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U.S. DEPARTMENT OF COMMERCE
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ABSTRACT

Diet of the spotted spiny dogfish, *Squalus suckleyi*, in Marmot Bay, Gulf of Alaska was studied from small-mesh surveys and large-mesh surveys conducted by Alaska Department of Fish and Game and the National Marine Fisheries Service between 2006 and 2014. A total of 333 spotted spiny dogfish stomachs were analyzed. By weight, the diet consisted mainly of Teleostei, and Cephalopoda. A total of 13 species of Teleostei were identified. The most frequently occurring fish taxa were walleye pollock (*Gadus chalcogramma*), capelin (*Mallotus villosus*), Pacific herring (*Clupea pallasi*), and eulachon (*Thaleichthys pacificus*). Euphausiids and pandalid shrimp were the most frequently occurring invertebrates.

CONTENTS

INTRODUCTION

In publications before 2010, the common name spiny dogfish referred to the species *Squalus acanthias* in the North Pacific. However, the group *Squalus acanthias* has been problematic where it is monospecific or contains more than one species. Ebert et al. (2010) confirmed that there are actually two species in the subgroup *Squalus acanthias* of the genus *Squalus*: the *S. acanthias* (spiny dogfish) and *S. suckleyi* (spotted spiny dogfish). They proposed that the North Pacific populations should now be separated into *S. suckleyi* and the *S. acanthias* in the Southwest Pacific.

Squalus suckleyi is a small shark. They occur in the eastern Pacific, from the Bering Sea to southern Baja California (Compagno 1984). In Alaska, they are most abundant in the central and eastern Gulf of Alaska (Conrath and Foy 2009). The estimated biomass of spotted spiny dogfish (*S. suckleyi*) in 2015 was 76, 452 metric tons (Tribuzio et al. 2015). The Alaska Department of Fish and Game (ADF&G) and National Marine Fisheries Service (NMFS) have collected stomach samples during their annual small-mesh survey and large-mesh survey between 2006 and 2014. This project covers arrowtooth flounder (*Atheresthes stomias*), Pacific cod (*Gadus macrocephalus*), walleye pollock (*G. chalcogramma*), flathead sole (*Hippoglossoides elassodon*), northern rock sole (*Lepidopsetta polyxystra*), Pacific halibut (*Hippoglossus stenolepis*), and spotted spiny dogfish.

Diets of spotted spiny dogfish have been studied in many areas, for example, in Patagonian waters, Argentina (Alonso et al. 2002); in the Northwest Atlantic (Bowman et al. 1984); in British Columbia (Jones and Geen 1977); and in coastal Washington and Oregon (Brodeur et al. 2009). In Alaska waters, there was only the diet study by Sturdevant et al. (2012). The objective of this report is to fill the knowledge gap of the trophic role of the spotted spiny dogfish, describing their diets in Marmot Bay, Gulf of Alaska, between 2006 and 2014.

METHODS

Study Area

The Alaska Department of Fish and Game (ADF&G) and National Marine Fisheries Service (NMFS) jointly conducted small-mesh and large-mesh surveys between 2006 and 2014. The survey area covered the Gulf of Alaska from long. 151.62 ° W to 152.77 ° W and from lat. 57.87 ° N to 58.21 ° N. Stomach samples were collected during the surveys.

Stomach Collection

Stomach samples were collected on the RV *Resolution*. In the small-mesh survey, high-opening bottom trawls with 32 mm stretched mesh throughout the net were used; in the large-mesh survey, 400-mesh Eastern otter trawl nets were used. Stomachs were collected in June on the large-mesh survey and between September and October on the small-mesh survey. The stomach sample was put in a cloth bag together with a field label with the species name, total extended length of the fish, and haul data (vessel, cruise, haul number, specimen number). The samples were then preserved in a 10% buffered formalin solution. In the laboratory the formalin was neutralized and samples were transferred into 70% ethanol before the stomach contents were analyzed.

Stomach Contents Analysis

In the laboratory the total stomach contents were recorded to the nearest one-tenth of a gram. The contents were then placed in a Petri dish and examined under the microscope. Each prey item was identified to the lowest practical taxonomic level. Prey weights of each prey item were obtained. The number of commercially important crabs and fish were recorded. If pollock otoliths were found, otolith lengths were measured and the pollock's standard length (SL) was derived through an otolith length-fish length regression table (from the Age and Growth Task of Resource Ecology and Fisheries Management (REFM) Division at the Alaska Fisheries Science Center (AFSC). Standard lengths of prey fish, carapace widths (CW) of Tanner crabs (*Chionoecetes bairdi*), snow crabs (*C. opilio*) and Korean horse-hair crabs (*Erimacrus isenbeckii*), and carapace length (CL) of pandalid shrimp were also recorded.

