	0.4	1.0	9.1	13
CRUSTACEA				
Gammaridean Amphipods	86.4	57.0	36.4	5,214
Crangon septemspinosa	2.3	22.0	18.2	442
Crangon sp.	0.8	0.5	9.1	11
Total Crustacea	89.5	79.5	36.4	6,152
INSECTS				
Dipteran Flies	0.4	0.3	9.1	7
Tipulid Flies	0.4	0.2	9.1	6
Unidentified	4.2	1.4	18.2	102
Total Insects	5.0	1.9	18.2	126
FISH				
Ammodytes hexapterus*	1.1	10.4	9.1	105
Gadidae	0.4	0.6	9.1	9
Unidentified*	1.5	6.1	27.3	207
Total Fish	3.0	17.1	27.3	549

*Included in regurgitation sample from 1 nestling.

Appendix Table 23. Data on Indices of Relative Importance (IRI) for prey of adult Black-legged Kittiwakes, pooled from birds collected in Alaskan waters

Species: Black-legged Kittiwake (Rissa tridactyla) Minimum # Prey Spp. = 23
N = 328 No. Empty Stomachs = 55(16.8%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereidae	8.0	0.7	9.2	79
MOLLUSCS				
Limacina helicina	5.0	0.6	0.7	4
Katharina tunicata	0.1	0.6	0.7	<1
Unidentified	<.1	<.1	0.4	<1
Bivalves				
Mytilus edulis	<.1	<.1	0.4	<1
Unidentified Mytilid	<.1	<.1	0.4	<1
Unidentified	0.2	0.1	1.5	<1
Cephalopod, Unidentified	0.2	0.1	1.5	1
CRUSTACEA				
Unidentified	0.1	0.1	0.7	<1
Barnacle	<.1	0.1	0.4	<1
Calanoid Copepod	0.5	0.1	1.8	<1
Gammaridean Amphipods				
Gammaridae	<.1	<.1	0.4	<1
Paracallisoma alberti	0.6	0.2	1.8	1
Unidentified	<.1	<.1	0.4	<1
Hypereiid Amphipods				
Parathemisto libellula	5.7	1.5	1.5	10
P. pacifica	0.1	<.1	0.4	<1
P. japonica	<.1	<.1	0.4	<1
Total Amphipods	6.4	1.7	1.8	15
Euphausiids				
Thysanoessa inermis	36.0	4.7	7.7	313
T. raschii	0.4	<.1	0.4	<1
T. spinifera	6.9	1.4	1.5	12
T. sp.	1.9	0.2	0.7	1
Unidentified	1.0	0.2	1.5	2
Total Euphausiids	46.2	6.5	7.7	406
Pandalopsis dispar	0.1	0.2	0.4	<1
Unident. Pandalid Shrimp	0.2	0.7	0.4	<1
Cancer sp. (Crab)	0.2	<.1	0.4	<1
Unidentified Decapod	0.1	<.1	0.4	<1
Total Crustacea	54.4	10.3	7.7	498

(cont'd)

Appendix Table 23. Pooled IRI Data, adult Black-legged Kittiwakes, p. 2 of 2

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
FISH				
Unidentified	4.9	7.0	26.7	320
Clupea harengus	0.5	0.2	0.4	<1
Mallotus villosus	15.3	50.9	35.5	2,354
Unidentified Osmeridae	2.2	5.9	6.6	53
Gadidae (Cods)				
Gadus macrocephalus	<.1	<.1	0.4	<1
Theragra chalcogramma	0.9	5.3	5.1	32
Unidentified	0.7	1.7	5.5	13
Total Gadidae	1.6	7.0	5.5	47
Trichodon trichodon	<.1	<.1	0.4	<1
Ammodytes hexapterus	7.8	17.1	13.2	329
Total Fish	32.3	88.1	35.5	4,274

Appendix Table 24. Data on Indices of Relative Abundance (IRI) for prey of sub-adult black-legged kittiwakes, pooled from birds and food samples collected in Alaskan waters.

