6- Food Habits of Surf Zone Fishes

Introduction

Information on fish food habits is critical to fully understanding how beach nourishment projects may potentially affect fish inhabitants of the surf zone. Rather dramatic differences in fish abundance and distributions are needed to conclude that beach nourishment has changed surf zone habitat value or function. Food habits data, however, can potentially be used to detect more subtle differences in habitat utilization. Beach nourishment may negatively affect benthic feeders by making infaunal prey unavailable. Alternatively, colonization of the newly placed sand by small infaunal recruits may increase prey availability. A shift in prey type or change in stomach fullness may indicate that food availability has been affected. Dietary changes may affect fish reproduction, growth, and survival, either in a positive or negative way depending on the type of dietary shift. There is little information available concerning whether beach nourishment projects have a significant impact on surf zone fish feeding habits (Hackney et al. 1996). Results of this study provide an important opportunity to examine how a beach nourishment project affects the food habits of bottom feeding surf zone fishes on a mid-Atlantic beach. This chapter compares the food habits of several benthic feeders between a baseline year (1996), during nourishment year (1997) and two post-nourishment years (1998 and 1999).

The stomach contents of the northern kingfish *Menticirrhus saxatilis*, rough silverside *Membras martinica*, and Atlantic silverside *Menidia menidia* collected in the beach seine portion of this monitoring study (Chapter 5) were analyzed to determine the amount of interannual variation in the diets of these fish, as well as whether dietary differences were evident between fish collected in the Reference and Beach Nourishment Areas during the nourishment project. Comparisons were also made between results from the baseline time period (1996; USACE, Chapter 7, 1998), during nourishment period (1997) and the post-nourishment years (1998 and 1999; USACE 1999). The baseline study (USACE, Chapter 7, 1998) established that rhyncocoels, the polychaete *Scolelepis squamata*, and the mole crab *Emerita talpoida* dominate the beach benthos. Polychaetes *S. squamata*, were a dominant prey item for northern kingfish, whereas Atlantic silversides consumed amphipods and copepods as well as polychaetes. Rough silversides also fed primarily on copepods and amphipods (USACE, Chapter 7, 1998). Baseline results indicated that the surf zone is used as foraging habitat by fish rather than solely as a source of refuge after feeding in other areas.

Methods

Specimens for food habits analyses were removed from fish collected by beach seine and fixed in 10% formalin. Where sample sizes were sufficient for a given species, the

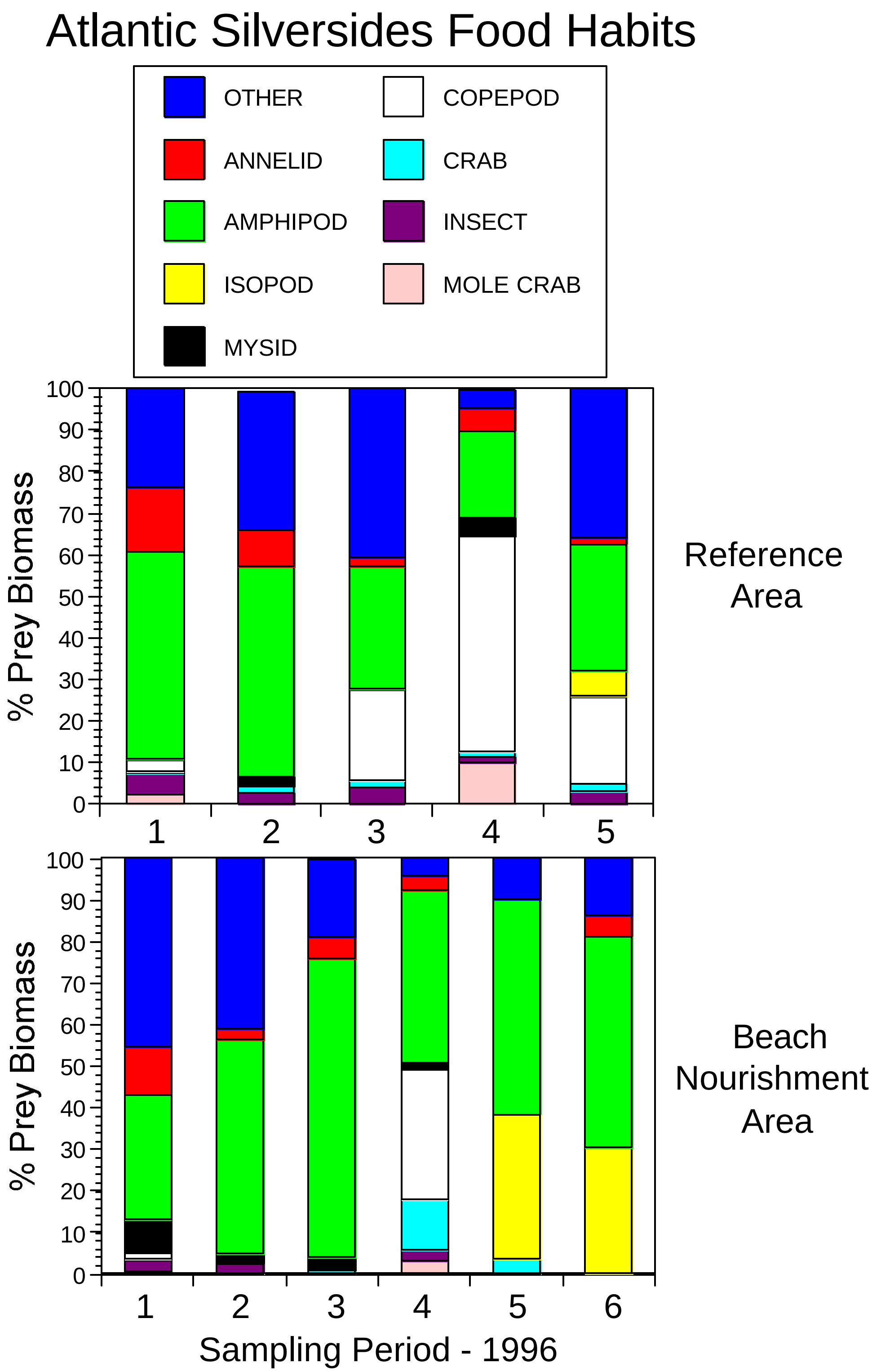

Figure 6-1. Stacked histogram bars depicting the percentage biomass of each prey item in Atlantic silversides captured in 1996 for every sampling period with sufficient sample sizes.

Table 6-1. Sampling periods for the collection of surf zone finfish during the baseline (1994-1996), nourishment (1997), and post-nourishment (1998) portions of the study period.

	1996	1997	1998	1999
1	Aug. 12-17	Aug. 4-7	Aug. 3-7	Aug. 9-12
2	Aug. 26-29	Aug. 19-23	Aug. 17-21	Aug. 23-25
3	Sept. 9-12	Sept. 2-4	---	---
4	Sept. 23-27	Sept. 15-17	Sept. 14-17	---
5	Oct. 7-12	Sept. 30-Oct. 3	Sept. 28-Oct. 1	Oct. 4-8
6	Oct. 26-27	Oct. 14,15,28,29	Oct. 15-17	Oct. 17-23

Appendix 6-1. Taxonomic identifications of surf zone fish food habits listed in order of relative abundance within each predator taxon.

Atlantic Silversides (<60mm)				
Prey Taxon	**1996**	**1997**	**1998**	**1999**
Crab	*Emerita talpoida*	*Emerita talpoida*	*Emerita talpoida*	*Emerita talpoida*
	Megalopal Stage Larvae	Megalopal Stage Larvae	Brachyura (LPIL)	Brachyura (LPIL)
				Megalopal Stage Larvae
Shrimp				*Crangon septemspinosa*
Amphipod	*Jassa falcata*	*Jassa falcata*	*Jassa falcata*	*Jassa falcata*
	Hyale plumulosa	*Hyale plumulosa*	*Hyale plumulosa*	*Hyale plumulosa*
Isopod			*Jaera marina*	
Shrimp	*Crangon septemspinosa*			
Mysid			*Neomysis americana*	
Insect		*Telmatogeton (LPIL)*	*Telmatogeton (LPIL)*	*Telmatogeton (LPIL)*
			Diptera	
			Flying Ants	Flying Ants
Polychaete	Large spionid	*Scolelepis squamata*	*Scolelepis squamata*	*Scolelepis squamata*
Atlantic Silversides (>60mm)				
Prey Taxon	**1996**	**1997**	**1998**	**1999**
Crab	*Emerita talpoida*	*Emerita talpoida*	*Emerita talpoida*	*Emerita talpoida*
	Megalopal Stage Larvae	Megalopal Stage Larvae	Megalopal Stage Larvae	Megalopal Stage Larvae
			Brachyura (LPIL)	Brachyura (LPIL)
Shrimp	*Crangon septemspinosa*		*Crangon septemspinosa*	*Crangon septemspinosa*
Amphipod	*Jassa falcata*	*Jassa falcata*	*Jassa falcata*	*Jassa falcata*
	Hyale plumulosa	*Hyale plumulosa*	*Hyale plumulosa*	*Hyale plumulosa*
Isopod	*Idotea balthica*	*Idotea balthica*		*Idotea baltica*
Mysid			*Neomysis americana*	
Insect	*Telmatogeton (LPIL)*	*Telmatogeton (LPIL)*	*Telmatogeton (LPIL)*	*Telmatogeton (LPIL)*
			Diptera (LPIL)	
			Flying Ants	Flying Ants
Polychaete	*Scolelepis squamata*	*Scolelepis squamata*	*Scolelepis squamata*	*Scolelepis squamata*
		Phylloduce (LPIL)	*Nepthys (LPIL)*	*Scoletoma acicularum*
			Polynoidae (LPIL)	
Bivalve				*Mytilus edulis*

Appendix 6-2. Taxonomic identifications of surf zone fish food habits listed in order of relative abundance within each predator taxon.

		Rough Silversides (<60mm)		
Prey Taxon	**1996**	**1997**	**1998**	**1999**
Crab	Megalopal Stage Larvae		*Emerita talpoida*	*Emerita talpoida*
Amphipod	*Jassa falcata*	*Jassa falcata*	*Jassa falcata*	
	Gammarus annulatus			
Insect			Diptera (LPIL)	
Polychaete				
		Rough Silversides (>60mm)		
Prey Taxon	**1996**	**1997**	**1998**	**1999**
	Megalopal Stage Larvae			
Amphipod	*Jassa falcata*	*Jassa falcata*	*Jassa falcata*	*Jassa falcata*
		Ampelisca (LPIL)	*Gammarus annulatus*	*Gammarus annulatus*
Isopod		*Idotea balthica*		
Insect			Diptera (LPIL)	
Polychaete	Large Spionid			

Appendix 6-3. Taxonomic identifications of surf zone fish food habits listed in order of relative abundance within each predator taxon.