Species: Black-legged Kittiwake (Rissa tridactyla) Minimum # Prey Spp. = 17

Sample Type	N	Number Empty
Nestling Regurgitations	129	-
Flying Birds	86	31 (36.0%)
TOTAL	215	31 (14.4%)

PREY NAME	% NUMBER	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
MOLLUSCA				
Katharina tunicata	0.1	<.1	0.5	<1
CRUSTACEA				
Unidentified	0.6	<.1	1.1	1
Ligia pollasi	0.1	0.1	0.5	<1
Paracallisoma alberti	0.1	0.1	0.5	<1
Thysanoessa inermis	0.1	<.1	0.5	<1
Unidentified Euphausiid	0.1	0.1	0.5	<1
Unidentified Decapod	0.1	0.1	0.5	<1
Hymenodora frontalis	0.1	0.1	0.5	<1
Pandalus borealis	0.3	0.4	0.5	<1
Pandalus sp.	0.7	1.1	1.6	3
Pandalopsis dispar	1.9	2.3	0.5	2
Unidentified	1.0	0.6	2.2	4
Total Pandalid Shrimp	3.9	4.4	2.2	18
Cancrid Crab	0.1	<.1	0.5	<1
Total Crustacea	5.2	4.9	2.2	22
INSECT, Dipteran Fly	0.7	<.1	1.1	1
FISH				
Onchorhynchus gorbuscha	0.3	<.1	0.5	<1
O. nerka	3.7	0.2	0.5	2
Mallotus villosus	31.7	36.3	39.7	2,697
Unidentified Osmerid	1.6	2.9	3.3	15
Gadidae				
Gadus macrocephalus	0.1	0.1	0.5	<1
Microgadus proximus	0.4	0.5	0.5	1
Theragra chalcogramma	1.0	2.3	3.3	11
Unidentified	1.6	2.5	3.8	16
Total Gadidae	3.1	5.4	3.8	32
Trichodon trichodon	1.8	2.4	3.8	16
Ammodytes hexapterus	44.2	39.3	49.5	4,127
Unidentified	7.1	8.4	14.1	219
Total Fish	93.5	94.9	49.5	9,326

Appendix Table 25. Data on Indices of Relative Importance (IRI) for prey of red-legged kittiwakes, pooled from birds collected in the Bering Sea (N = 2) and the Aleutian Islands regions (N = 1).

Species: Red-legged Kittiwake (Rissa brevirostris) Minimum # Prey Species = 4

N = 3 (none empty)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
CEPHALOPOD, Unidentified	12.5	0.5	33.3	433
CRUSTACEANS				
Thysanoessa inermis Euphausiid	12.5	0.5	33.3	433
Hymenodora frontalis Pacific Ambereye Shrimp	25.0	12.5	33.3	1,249
Unidentified Decapod	25.0	12.3	66.7	2,488
FISH, Unidentified	25.0	74.2	66.7	6,616

Appendix Table 26. Data on Indices of Relative Importance (IRI) for prey of adult Arctic terns, pooled from birds collected in Alaskan waters.

Species: Arctic Tern (Sterna paradisea) Minimum # Prey Species = 8
N = 36 Number Empty = 2(5.6%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereid	0.1	<.1	2.9	<1
CRUSTACEA				
Parathemisto libellula	0.4	1.0	2.9	4
Thysanoessa inermis	92.6	76.1	52.9	8,930
T. raschii	0.1	0.5	2.9	2
T. spinifera	4.4	3.6	26.5	211
Total Euphausiids	97.1	80.2	52.9	9,379
Unidentified Decapod	0.1	1.0	2.9	3
Total Crustaceans	97.6	82.2	52.9	9,511
FISH				
Mallotus villosus	0.6	6.8	17.6	130
Ammodytes hexapterus	1.4	9.4	11.8	126
Unidentified	0.4	1.6	11.8	24
Total Fish	2.4	17.8	17.6	356

Appendix Table 27. Data on Indices of Relative Importance for prey of sub-adult Arctic terns, pooled from birds and food samples collected in Alaskan waters (all from Kodiak Island area).

Species: Arctic Tern (Sterna paradisea) Minimum # Prey Species = 6

Sample Type	N	Number Empty
Nestling Regurgitations	20	-
Flying Sub-adults	12	1(8.3%)
TOTAL	32	1(3.0%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
FISH				
Mallotus villosus	50.1	40.3	48.4	4,368
Unidentified Osmeridae	5.9	4.4	6.5	66
Hexagrammos lagocephalus	5.9	7.1	3.2	42
H. stelleri	2.9	1.8	3.2	15
Trichodon trichodon	2.9	3.1	3.2	19
Zaprora silensus	2.9	8.8	3.2	38
Ammodytes hexapterus	26.5	33.6	29.0	1,745
Unidentified	2.9	0.9	3.2	12
Total Fish	100	100	48.4	9,680

Appendix Table 28. Data on Indices of Relative Importance (IRI) for prey of adult Aleutian terns, pooled from birds collected in Alaskan waters.

Species: Aleutian Tern (Sterna aleutica) Minimum # Prey Species = 8
N = 14 Number Empty = 1(7.1%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereid	1.2	0.1	7.7	10
CHELICERATE ARTHROPOD	0.4	1.8	7.7	17
CRUSTACEA				
Thysanoessa inermis	88.5	54.7	23.1	3,306
Synidotea sp.	0.4	0.9	7.7	10
Pentidotea sp.	0.4	10.5	7.7	83
Total Crustacea	89.3	66.1	23.1	3,590
INSECT, Unidentified	1.2	1.4	15.4	39
FISH				
Mallotus villosus	1.6	7.3	15.4	137
Gadidae	0.4	5.5	7.7	45
Ammodytes hexapterus	4.7	12.2	30.8	521
Unidentified	1.2	5.6	23.1	157
Total Fish	7.9	30.6	30.8	1,186

Appendix Table 29. Data on Indices of Relative Importance (IRI) for prey of sub-adult Aleutian terns, pooled from food samples collected in Alaskan waters.

Species: Aleutian Tern (Sterna aleutica) Minimum # Prey Species = 8

Sample Type	N	Number Empty
Nestling Regurgitation	43	-
Flying Sub-adults	5	1(20%)
TOTAL	48	1(2.1%)

PREY NAME	% NUMBER	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
EUPHAUSIIDS, Thysanoessa sp.	1.5	0.1	2.1	3
INSECT, Unidentified	1.5	<.1	2.1	3
FISH				
Mallotus villosus	32.8	33.9	34.0	2,273
Unidentified Osmerid	13.4	12.8	12.8	335
Hexagrammos lagocephalus	1.5	3.8	2.1	11
Hexagrammos sp.	1.5	3.2	2.1	10
Pleurogrammus monopterygius	1.5	2.5	2.1	9
Cottidae	3.0	0.6	2.1	8
Blepsius cirrhosus	4.5	5.1	6.4	61
Trichodon trichodon	1.5	1.3	2.1	6
Ammodytes hexapterus	10.4	15.8	12.8	335
Unidentified	26.9	20.9	31.9	1,524
Total Fish	97.0	99.9	34.0	6,695

Appendix Table 30. Data on Indices of Relative Importance (IRI) for prey of nestlings of Arctic and/or Aleutian terns, pooled from bill loads dropped at a nesting colony used by both species on Kodiak Island, Alaska.

Species: Arctic and/or Aleutian Terns (*Sterna paradisea* and/or *S. aleutica*)
N = 11

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
FISH				
Ochorhynchus kisutch Silver Salmon	7.1	13.0	9.1	183
Hypomesus pretiosus Surf Smelt	7.1	8.3	9.1	140
Mallotus villosus Capelin	14.3	16.9	18.2	567
Unidentified Osmeridae	7.1	2.6	9.1	89
Hexagrammos lagocephalus Rock Greenling	7.1	5.2	9.1	112
Blepsius cirrhosus Silverspotted Sculpin	7.1	2.6	9.1	89
Stichaeidae (Pricklebacks)	7.1	3.9	9.1	100
Ammodytes hexapterus Pacific Sand Lance	28.6	39.7	36.4	2,484
Hippoglossus stenolepis Pacific Halibut	7.1	5.2	9.1	112
Unidentified	7.1	2.6	9.1	89

Appendix Table 31. Data on Indices of Relative Importance (IRI) for prey of common murres, pooled from birds collected in Alaskan waters.