Kingfish (5-10 cm SL)				
Prey Taxon	**1996**	**1997**	**1998**	**1999**
Crab	*Emerita talpoida*	*Emerita talpoida*	*Emerita talpoida*	*Emerita talpoida*
			Brachyura (LPIL)	
			Megalopal Stage Larvae	
Shrimp	*Crangon septemspinosa*	*Crangon septemspinosa*	*Crangon septemspinosa*	*Crangon septemspinosa*
Amphipod			*Gammarus annulatus*	*Gammarus annulatus*
	Jassa falcata	*Jassa falcata*	*Jassa falcata*	*Jassa falcata*
	Hyale plumulosa	*Hyale plumulosa*	*Haustoriidae*	
Isopod	*Idotea baltica*	*Idotea balthica*		
Mysids		*Neomysis americana*	*Neomysis a mericana*	
Polychaete	Large Spionid	*Scolelepis squamata*	*Scolelepis squamata*	*Scolelepis squamata*
		Scoletoma acicularum		
Bivalve			*Mytilus edulis*	
Kingfish (10-15 cm SL)				
Prey Taxon	**1996**	**1997**	**1998**	**1999**
Crab		*Emerita talpoida*	*Emerita talpoida*	*Emerita talpoida*
		Brachyura (LPIL)	Brachyura (LPIL)	Brachyura (LPIL)
			Pagurus longicarpus	
Shrimp	*Crangon septemspinosa*	*Crangon septemspinosa*	*Crangon septemspinosa*	*Crangon septemspinosa*
Isopod	*Idotea baltica*	*Idotea balthica*		
Amphipod		*Hyale plumulosa*	*Gammarus annulatus*	*Gammarus annulatus*
		Jassa falcata	*Jassa falcata*	*Jassa falcata*
			Haustoriidae (LPIL)	
Insect	*Telmatogeton (LPIL)*			
Polychaete	Large Spionid	*Scolelepis squamata*	*Scolelepis squamata*	*Scolelepis squamata*
		Scoletoma acicularum	*Nepthys (LPIL)*	
Kingfish (15-20 cm SL)				
Prey Taxon	**1996**	**1997**	**1998**	**1999**
Crab				*Emerita talpoida*
			Brachyura (LPIL)	Brachyura (LPIL)
Shrimp			*Crangon septemspinosa*	*Crangon septemspinosa*
Amphipod		*Hyale plumulosa*	*Gammarus annulatus*	*Gammarus annulatus*
			Jassa falcata	
Polychaete			*Scolelepis squamata*	*Scolelepis squamata*

Table 6-2. Summary of the sample sizes of the number of fish with filled stomachs captured from 1996 to 1999 by size class and project area.

	Atlantic Silverside		Rough Silverside		Northern Kingfish		
Area	<60 mm	>60 mm	<60 mm	>60 mm	< 10 cm	10-15 cm	> 15 cm
1996							
Reference	1024	910	170	665	104		
Beach Nour.	685	461	201	608	31		
Total	4534	2858	707	3306	135		
1997							
Reference	787	1473	116	340	180	4	0
Beach Nour.	457	1146	173	189	574	61	1
Total	1244	2619	289	529	754	65	1
1998							
Reference	781	1730	49	63	266	215	23
Beach Nour.	1063	1012	38	136	277	69	5
Total	1844	2742	87	199	543	284	28
1999							
Reference	926	2000	114	52	60	33	28
Beach Nour.	1998	3705	216	0	141	90	33
Total	2924	5705	330	52	201	123	61

Table 6-3. Summary of tests for differences in the stomach contents of fish captured at Reference and Beach Nourishment stations in 1997. Observations indicate condition at Beach Nourishment stations as compared to Reference stations ($p \leq 0.01$).

Sampling Period						
Predator	1	2	3	4	5	6
Kingfish	no data	< mysids > annelids	NS	NS	NS	NS
Atlantic Silversides	> prey biomass > amphipods	> crabs	NS	NS	> mole crabs	> fish prey for lg. silversides > mole crabs > amphipod > prey biomass

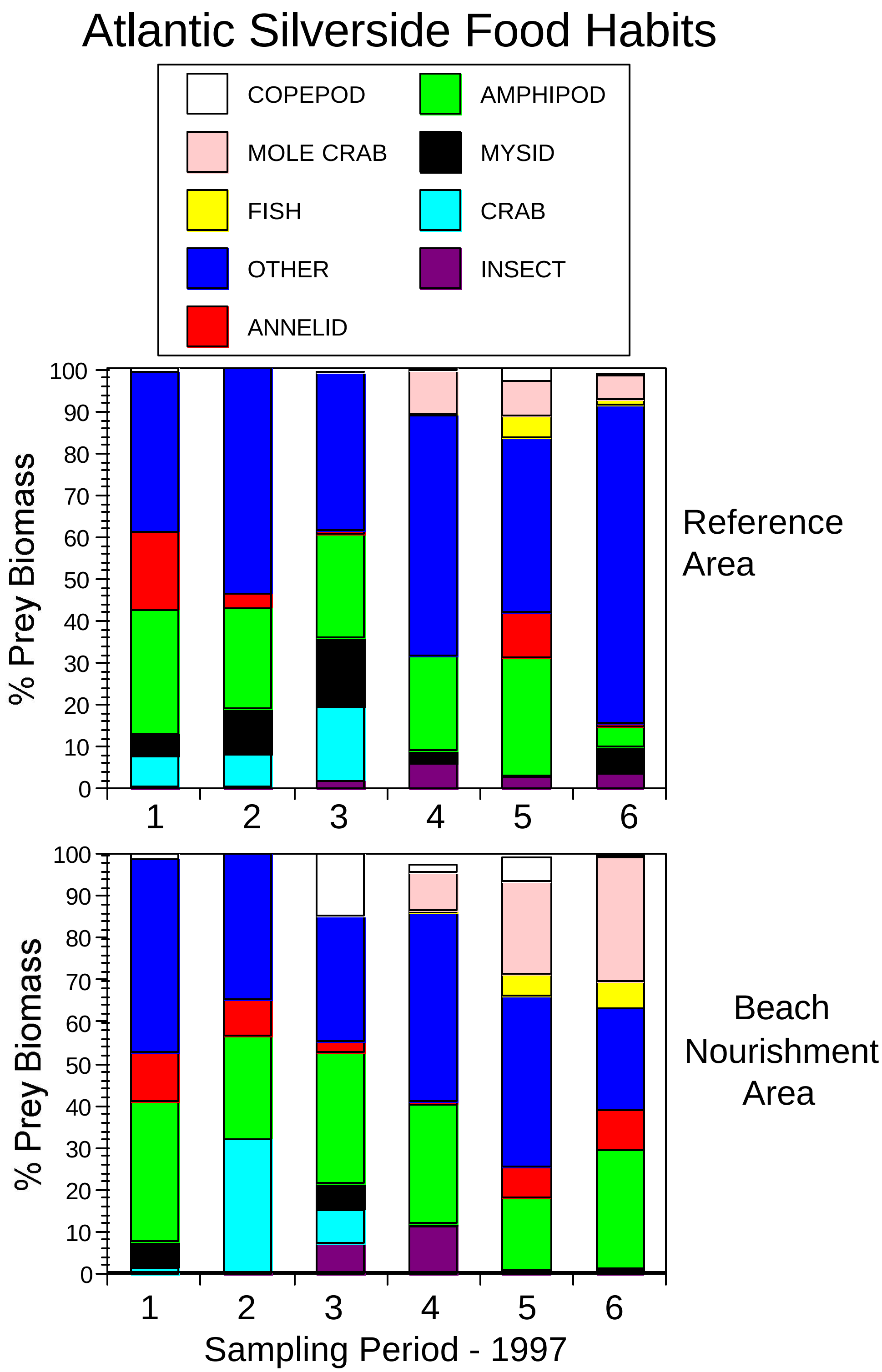

Figure 6-2. Stacked histogram bars depicting the percentage biomass of each prey item in Atlantic silversides captured in 1997 for every sampling period with sufficient sample sizes.

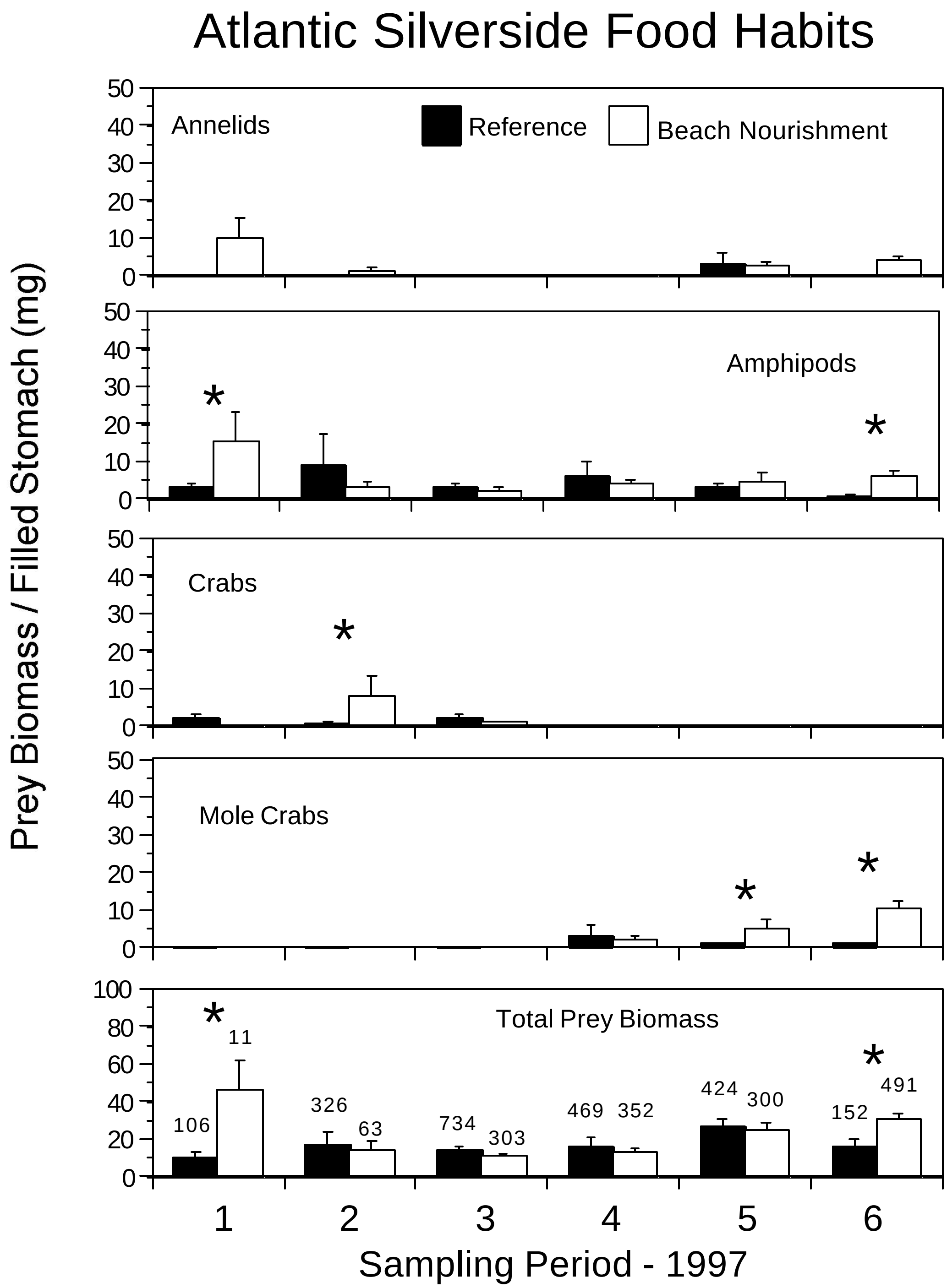

Figure 6-3. Average prey biomass (mg)/filled stomach by major prey category for Atlantic silversides captured at reference (black bars) and beach nourishment (white bars) stations in 1997. Numbers over the bars in the bottom graph indicate the number of filled stomachs analyzed. Asterisks indicate statistically significant results for that prey item and sampling period.