Species: Common Murre (Uria aalge) Minimum # Prey Species = 23
N = 251 No. Empty = 85 (33.9%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereidae	<.1	<.1	0.6	<1
CEPHALOPODA				
Unidentified Squid	<.1	0.2	0.6	<1
Gonatidae	0.1	0.1	0.6	<1
CRUSTACEA				
Unidentified	0.2	0.2	1.8	1
Neomysis rayii (Mysid)	16.5	8.1	6.6	162
Leucon sp. (Cumacean)	0.8	<.1	0.6	<1
Amphipoda				
Gammaridea	<.1	<.1	0.6	<1
Protomedeia sp.	<.1	<.1	0.6	<1
Anonyx sp.	0.1	0.1	0.6	<1
Euphausiids				
Thysanoessa inermis	16.2	1.0	2.4	41
T. raschii	0.5	0.3	0.6	<1
T. sp.	19.0	2.4	1.8	38
Total Euphausiids	35.7	3.7	2.4	94
Decapods				
Unidentified	0.2	0.2	1.2	<1
Eualus c.f. stimpsoni Shrimp	<.1	0.1	0.6	<1
Pandalidae				
Pandalus borealis	1.1	2.8	3.6	14
P. goniuris	<.1	0.1	0.6	<1
P. sp.	0.3	0.9	3.0	3
Unidentified	0.2	0.6	1.8	1
Total Pandalidae	1.6	4.3	3.6	21
Crangon franciscorum	0.2	0.9	2.4	3
Total Decapods	2.0	5.5	3.6	27
Total Crustacea	54.3	17.6	6.6	474
INSECTA, Unidentified	<.1	0.1	0.6	<1
ECHINODERMATA, Amphipodia sp.	0.2	<.1	0.6	<1
FISHES				
Unidentified	4.0	4.5	24.0	204
Clupea harengus	<.1	0.9	0.6	1
Mallotus villosus	14.1	29.9	22.8	1,003
Unidentified Osmerid	1.1	2.8	7.2	28
Gadidae				
Gadus macrocephalus	0.1	<.1	0.6	<1
Microgadus proximus	0.8	1.2	1.8	4

Appendix Table 31. Pooled IRI Data, Common Murres, p. 2 of 2

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
Theragra chalcogramma	7.2	14.3	13.8	297
Unidentified	4.2	2.5	18.0	121
Total Gadidae	12.3	18.0	18.0	547
Trichodon trichodon	0.3	1.3	2.4	4
Lumpenus maculatus	0.2	0.4	1.8	1
L. saggita	0.3	1.0	1.2	2
Ammodytes hexapterus	11.4	22.3	18.0	607
Total Fish	43.7	81.1	24.0	2,995

Appendix Table 32. Data on Indices of Relative Importance (IRI) for prey of Thick-billed Murres collected in Alaskan waters.

Species: Thick-billed Murre (*Uria lomvia*) Minimum # Prey Species = 14
N = 64 # Empty Stomachs = 26 (40.6%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Neridae	0.7	0.3	2.7	3
GASTROPODA, Unidentified	0.5	<.1	2.7	1
CEPHALOPODA, Unidentified	47.4	25.9	51.4	3,765
CRUSTACEA				
Unidentified	0.7	<.1	2.7	2
Calanoid Copepod	0.2	<.1	2.7	1
Gammarid Amphipod	0.2	<.1	2.7	1
Parathemisto libellula	24.4	16.1	10.8	438
P. pacifica	1.1	0.3	2.7	4
Thysanoessa inermis	0.5	<.1	2.7	1
Unidentified Euphausiid	1.8	2.0	2.7	10
Pandalus goniuris	0.5	3.8	5.4	23
Crangon sp.(Shrimp)	3.4	7.5	2.7	29
Unidentified Decapod	0.2	0.1	2.7	1
Total Crustacea	33.0	29.8	10.8	678
FISH				
Mallotus villosus	2.7	16.6	8.1	156
Boreogadus saida	1.6	0.5	2.7	6
Theragra chalcogramma	1.6	9.1	8.1	86
Unidentified Gadidae	7.7	3.2	16.2	176
Total Gadidae	10.9	12.8	16.2	384
Ammodytes hexapterus	1.8	4.8	10.8	71
Unidentified	3.2	9.7	18.9	243
Total Fish	18.6	43.9	18.9	1,181

Appendix Table 33. Data on Indices of Relative Importance (IRI) for prey of pigeon guillemots, pooled from birds collected in Alaskan waters.