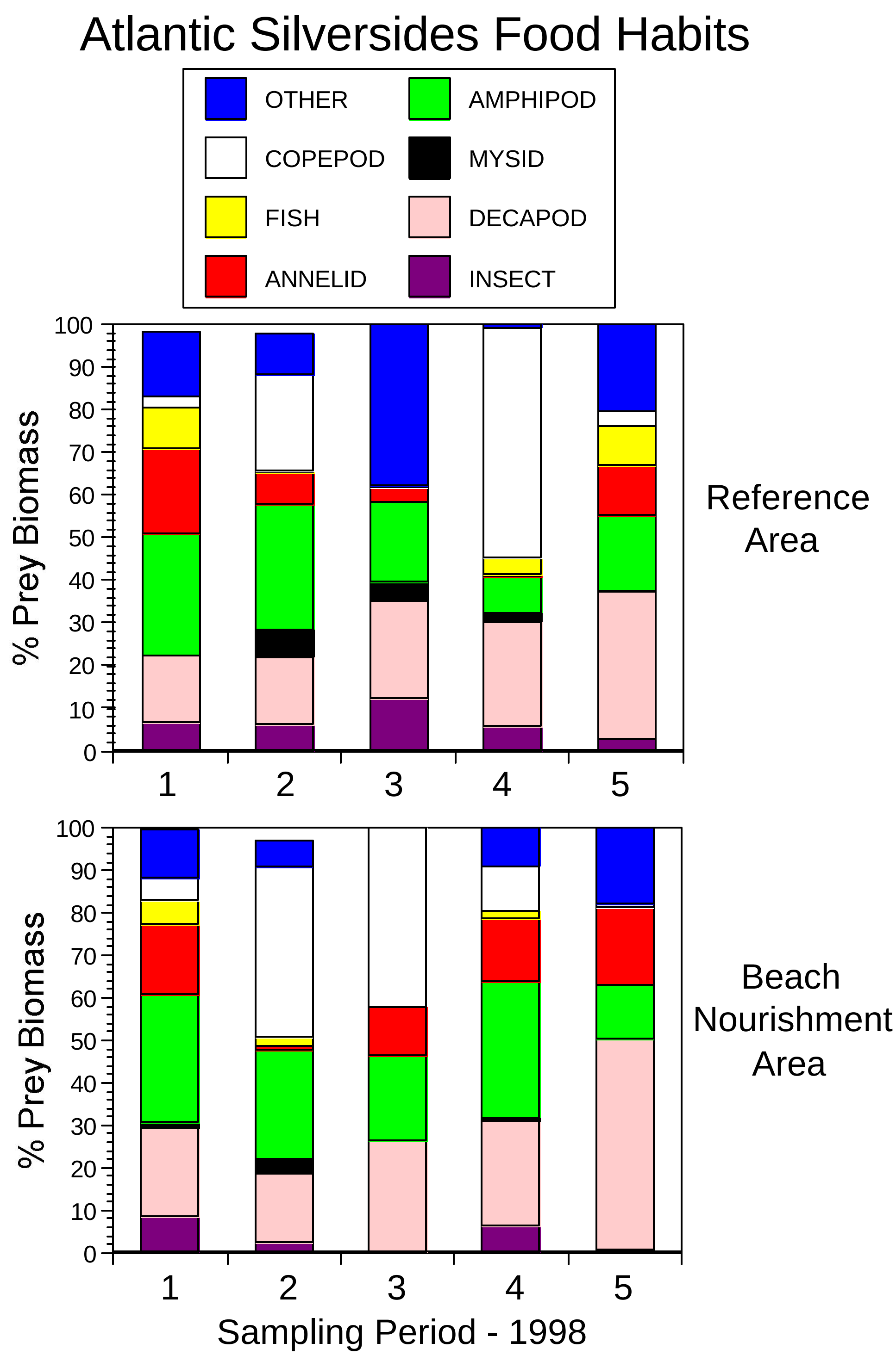

Figure 6-4. Stacked histogram bars depicting the percentage biomass of each prey item in Atlantic silversides captured in 1998 for every sampling period with sufficient sample sizes.

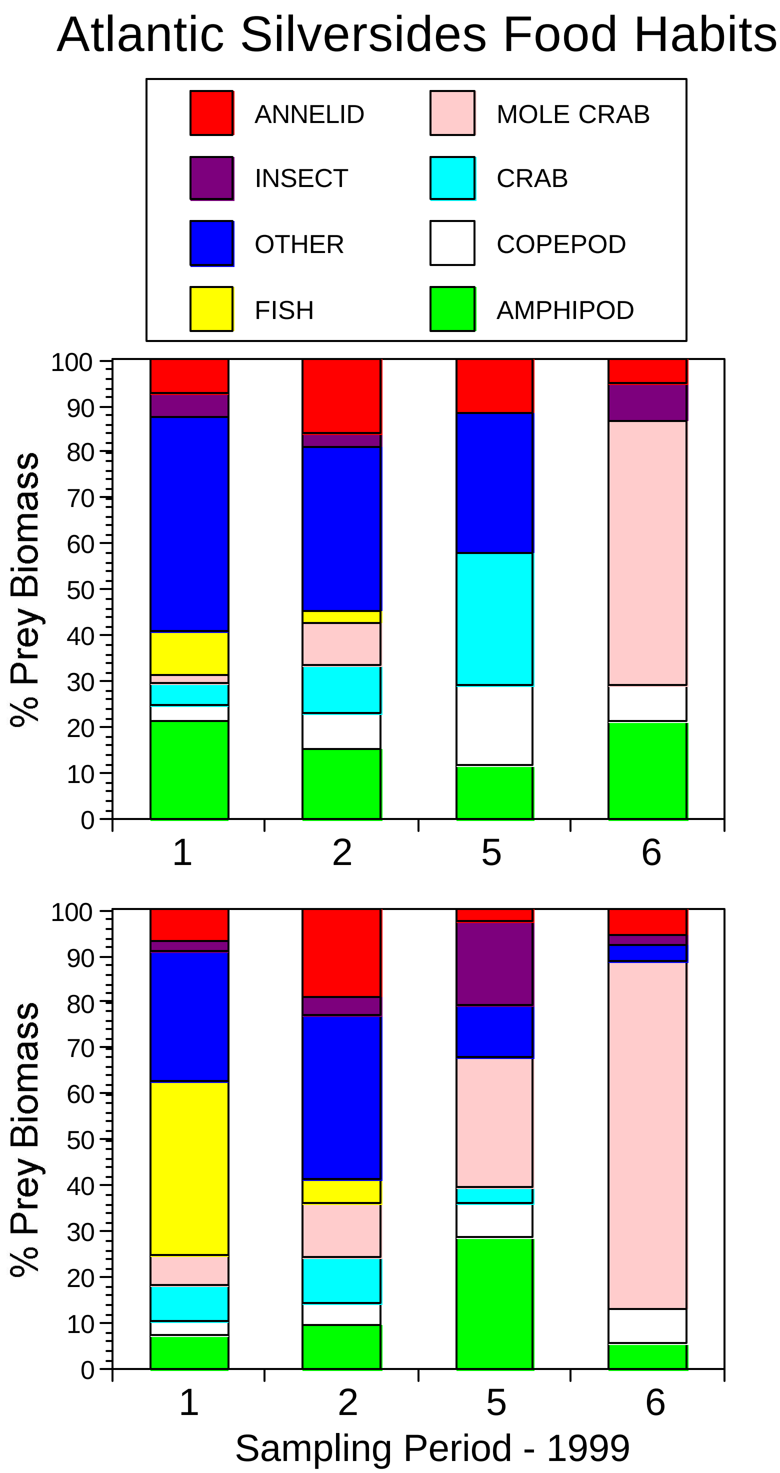

Figure 6-5. Stacked histogram bars depicting the percentage biomass of each prey item in Atlantic silversides captured in 1999 for every sampling period with sufficient sample sizes.

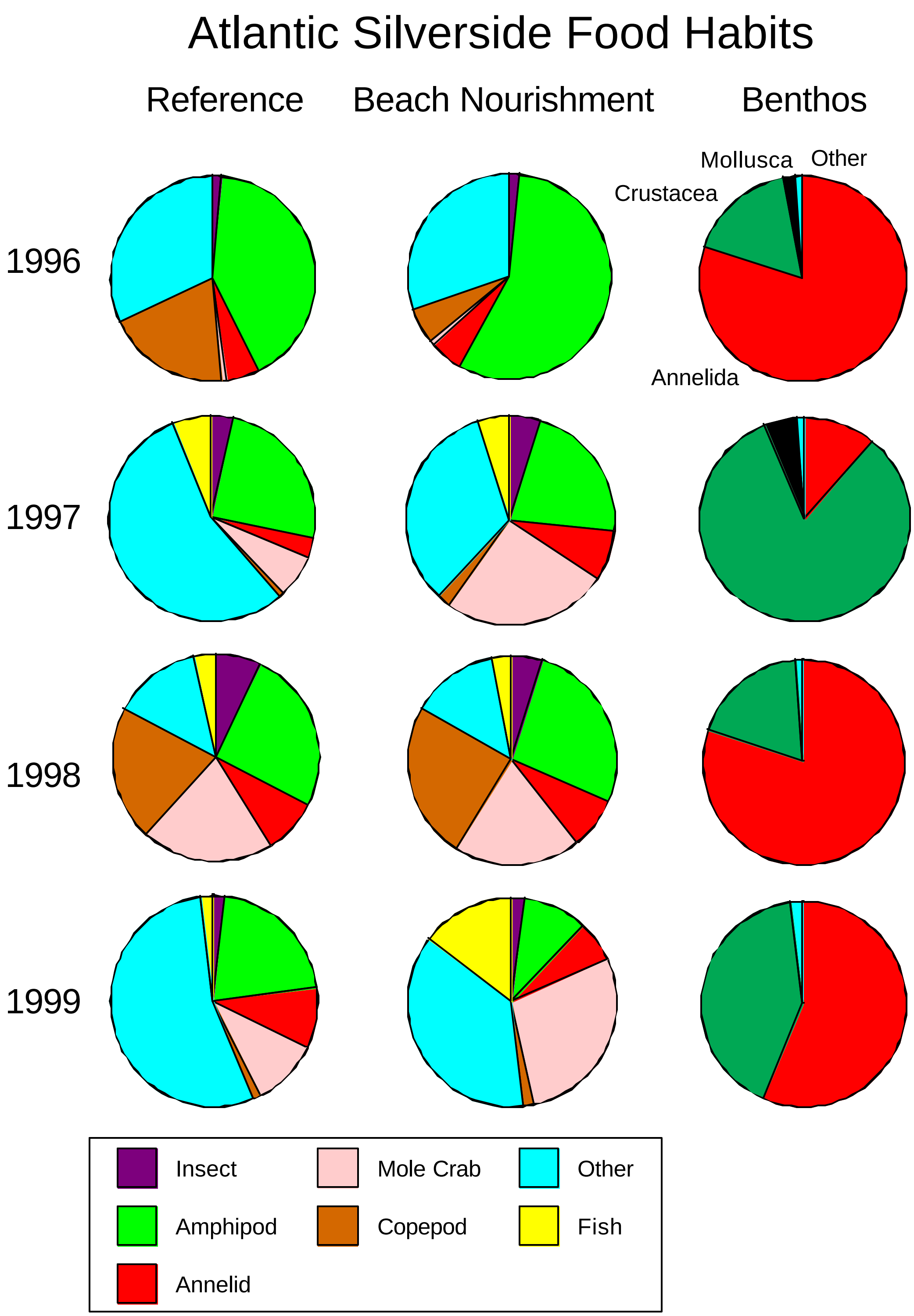

Figure 6-6. The overall annual prey consumption of Atlantic silversides in the Reference and Beach Nourishment Areas relative to the composition of the benthic prey biomass for each year.

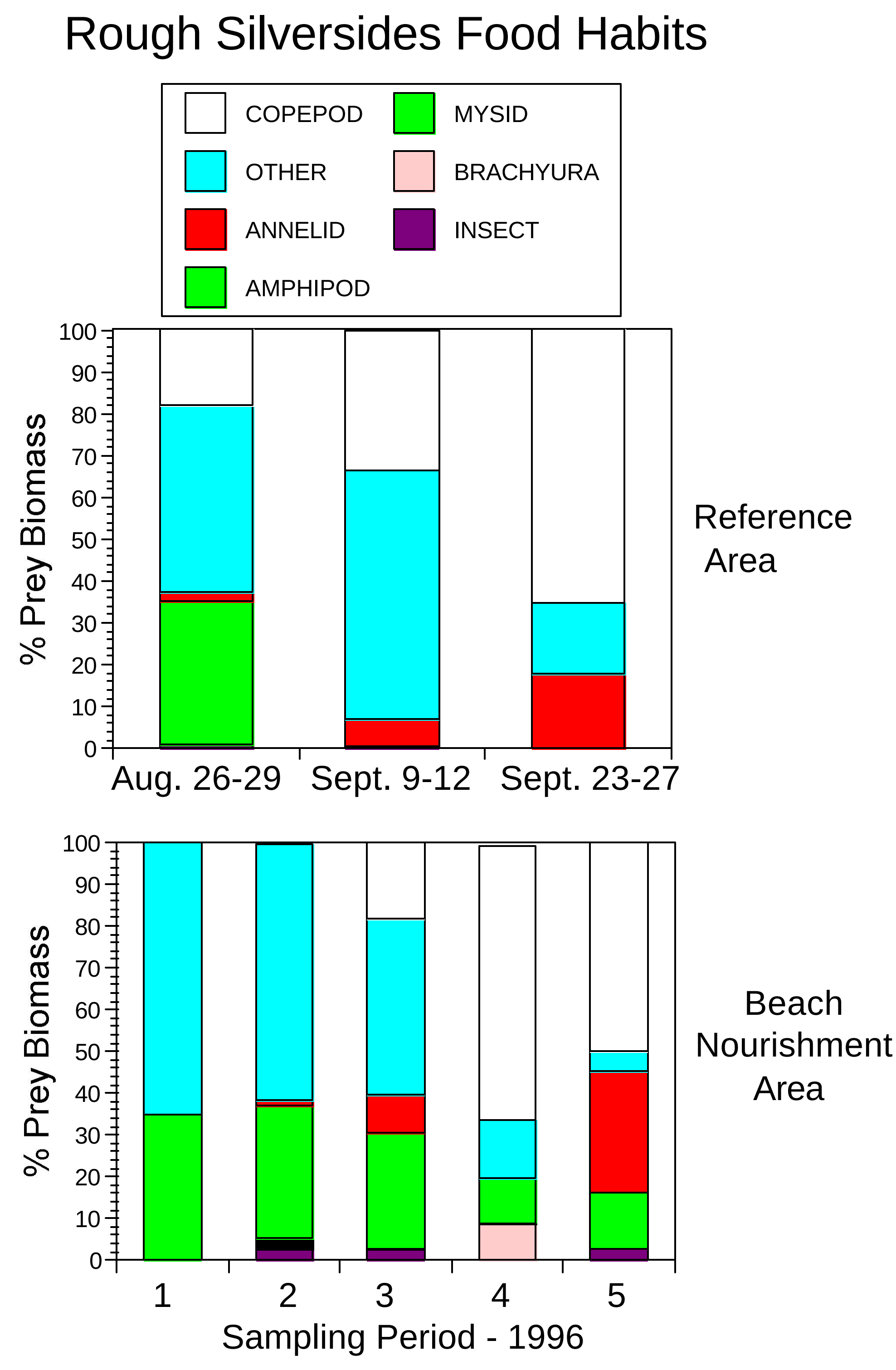

Figure 6-7. Stacked histogram bars depicting the percentage biomass of each prey item in rough silversides captured in 1996 for every sampling period with sufficient sample sizes.

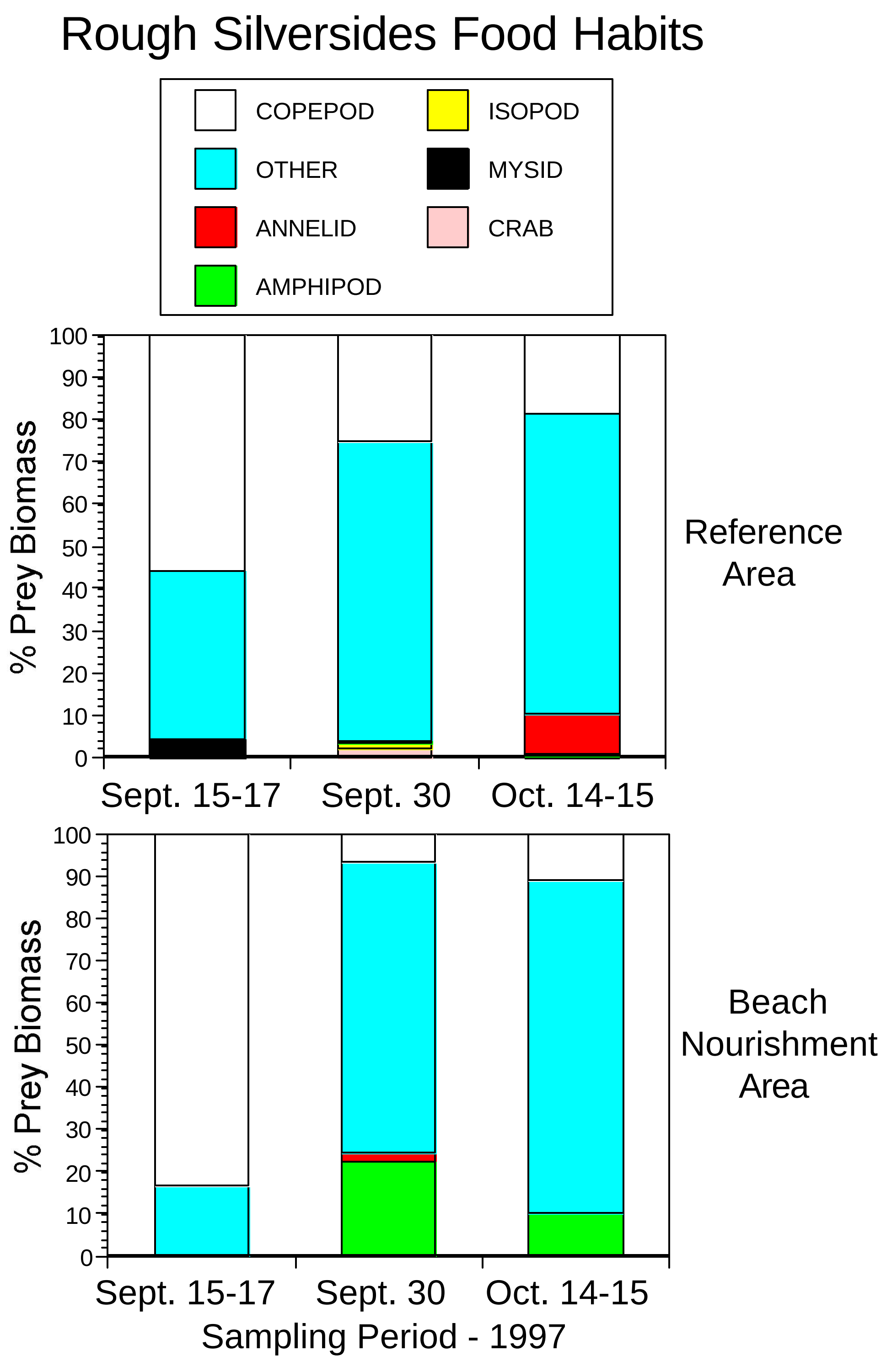

Figure 6-8. Stacked histogram bars depicting the percentage biomass of each prey item in rough silversides captured in 1997 for every sampling period with sufficient sample sizes.