Species: Pigeon Guillemot (Cepphus columba) Minimum # Prey Species = 29
N = 64 Number of Empty Stomachs = 6 (9.4%)

PREY NAME	% NUMBER	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA				
Nereidae	0.6	<.1	3.4	2
Unidentified	0.3	0.6	1.7	2
GASTROPODA, Lacuna vincta	4.2	0.4	1.7	8
BIVALVES				
Musculus sp.	3.1	0.6	3.4	13
Unidentified Veneridae	0.3	0.3	1.7	1
Unidentified	0.3	0.3	1.7	1
CRUSTACEA				
Mysidae	0.6	0.1	1.7	1
Gammarid Amphipods	0.3	0.6	1.7	1
Unidentified Decapod	7.5	5.3	8.6	111
Unidentified	0.3	0.2	1.7	1
Shrimps				
Spirontocaris arcuata	0.3	0.4	1.7	1
S. spinus	0.8	0.1	1.7	2
Lebbeus sp.	0.6	0.6	3.4	4
Eualus fabricii	0.3	0.1	1.7	1
E. sp.	1.1	0.9	1.7	4
Heptacarpus tridens	1.4	0.5	1.7	3
H. brevirostris	16.2	5.8	1.7	38
H. sp.	0.6	0.7	3.4	4
Unidentified Hippolytid	0.3	0.2	1.7	1
Total Hippolytidae	18.5	7.2	3.4	87
Pandalid Shrimps				
Pandalus goniuris	1.1	1.8	3.4	10
P. jordani	0.8	2.4	1.7	6
P. sp.	0.6	1.8	1.7	4
Unidentified	1.1	2.5	5.2	19
Total Pandalidae	3.6	8.5	5.2	63
Crangon septemspinosa	4.5	2.3	1.7	12
Sclerocrangon alata	1.1	0.1	1.7	2
Total Shrimps	33.9	20.3	5.2	282
Crabs				
Dermaterus manotti	0.3	0.4	1.7	1
Brachyuran sp.	3.1	1.1	10.3	43
Hyas lyratus	2.0	1.8	1.7	7
Telmessus cheiragonus	0.3	0.6	1.7	1
Cancer oregonensis	17.3	5.7	22.4	516
Unidentified	1.4	1.2	6.9	18
Total Crabs	24.4	10.8	22.4	788
Total Crustacea	67.0	37.3	22.4	2,336

Appendix Table 33. Pooled IRI data, pigeon guillemot, page 2 of 2

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
INSECT, Dolichopodid Fly	0.3	<.1	1.7	<1
FISH				
Mallotus villosus	3.9	19.0	12.1	277
Microgadus proximus	0.3	0.2	1.7	1
Gadidae	2.8	4.7	12.1	90
Myxocephalus sp.	2.0	2.0	1.7	7
Cottidae	0.3	0.7	1.7	2
Trichodon trichodon	2.8	12.0	6.9	102
Lumpenus sagitta	0.8	1.5	1.7	4
L. sp.	0.3	1.2	1.7	3
Stichaeidae	1.4	4.5	3.4	20
Pholis laeta	0.3	1.2	1.7	2
Pleuronectidae	0.8	2.2	3.4	11
Unidentified	8.7	11.0	37.9	747
Total Fish	23.6	60.2	37.9	3,176

Appendix Table 34. Data on Indices of Relative Importance (IRI) for prey of Marbled Murrelets, pooled from birds collected in Alaskan waters.

Species: Marbled Murrelet (*Brachyramphus marmoratum*) Minimum # Prey Species = 16
N = 158 Number of Empty Stomachs = 29 (18.3%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereidae	0.1	<.1	0.8	<1
GASTROPODA				
Littorina sitkana	0.6	0.2	0.8	1
Unidentified	<.1	<.1	0.8	<1
BIVALVIA, *Mytilus edulis*	<.1	<.1	0.8	<1
CEPHALOPODA, Unidentified	<.1	0.2	0.8	<1
CRUSTACEA				
Gammarid Amphipoda	0.3	0.4	3.1	2
Mysida				
Acanthomysis sp.	20.9	9.3	10.9	327
Neomysis rayii	0.4	0.6	2.3	2
Neomysis sp.	2.7	2.1	4.7	22
Unidentified Mysidae	0.3	0.3	1.6	1
Unidentified	6.3	1.3	2.3	18
Total Mysida	30.6	13.6	10.9	482
Euphausiids				
Thysanoessa inermis	9.6	5.9	8.5	132
T. raschii	3.8	1.4	3.9	20
T. spinifera	0.2	0.4	2.3	1
T. sp.	4.5	1.2	4.7	27
Unident. Euphausiidae	0.1	0.2	1.6	<1
Unidentified	0.1	0.2	0.8	<1
Total Euphausiids	18.3	9.3	8.5	235
Pandalus borealis	<.1	0.1	0.8	<1
Unidentified Decapod	<.1	<.1	0.8	<1
Total Crustacea	49.2	23.4	8.5	617
CHAETOGNATHA, Unidentified	<.1	<.1	0.8	<1
FISH				
Mallotus villosus	37.5	26.7	26.4	1,692
Unidentified Osmeridae	6.3	7.2	10.9	147
Theragra chalcogramma	0.1	0.1	1.6	<1
Unidentified Gadidae	0.1	0.5	1.6	1
Trichodon trichodon	0.3	2.3	3.9	10
Ammodytes hexapterus	3.5	28.4	23.3	741
Unidentified	2.0	11.2	25.6	337
Total Fish	50.0	76.4	26.4	3,337