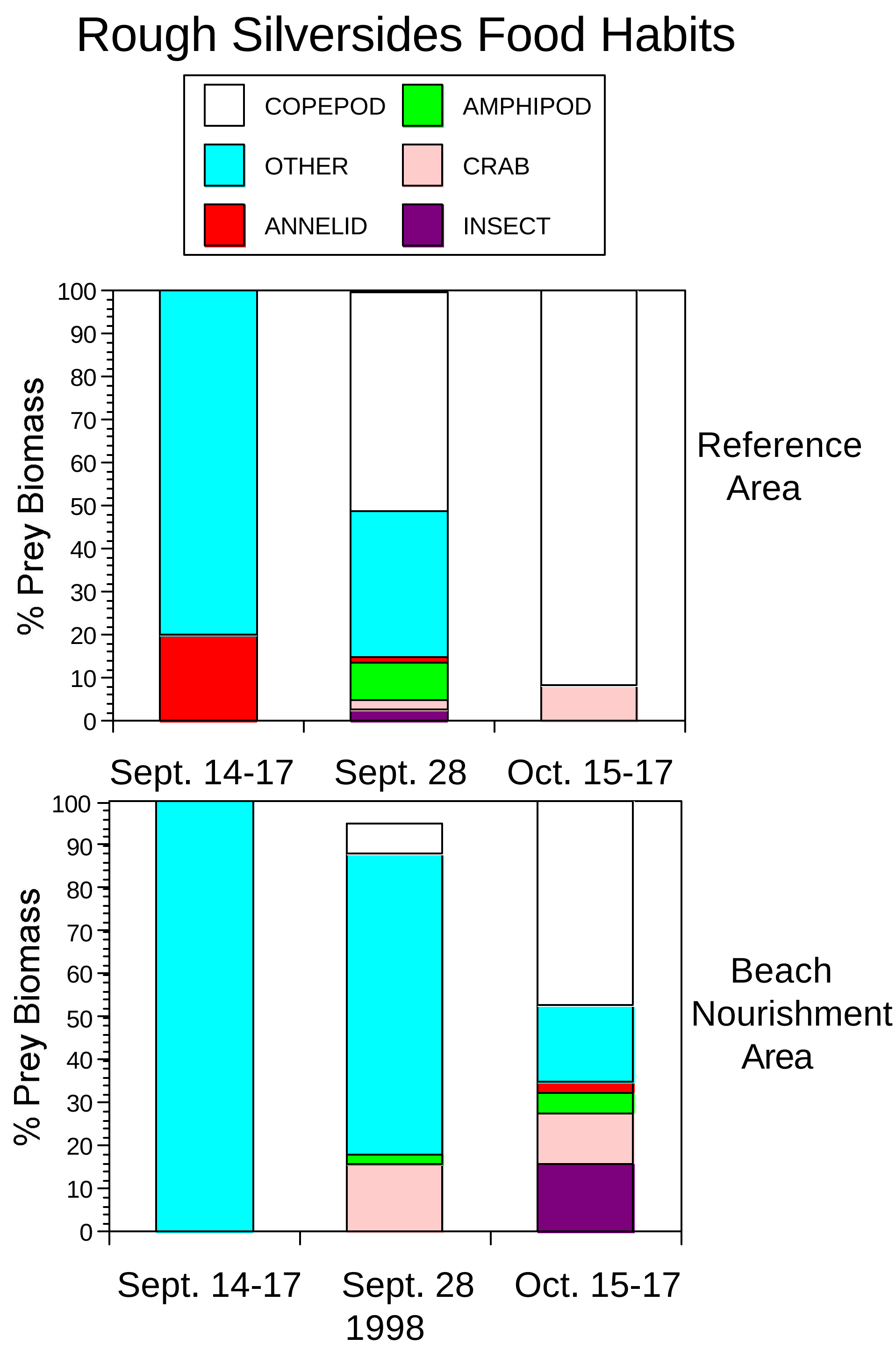

Figure 6-9. Stacked histogram bars depicting the percentage biomass of each prey item in rough silversides captured in 1998 for every sampling period with sufficient samp le sizes.

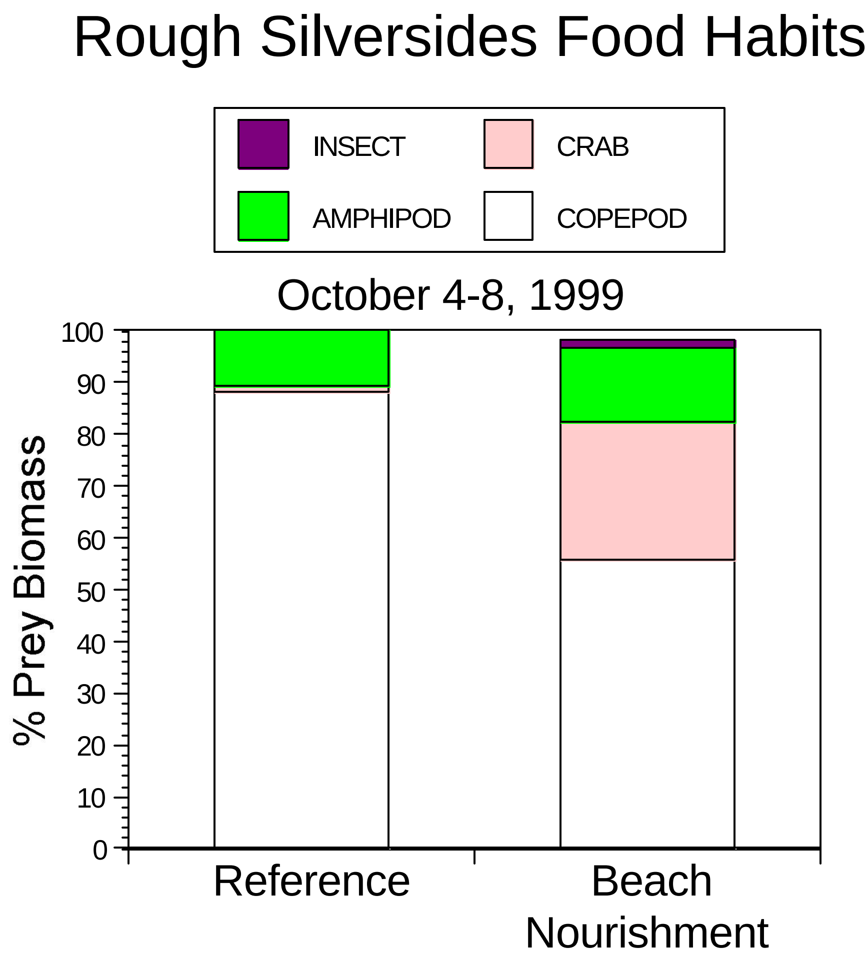

Figure 6-10. Stacked histogram bars depicting the percentage biomass of each prey item in rough silversides captured in 1999 for every sampling period with sufficient sample sizes.

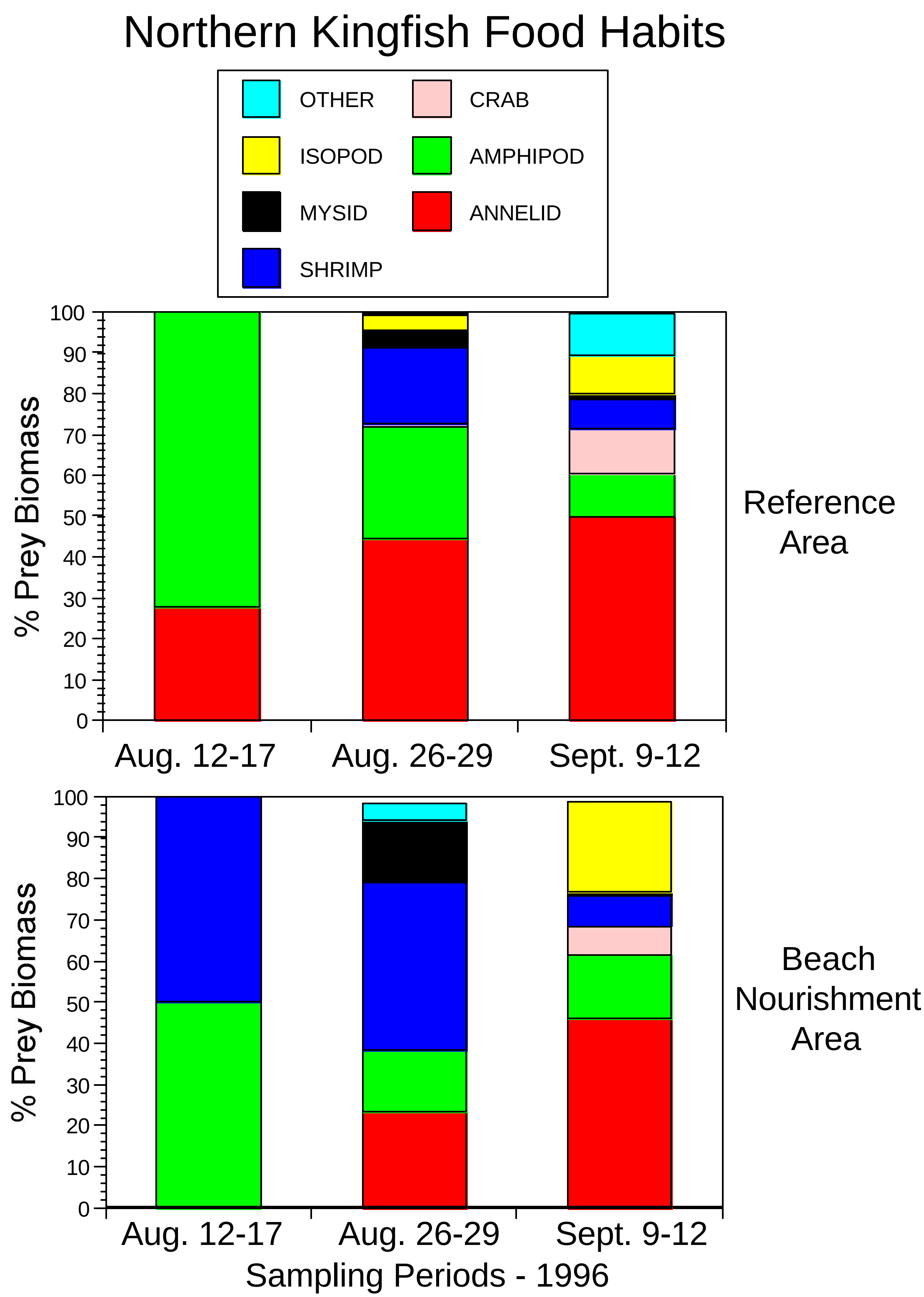

Figure 6-11. Stacked histogram bars depicting the percentage biomass of each prey item in northern kingfish captured in 1996 for every sampling period with sufficient sample sizes.

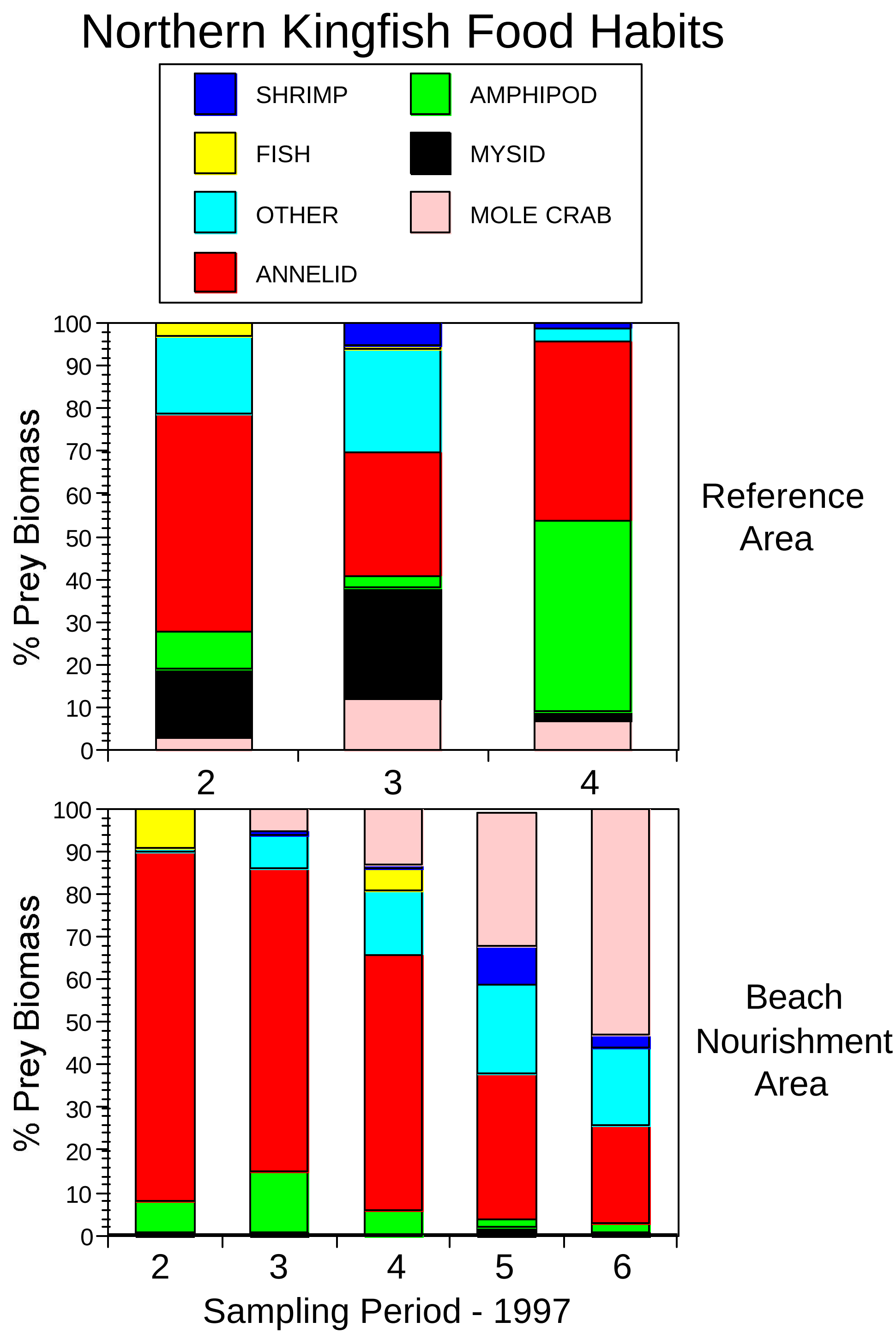

Figure 6-12. Stacked histogram bars depicting the percentage biomass of each prey item in northern kingfish captured in 1997 for every sampling period with sufficient sample sizes.

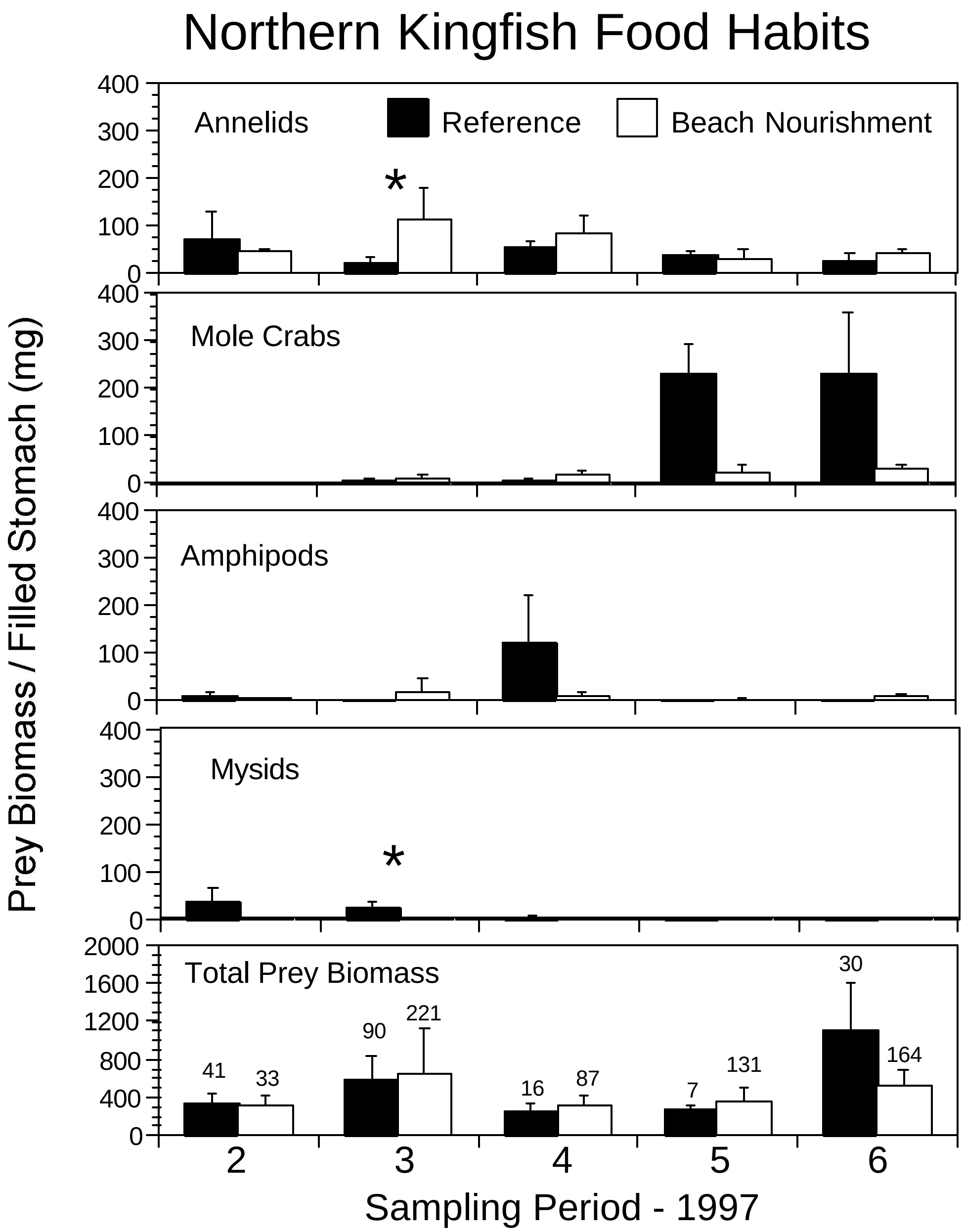

Figure 6-13. Average prey biomass (mg)/filled stomach by major prey category for northern kingfish captured at reference (black bars) and beach nourishment (white bars) stations in 1997. Numbers over the bars in the bottom graph indicate the number of filled stomachs analyzed. Asterisks indicate statistically significant results for that prey item and sampling period.

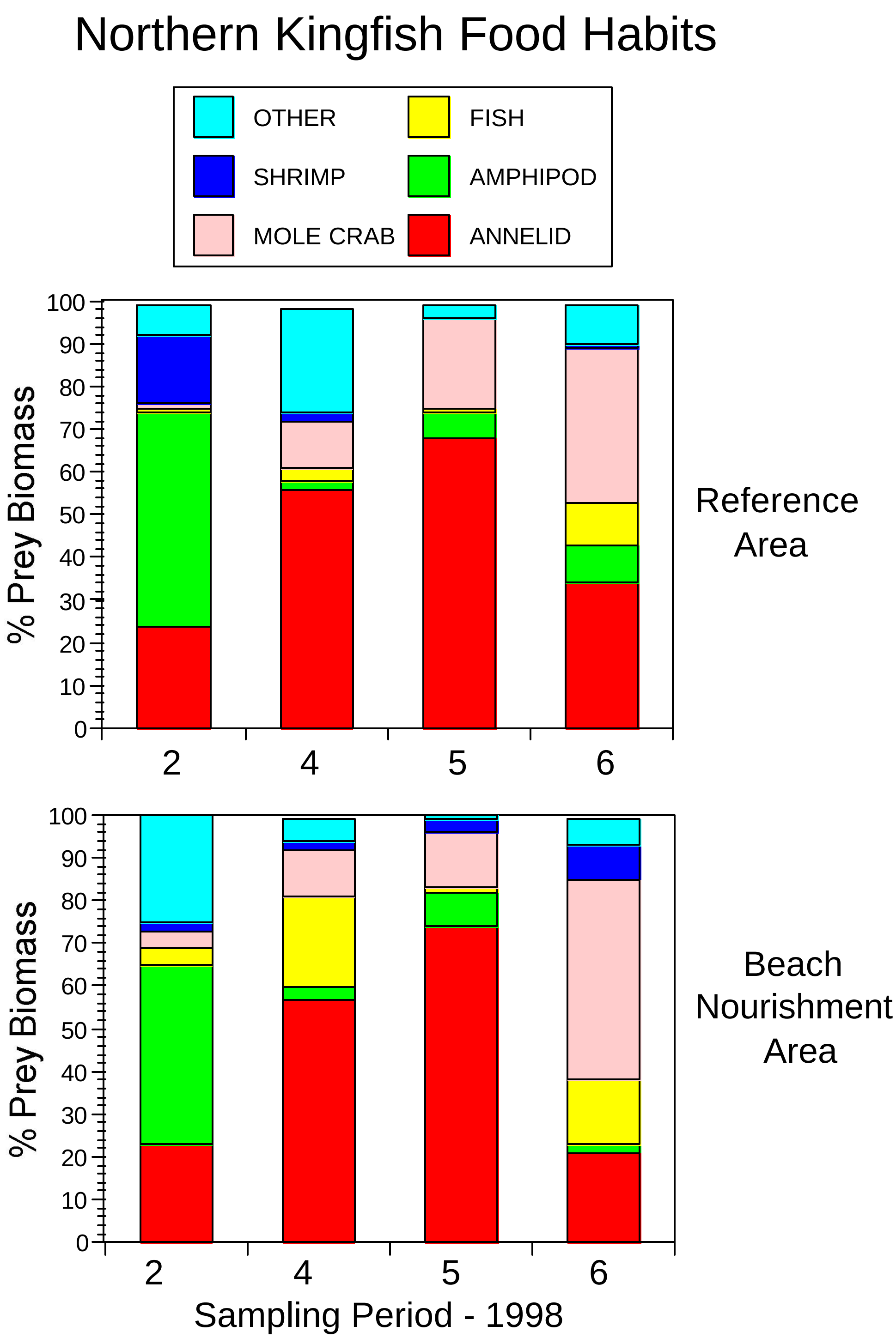

Figure 6-14. Stacked histogram bars depicting the percentage biomass of each prey item in northern kingfish captured in 1998 for every sampling period with sufficient sample sizes.