Appendix Table 35. Data on Indices of Relative Importance (IRI) for prey of Kittlitz's murrelets, pooled from birds collected in Alaskan waters.

Species: Kittlitz's Murrelet (*Brachyramphus brevirostris*) Min. # Prey Spp. = 7
N = 16 Number of Empty Stomachs = 1 (6.2%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
CRUSTACEA				
Gammarid Amphipoda	1.1	0.9	6.7	13
Euphausiids				
Thysanoessa inermis	24.9	14.5	20.0	788
T. spinifera	5.9	5.5	13.3	152
Unidentified	3.2	8.8	26.7	321
Total Euphausiids	34.0	28.8	26.7	1,667
Total Crustacea	35.1	29.7	26.7	1,730
FISH				
Clupea harengus	0.5	3.8	6.7	29
Mallotus villosus	1.6	12.1	6.7	92
Unidentified Osmeridae	1.1	2.7	6.7	25
Trichodon trichodon	1.6	11.4	6.7	87
Ammodytes hexapterus	7.0	6.7	13.3	183
Unidentified	53.0	33.6	40.0	3,464
Total Fish	64.8	70.3	40.0	5,404

Appendix Table 36. Data on Indices of Relative Importance (IRI) for prey of ancient murrelets, pooled from birds collected in Alaskan waters.

Species: Ancient Murrelet (*Synthliboramphus antiquus*) Min. # Prey Spp. = 5
N = 18 Number of Empty Stomachs = 3 (16.7%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
CEPHALOPODA, Unidentified	0.8	0.8	6.7	11
CRUSTACEA				
Unidentified	0.4	1.9	6.7	16
Neomysis sp.	0.8	0.8	6.7	11
Euphausiids				
Thysanoessa inermis	51.9	48.7	33.3	3,353
T. sp.	2.5	0.8	6.7	22
Unidentified	0.8	5.1	13.3	79
Total Euphausiids	55.2	54.6	33.3	3,656
Total Crustacea	56.4	57.3	33.3	3,786
FISH				
Mallotus villosus	34.4	6.2	6.7	16
Theragra chalcogramma	1.2	7.2	6.7	56
Unidentified Gadidae	4.1	17.7	20.0	437
Unidentified	2.9	10.9	33.3	460
Total Fish	42.6	42.0	33.3	2,817

Appendix Table 37. Data on Indices of Relative Importance (IRI) for prey of Cassin's auklet, pooled from birds collected in Alaskan waters.

Species: Cassin's Auklet (*Ptychoramphus aleuticus*) Min. # Prey Spp. = 6
N = 8 (None empty)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
CEPHALOPODA, Squid	0.4	7.7	12.5	101
CRUSTACEA				
Calanoid Copepods	78.4	59.0	50.0	6,870
Gammarid Amphipods	0.2	0.4	12.5	8
Thysanoessa spinifera	4.2	8.4	25.0	315
Unidentified Decapods	15.9	9.1	50.0	1,250
Total Crustacea	98.7	76.9	50.0	8,780
FISH, Unidentified	0.9	15.4	25.0	408

Appendix Table 38. Data on Indices of Relative Importance (IRI) for prey of parakeet auklets, pooled from birds collected in Alaskan waters.

Species: Parakeet Auklet (*Cyclorrhynchus psitaccula*) Min. # Prey Spp. = 3
N = 13 Number of Empty Stomachs = 8 (61.5%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
CRUSTACEA				
Euphausiids				
Thysanoessa sp.	93.3	16.7	20.0	2,200
Unidentified	0.2	16.7	20.0	338
Total Euphausiids	93.5	33.4	20.0	2,538
Decapoda, Unidentified	0.7	15.8	40.0	660
FISH, Unidentified	5.8	50.8	40.0	2,264

Appendix Table 39. Data on Indices of Relative Importance (IRI) for prey of least auklets (top) and crested auklets (bottom), each pooled from birds collected in Alaskan waters.