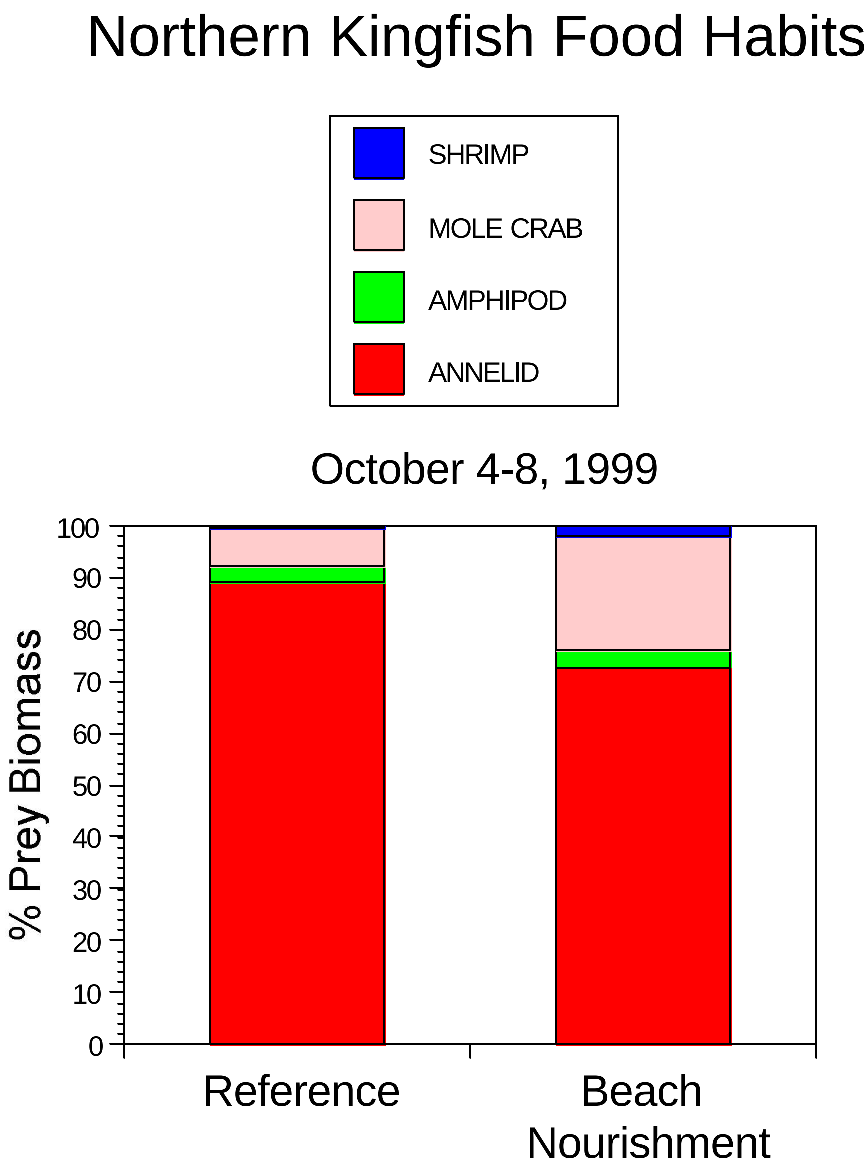

Figure 6-15. Stacked histogram bars depicting the percentage biomass of each prey item in northern kingfish captured in 1999 for every sampling period with sufficient sample sizes.

specimens were sorted into distinct Standard Length (SL) size classes. Individual fish within each size class were dissected in the laboratory and the stomach contents were removed. Stomach contents were then pooled according to location (in relation to groin cell morphology), study area, and date dependent on the total number of stomachs available. Pooling was conducted as described by Borgeson (1963) and Sheridan (1979), contents sorted, and major taxonomic categories wet-weighed to yield a composite characterization of the diets of size classes of each predator species. This method sacrifices information on variation in diets on an individual fish basis, but allows an accurate characterization of foraging behavior at the population level.

Mann Whitney analyses were used to test for differences in the biomass/filled fish stomach of each prey item between fish caught at the Reference and Beach Nourishment stations. All statistical tests were performed on prey biomass/filled stomach data for samples in which at least five fish with filled stomachs were captured. Other factors, such as fish size and substation (A, B, and C) were also used as independent variables as data permitted. The Bonferroni criterion was used to control for multiple tests (Wilkinson 1990). The relationship between food habits and fish size was not extensively addressed in this report because it was not relevant to detecting potential beach nourishment impacts. Although ontogenetic shifts in dietary habits may be expected, there were no differences in the distribution of either kingfish or silversides by size class throughout the study area (Chapter 5); therefore fish size did not complicate the interpretation of results. One-factor ANOVAs were used to test for differences in the total biomass of prey/filled stomach between the two beach areas. Stacked histogram bars depict the percentages of biomass of each prey group for each beach location and sampling period in which fish were captured. Sampling periods are denoted by their order of occurrence in both tables and figures and are listed in Table 6-1.

Food habits were examined with reference to some distribution anomalies noted for kingfish and silversides in 1997 in the beach seine chapter (Chapter 5). Briefly stated, kingfish were more common at the Beach Nourishment stations than at the Reference stations in 1997, whereas no such difference in distribution occurred during the baseline years or post-nourishment years. Silversides were present in every haul taken at five stations (19-23) in October of 1997, which was an unusually consistent occurrence compared to other portions of the beach and other sampling periods. A common or unique dietary component that may be associated with either of these distribution patterns was investigated.

Results

The species composition of each prey taxon was relatively consistent throughout the duration of the monitoring study for all fish examined (Appendix 6-1 through 6-3). Amphipods included *Hyale plumulosa, Gammarus annulatus, Jassa falcata.* Annelids were dominated by the polychaete, *S. squamata,* along with *Phylloduce* (LPIL), *Nepthys* (LPIL), and

Scoletoma acicularum. Shrimp were identified as *Crangon septemspinosa*. The brachyuran prey category for rough silversides in 1996 includes the anomuran mole crabs, *E. talpoida* and brachyuran crab megalopae.

Atlantic Silverside: A total of 3,080 filled fish stomachs were examined in 1996 (Table 6-2), with 312 additional stomachs determined to be empty. Amphipods and copepods were the most dominant prey items by weight with amphipods comprising the majority of the identifiable prey biomass during August and early September and copepods and isopods becoming more prevalent later in September and October (Figure 6-1). The prey composition of fish collected in the Reference area did not differ significantly from that of fish collected in the Beach Nourishment area in 1996 (all p-values > 0.05). Likewise, stomach fullness, measured as mean prey biomass per stomach did not differ between beach areas. The isopod component of the silverside diet was greater during the last two sampling periods, especially at the beach nourishment stations due the consumption of this prey type by a few fish.

The filled stomachs of 3,863 Atlantic silversides were analyzed over the six 1997 sampling periods (894 silversides had empty stomachs). Silverside prey composition was relatively diverse, with up to eight major prey taxa represented during a single sampling period (Figure 6-2). The percentage of silversides with filled stomachs was relatively low during the first two sampling periods (46% and 66%, respectively), compared to September and October (average = 84%). During the first sampling period, silversides captured at the Beach Nourishment stations had significantly higher prey biomass/filled stomach than fish from Reference stations ($F = 6.8$, $p = 0.018$, Table 6-2). Amphipods were the dominant prey item of the identifiable stomach contents (Figure 6-2) and comprised significantly more biomass/filled stomach in fish captured at the beach nourishment stations (Figure 6-3). During the second sampling period, amphipods remained the dominant prey item in the Reference Area, while crab megalopae made up the majority of the prey biomass at the Beach Nourishment stations (Figures 6-2 and 6-3).

In September, amphipods were the dominant identifiable prey item. There were no significant differences in prey composition between the diets of silversides captured at the Beach Nourishment and Reference stations. Crab megalopae were present in the diets of silversides captured in early September, but were not present in mid-September, when mole crabs first appeared as a prey item. In early October, fish were a component of the diet of large (> 60 mm SL) silversides at three stations. Fish prey included the American sand lance *Ammodytes americanus* and anchovies in the 10 - 20 mm size range.

Several notable patterns were present in the diets of silversides captured during the sixth sampling period of 1997. Amphipods and mole crabs remained the dominant components of small (< 60 mm SL) silversides' diets at both the Reference and Beach Nourishment stations. Fish were present in the stomachs of large silversides and were significantly more common in the diets of silversides captured at stations 19-23 (64% of hauls) compared to other Beach Nourishment (25%) and Reference (12%) stations (Yate's corrected Chi-square = 6.7, $p < 0.05$). Stations 19-23 were nourished at the same time (in early September). Silversides were captured in all hauls at these stations during the last sampling period (Chapter 5). Mole crab ($U = 54.5$, $p = 0.002$) and amphipod biomass ($U = 42.5$, $p = 0.001$) was significantly greater in the diets of silversides from the Beach Nourishment stations than silversides from the Reference stations (Table 6-3, Figure 6-3). The insect component of the reference fish diets consisted of pupae in the stomachs of fish from a single seine haul.

In 1998, the filled stomachs of 4,586 silversides were examined. Over 70% of silversides in each sampling period had filled stomachs. The taxonomic composition of the prey items was similar to that of silversides captured in 1996 and 1997. Decapods, annelids, and amphipods dominated the prey biomass during the early August sampling period (Figure 6-4). Silversides captured during the second sampling period consumed more copepods than previously observed. The prevalence of copepods in the silversides' diet varied by sampling period and beach area with a relatively high occurrence (42% of total prey biomass) from fish captured at the Beach Nourishment stations in mid-September (sampling period 3) and the Reference stations (54%) in late September (sampling period 4, Figure 6-4). Mole crabs comprised a major portion of the prey biomass for the last sampling period at both beach locations (Figure 6-4). There were no statistically significant differences in prey biomass between the beach areas for this year of sampling.

The filled stomachs of 8,629 Atlantic silversides were analyzed over the four 1999 sampling periods (1899 silversides had empty stomachs). The silversides food habits did not differ between the Reference and Beach Nourishment area for any sampling period in 1999, although there were several prey species that were consumed in varying amounts by sampling effort (Figure 6-5) and fish size class. Silversides captured in the first sampling periods contained significantly more fish as a food item than other sampling periods ($U = 366$, $p = 0.002$) and only large silversides (> 60 mm SL) consumed fish. Food habits changed between August and October, with more amphipods and insects consumed during the first October sampling period (Figure 6-5) and more mole crabs and copepods present as prey items during both the October sampling periods (all p-values < 0.001). The biomass of mole crabs/filled stomach was significantly greater for large silversides ($U = 1565$; $p < 0.001$).

Benthic prey biomass consisted primarily of annelids (Figure 6-6), predominantly the polychaete *S.squamata.* While polychaetes were present in Atlantic silversides diet, amphipods, which were not common in the intertidal benthos, were a more common prey item. The amphipods *J. falcata* and *H. plumulosa* were common in the Atlantic silversides diets for most years (Appendix 6-1) and were most probably consumed while fish were foraging near rock groins (Chapter 4). The biomass of amphipods per filled stomachs did not differ between the groin substations (A and C) and the mid-groin substations (B), however, probably reflecting substantial movement of silversides within the groin field.

Rough Silverside: - In 1996, the filled stomach contents of 1,644 rough silversides were examined, while 133 dissected stomachs were empty. Amphipods were a primary component of their diet in August with copepods becoming more common in September and October (Figure 6-7). For many samples, the majority of the stomach contents were unidentifiable. There were no significant differences between the Reference and Beach Nourishment areas for any prey item or sampling period.

In 1997, the stomach contents of 818 rough silversides that were captured in the last three sampling periods were analyzed (500 fish stomachs were empty). In mid-September, copepods and mysids made up all of the identifiable prey biomass, with copepods the dominant prey item (Figure 6-8). In October, small amounts of amphipods, isopods, annelids, and crabs were also present in the diet. For all three sampling periods, the unidentified "other" category was large, comprising over 50% of the prey biomass. Atlantic silversides in northern latitudes feed mostly on rising tides (Gilmurray and Daborn 1981), which may be reflected in stomach contents samples that have been collected at particular stages of the tide. Rough silversides may feed at a different stage of the tide or could be crepuscular feeders, in which case the time between prey ingestion and sample collection would be extended. Temporal partitioning among species foraging on similar resources is common in fish communities. This could account for the observed difference in stage of digestion (fish were captured at low tide) between Atlantic and rough silverside stomach contents. Consequently, successful identification of rough silverside prey items may have been reduced.

In 1998, the stomach contents of 286 rough silversides collected in September and October were examined. The taxonomic make-up of the prey items was similar to that of the rough silversides captured in 1996 and 1997. Copepods and dipteran insects comprised the majority of the diet in each of the last three sampling periods (Figure 6-9).

The stomach contents of 382 rough silversides captured primarily during the October 4-8, 1999 sampling period were examined, 93 fish had empty stomachs. Amphipods, copepods, insects and mole crabs made up the identifiable prey biomass of rough silversides. Copepods and mole crabs comprised 54% and 40% of the prey biomass in large rough silversides (> 60 mm SL) in early October, respectively. Mole crabs were not present in the diets of smaller rough silversides. There were no indications that prey biomass differed between Reference and Beach Nourishment stations (Figure 6-10).

Northern Kingfish Summary: The stomach contents of 135 kingfish were analyzed from the first three sampling periods in 1996. Fourteen kingfish had empty stomachs. The kingfish diet became more diverse in the second and third sampling periods, with the inclusion of shrimp, mysids, and isopods (Figure 6-11). Polychaetes *S. squamata* and amphipods *J. falcata* (Appendix 6-3) were the predominant food items, with shrimp *C. septimspinosa* making up roughly half of the total prey biomass for fish captured at the Beach Nourishment area during the August 12-17th sampling period.

The stomach contents of 820 kingfish were analyzed by sampling period for the during-nourishment (1997) time period (Table 6-2). An additional 249 kingfish were dissected, but had empty stomachs. Although kingfish were captured during all six sampling periods, stomach contents were not analyzed for the early August sampling period in which most individuals captured were less than 5 cm SL. Annelids comprised the majority of the prey items for the second sampling period at both the Reference (51%) and Beach Nourishment (82%) stations (Figure 6-12). During the second sampling period, the mysid biomass per filled stomach was significantly greater for kingfish captured at Reference stations than for those at Beach Nourishment stations (Mann Whitney $U = 285.0$, $p = 0.005$, Figure 6-13). Annelid biomass was greater in fish captured at the Beach Nourishment stations ($U = 88$, $p = 0.01$, Table 6-3). Overall, annelids accounted for 71% of the biomass in kingfish stomachs from the Beach Nourishment stations compared to 29% for kingfish from the Reference stations (Figure 6-12). Prey composition of the diets of kingfish did not differ significantly between the Reference and Beach Nourishment Areas for any other sampling period (Table 6-3). In mid-September, the amphipod component of the diet was relatively high (45%) for the Reference Area fish due to a single fish that was filled exclusively with amphipods. The annelid portion of the diet totaled 60% of the prey biomass of fish from the Beach Nourishment stations (Figure 6-12). In October, the majority of fish were captured at the Beach Nourishment stations (28 of 34 hauls with kingfish were from Beach Nourishment stations during the fifth sampling period and similarly, 28 of 33 hauls for the sixth sampling period). The annelid component of the kingfish diet was notably smaller during these sampling periods, whereas mole crab biomass increased over that previously observed (Figure 6-12). Parameters used to estimate whether the nourishment process affected prey availability included total prey biomass/filled stomach and the percentage of filled stomachs for all fish dissected. Neither of these parameters differed significantly between the Reference and Beach Nourishment stations for any sampling period in 1997 for kingfish. Prey biomass/fish was greater for the larger kingfish size classes, as may be expected due to greater prey consumption by larger individuals. Prey taxonomic composition, however, did not differ between size classes.

In 1998, the stomach contents of 855 kingfish revealed similar dietary patterns to that observed previously in terms of the types of prey items consumed. In 1998, however, prey biomass did not differ for any taxonomic category between kingfish captured in the Reference and Beach Nourishment areas for any sampling period. Amphipods were a major food item in the diets of kingfish captured in mid-August (Figure 6-14) at both the Reference and Beach Nourishment stations. All of the kingfish captured during this sampling period were < 10 cm

(SL). By mid-September, larger kingfish (10-15 cm SL) were captured and annelids dominated the diets of kingfish from both areas (Figure 6-14). Food habits did not differ by kingfish size class within a sampling period. Mole crabs became an increasingly greater component of the kingfish diet in September and October.

The stomach contents of 385 northern kingfish were analyzed in 1999 (Table 6-2). An additional 38 kingfish were dissected but had empty stomachs. The kingfish captured during the first sampling period of 1999 were small (< 5 cm SL) and their stomach contents were not analyzed. Kingfish were only caught in sufficient numbers to permit statistical analysis of food habits data during the first sampling period of October. The polychaete, *S. squamata*, continued to be the predominant prey item for kingfish of all sizes examined (Figure 6-15). There were no significant differences in the prey composition of kingfish captured at the Reference vs. the Beach Nourishment stations. The only significant difference involving kingfish diet was more annelid biomass/filled stomach for medium and large kingfish size categories ($U = 13.95$, $p = 0.001$).

Discussion

Changes in surf zone habitat use and function for fish may be indicated by a dietary shift among prey species and/or a change in the amount of prey consumed. Potential detrimental effects include shifts from prey that result in net energy gains to the predator, i.e., energy expended foraging for the prey is less than that consumed, to less beneficial prey species. Deleterious impacts could also be indicated by a decrease in the percentage of fish with filled stomachs or reduced prey biomass for fish captured at Beach Nourishment stations. In this study, there were no indications of negative impacts related to beach nourishment for either kingfish or silversides based on the analyses of these “prey availability” parameters. The percentage of fish with filled stomachs did not differ for any species, indicating that foraging success was comparable at the Reference and Beach Nourishment stations in 1997. During the second sampling period of 1997, kingfish at Beach Nourishment stations contained less mysids (by weight) and more annelids than their Reference station counterparts. These differences may reflect localized differences in mysid and polychaete prey abundances at the different beach types. There were no other dietary differences between the two station types for kingfish.

Silverside prey biomass in 1997, however, differed between Reference and Beach Nourishment stations in ways that suggest foraging efficiency and/or prey availability may have differed between these areas for several sampling periods. Overall prey biomass was greater during the first sampling period for silversides at the Beach Nourishment stations. During the sixth sampling period, mole crabs and amphipods were more prevalent in Beach Nourishment fish and large ($\geq$ 60 mm SL) silversides at these stations had significantly more fish in their diets (Table 6-3). Atlantic silversides, with their upturned mouth gape, feed primarily from the water column (Bengston 1984). One possible explanation for increased prey availability at the Beach

Nourishment stations may be that prey are more readily suspended by wave action from the newly deposited sand and are then fed upon by silversides. Kingfish may be attracted to areas with relatively high suspended prey concentrations (as is suggested by the beach seine results for 1997, Chapter 5), but appear to be unable to capitalize through greater feeding due to their down-turned mouth gapes and strictly benthic foraging habits.

During the October sampling periods of 1997, fish made their first appearance as a prey item for Atlantic silversides, primarily at the Beach Nourishment stations. It does not appear that silversides fed on small sand lance and anchovies at the Beach Nourishment sites because other more common prey items were unavailable. Amphipods and mole crabs were consumed in greater quantities at the Beach Nourishment stations during the same sampling period. The consistent occurrence of fish prey in the stomachs of silversides captured at stations 19-23 is interesting and open to speculation. These stations were nourished at the same time, which was approximately 4-6 weeks prior to this sampling period. Silversides appear attracted to these stations given their unprecedented occurrence in every haul and may be ingesting the fish incidentally while foraging on other prey items. Fish were present as a prey item to a smaller extent in 1998 (Figure 6-4) and more substantially during the first sampling period of 1999 (Figure 6-5). Many surf zone fishes shift their diets in response to prey availability (Lasiak and McLachlan 1987).

Kingfish food habits did not change substantially between the baseline study period and during- and post-nourishment time periods for the months with adequate sample sizes. The baseline analysis of kingfish food habits revealed their dominant prey item was the polychaete *S. squamata* (Figure 6-11), which remained an important component of the kingfish diet in other years; however, some temporal dietary shifts were evident, such as an increased proportion of mole crab biomass in their diets during the October sampling periods. The increase in mole crab consumption may reflect greater mole crab availability or an increased importance of mole crabs in the diets of larger kingfish, as was observed for the gulf kingfish *Menticirrhus littoralis* (DeLancey 1989).

Conclusions

Results of the food habits analyses for each year of monitoring indicate that dietary shifts that may be related to the beach nourishment project were on a small scale both temporally and geographically. The relative composition of prey items in rough silversides, Atlantic silversides and northern kingfish did not differ between Reference and Beach nourishment areas two years after the completion of the beach nourishment project. If differences in prey availability were caused by the beach nourishment project, they were short-lived, because no differences in prey biomass/filled stomach were distinguishable for any fish species in 1998 and 1999. Kingfish did not exhibit any dietary changes that could be associated with the beach nourishment project even though their distributions suggested they were attracted to the active beach fill location during some sampling periods (Chapter 5).

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