Species: Least Auklet (Aethia pusilla) Min. # Prey Spp. = 4
N = 3 (None Empty)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
CRUSTACEA				
Calanoid Copepoda	55.2	17.7	66.7	4,863
Gammarid Amphipoda	11.9	6.7	33.3	621
Decapoda	3.0	11.0	33.3	467
Unidentified	1.5	33.4	33.3	1,165
Total Crustacea	71.6	68.8	66.7	9,365
CHAETOGNATHA, Arrow Worms	28.4	31.1	66.7	3,964

Species: Crested Auklet (Aethia cristatella) Min. # Prey Spp. = 3

N = 25 Number of Empty Stomachs = 12 (48%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
CRUSTACEA				
Acanthomysis sp. Mysid	79.5	42.7	15.4	1,880
Hyperiid Amphipod	3.5	10.9	15.4	221
Thysanoessa inermis Euphausiid	15.4	25.0	30.8	1,242
Unidentified	1.6	21.4	46.2	1,064

Appendix Table 40. Data on Indices of Relative Importance (IRI) for prey of adult rhinoceros auklets, pooled from birds collected in Alaskan waters.

Species: Rhinoceros Auklets (Cerohynchus monocerata) Min. # Prey Spp. = 5
N = 21 Number of Empty Stomachs = 5 (23.8%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
CEPHALOPODA, Unidentified	6.1	1.0	6.3	44
FISH				
Mallotus villosus	24.2	60.6	12.5	1,061
Unidentified Osmeridae	3.0	4.1	6.3	45
Cololabis saira	3.0	6.2	6.3	58
Sebastes sp.	18.2	6.2	6.3	152
Ammodytes hexapterus	18.2	11.5	12.5	372
Unidentified	27.3	10.3	56.3	2,114
Total Fish	93.9	98.9	56.3	10,855

Appendix Table 41. Data on Indices of Relative Importance (IRI) for prey of nestling rhinoceros auklets, pooled from birds collected in Alaskan waters.

Species: Rhinoceros Auklet (Cerohynchus monocerata) Min. # Prey Spp. = 9
N = 25 (nestling regurgitations)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
FISH				
Clupea harengus	22.6	32.9	44.0	2,439
Unidentified Salmonid	0.3	7.7	4.0	32
Mallotus villosus	1.2	6.9	4.0	32
Theragra chalcogramma	0.3	0.1	4.0	2
Cololabis saira	0.9	6.0	12.0	83
Sebastes sp.	3.4	2.9	16.0	101
Unidentified Scorpaenid	1.2	0.3	8.0	13
Hexagrammos decagrammus	0.6	1.1	4.0	7
H. lagocephalus	2.1	3.4	12.0	67
Anoplopoma fimbria	0.3	1.3	4.0	61
Ammodytes hexapterus	66.8	37.3	44.0	4,578
Unidentified	0.3	<.1	4.0	1

Appendix Table 42. Data on Indices of Relative Importance (IRI) for prey of adult horned puffins, pooled from birds collected in Alaskan waters.

Species: Horned Puffin (Fratercula corniculata) Min. # Prey Spp. = 13
N = 54 Number of Empty Stomachs = 14 (25.9%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereidae	3.0	0.2	5.0	16
POLYPLACOPHORA (Chitons)	0.4	0.2	2.5	1
CEPHALOPODA				
Gonatid Squid	3.0	10.4	2.5	34
Unidentified	8.7	0.1	2.5	22
CRUSTACEA				
Acanthomysis sp. (Mysid)	0.4	0.3	2.5	2
Anisogammarus pugettensis	0.4	0.1	2.5	1
Euphausiacea				
Thysanoessa inermis	2.7	0.1	5.0	14
T. spinifera	0.4	0.3	2.5	2
Unidentified	0.4	0.4	2.5	2
Total Euphausiacea	3.5	0.8	5.0	22
Pandalus montagui	1.1	0.5	5.0	8
Total Crustacea	5.8	1.9	5.0	38
FISH				
Mallotus villosus	51.3	50.2	27.5	2,793
Theragra chalcogramma	0.4	0.5	2.5	2
Unidentified Gadid	0.4	0.3	2.5	2
Gasterosteus aculeatus	1.1	1.2	2.5	6
Ammodytes hexapterus	15.2	26.9	17.5	736
Unidentified Pleuronectid	2.3	0.2	2.5	6
Unidentified	8.4	7.8	55.0	890
Total Fish	79.1	87.1	55.0	9,141

Appendix Table 43. Data on Indices of Relative Importance (IRI) for prey of nestling Horned Puffins, pooled from samples from the northern Gulf of Alaska.

Species: Horned Puffin (Fratercula corniculata) Min. # Prey Spp. = 3
N = 4 (bill load samples)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
FISH				
Clupea harengus	5.9	1.5	25.0	185
Hexagrammos decagrammus	41.2	70.0	50.0	5,559
Ammodytes hexapterus	52.9	28.5	50.0	4,072

Appendix Table 44. Data on Indices of Relative Importance (IRI) for prey of adult tufted puffins, pooled from birds collected in Alaskan waters.

Species: Tufted Puffin (Fratercula cirrhata) Min. # Prey Spp. = 22
N = 440 Number of Empty Stomachs = 76 (17.3%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereidae	0.2	0.1	2.2	1
PTEROPODA, Limacina helicina	<.1	<.1	0.3	<1
CEPHALOPODA				
Squid	16.9	0.6	4.1	72
Unidentified	5.2	2.1	14.6	106
Total Cephalopods	22.1	2.7	14.6	362
ACARINA, Unidentified Mite	1.6	<.1	0.3	<.1
CRUSTACEA				
Unidentified	0.8	0.2	1.9	2
Calanoid Copepod	0.1	<.1	0.3	<1
Gammarid Amphipod	<.1	<.1	0.3	<1
Parathemisto libellula	1.1	0.1	0.5	1
Euphausiids				
Thysanoessa inermis	39.1	8.4	10.4	497
T. raschii	<.1	<.1	0.5	<1
T. spinifera	2.0	0.4	4.1	10
T. sp.	4.0	0.9	2.7	14
Unidentified	0.1	<.1	0.5	<1
Total Euphausiids	45.2	9.7	10.4	571
Pandalus sp.	0.3	0.1	0.3	<1
Pandalid Shrimp	0.2	<.1	0.5	<1
Unidentified Shrimp	<.1	<.1	0.3	<1
Pagurid Crab	<.1	<.1	0.3	<1
Unidentified	0.1	0.2	1.4	<1
Total Crustacea	47.8	10.3	10.4	604
FISH				
Onchorhynchus nerka	<.1	0.2	0.3	<1
Mallotus villosus	17.0	61.3	44.2	3,464
Unidentified Osmerid	0.1	0.2	1.1	<1
Gadidae (Cods)				
Microgadus proximus	0.4	1.0	0.8	1
Theragra chalcogramma	1.9	3.6	5.2	29
Unidentified	0.5	0.6	4.9	5
Total Gadidae	2.8	5.2	5.2	42
Hemilepidotus jordani	0.6	0.8	2.2	3
H. sp.	<.1	<.1	0.3	<1
Unidentified Cottid	<.1	<.1	0.3	<1
Cyclopteridae	<.1	<.1	0.3	<1
Trichodon trichodon	0.4	1.3	3.8	7
Ammodytes hexapterus	5.1	14.6	12.9	254
Total Fish	26.0	83.6	44.2	4,844

Appendix Table 45. Data on Indices of Relative Importance (IRI) for prey of subadult tufted puffins, pooled from food samples collected in Alaska.

Species: Tufted Puffin (Fratercula cirrhata) Min. # Prey Spp. = 7
N = 80 Number of Empty Stomachs = 20 (25%)

PREY NAME	% NUMBERS	% VOLUME	% FREQUENCY OF OCCURENCE	IRI
POLYCHAETA, Nereidae	9.5	0.4	1.7	17
CEPHALOPODA				
Unidentified Octopi	0.4	0.1	1.7	1
Unidentified	0.4	0.5	1.7	1
FISH				
Mallotus villosus	42.1	52.7	61.7	5,850
Theragra chalcogramma	4.5	6.8	10.0	113
Unidentified Gadid	1.2	1.2	1.7	4
Hemilepidotus hemilepidotus	0.4	0.1	1.7	1
Trichodon trichodon	0.8	1.2	3.3	7
Ammodytes hexapterus	39.7	35.3	40.0	2,998
Unidentified	0.8	1.8	1.7	4
Total Fish	89.5	99.1	61.3	11,561