Data Analysis

The general diets of spotted spiny dogfish were summarized by the percent frequency of occurrence (%FO) and the percent of the total weight (%WT) of each prey item found in the stomach. The prey size data were also summarized and the size frequency distributions of the main prey were analyzed. Diet overlap was compared for each of the cruise by using the percent by weight of the main prey items. In this report, diet variations of the spotted spiny dogfish were analyzed by predator size.

To compare the diet similarities between different sets of data, the percent similarity index (PSI) was calculated by using the proportions of the prey items found in the stomachs. The PSI is calculated as

$$PSI = \sum (\text{the smallest of } P_{xi} \text{ and } P_{yi}),$$

where P_{xi} and P_{yi} are the proportions by weight of prey i in the diets of species x and y, respectively.

RESULTS

General Diet

Figure 1 shows the study area. Haul information is listed in Appendix, Table 1. A total of 333 spotted spiny dogfish stomachs were analyzed, of which 300 contained food. Results indicated that spotted spiny dogfish diet consisted mainly of Teleostei (70.4%WT) and Cephalopoda (20.3% WT) (Table 1). A total of 13 species of Teleostei were identified. The most frequently occurring fish taxa were walleye pollock (*Gadus chalcogramma*), capelin (*Mallotus villosus*), Pacific herring (*Clupea pallasi*), and eulachon (*Thaleichthys pacificus*). By weight, walleye pollock comprised 33.0 % of the dogfish diet, followed by Pacific herring (18.3% WT) and eulachon (9.0% WT). Although Euphausiacea and Pandalidae occurred quite frequently (31% and 26% FO, respectively), they contributed only 2.3% and 3.1 % by weight of the total stomach contents. Tanner crab (*Chionoecetes bairdi*), Holothuroidea (sea cucumbers), Stichaeidae, Cottoidei, Zoarcidae, Ammodytidae, and Pleuronectidae were also present in stomachs, but were all minor contributors to the overall diet of spotted spiny dogfish.

Diet Variations Based on Predator Size

Figure 2 illustrates the main prey items of spotted spiny dogfish by predator size. Teleostei dominated the diet of all size groups. They comprised more than 68% of the diets of all size groups except the 81-85 cm size group (they comprised only 50%). Walleye pollock and other gadids were the most important prey fish in most of the size groups. Pacific herring were important prey in the size group < 66 cm and the size group 86 - 90 cm. Cephalopods were the most dominant invertebrate prey in most size groups, especially in size groups 81-85 cm (40.7 %WT) and > 90 cm (27.7%WT). Shrimp and euphausiids together comprised less than 10% WT of each size groups.

Sizes of the Important Prey Consumed

No significant relationship was found between predator length and prey length in spotted spiny dogfish (Fig. 3). Walleye pollock consumed by spotted spiny dogfish were mainly age-0 fish (< 140 mm SL) with a few age-1 to age-3 fish (Fig. 4). Mean SL ($\pm$ SD) of pollock consumed by spotted spiny dogfish was 88.9 $\pm$ 44.8 mm with a range of 54 to 321 mm. The mean SL (± SD) of the capelin consumed was 68.7 ± 14.5 mm with a range of 43 to 107 mm (Fig. 5). Pacific herring consumed by spotted spiny dogfish had a mean SL (±SD) of 177 ± 47.7 mm with a range of 105 to 301 mm SL (Fig. 6). The mean SL of eulachon consumed by spotted spiny dogfish was 149.8 ± 21.1 mm with a range of 97.8 to 183 mm SL (Fig. 7). Pandalid shrimp (mainly *Pandalus euos*) consumed by spotted spiny dogfish had a mean CL (±SD) of 17.2 ± 4.4 mm with a range of 6.8 to 25.7 mm CL (Fig. 8). Mean CW (±SD) of Tanner crab consumed was 31.0 ± 5.9 mm with a range of 23.4 to 39.4 mm. Most of the Tanner crabs measured from spotted spiny dogfish stomachs were age-0 and age-1 crab (< 36 mm CW). Spotted spiny dogfish also consumed sand lance, Cottoidei, flathead sole, Pacific cod, Stichaeidae, Osmeridae, unidentified Pleuronectidae, Salmonidae, and Zoarcidae. Their means, minimum lengths, maximum lengths, standard deviations, and samples sizes are listed in Table 2.

Diet Overlap

The percent similarity index (PSI) was calculated by using the proportions of the main prey items in the stomachs (values in Table 3) to show the diet overlap between different cruises from 2006 to 2014. The upper diagonal section in Figure 9 shows the percent similarity values between different cruises. The lower diagonal section shows the diet overlap between species by categorizing the percent similarities into low (< 30%), medium (30-60%), and high (> 60%).

The diet of spotted spiny dogfish from the 2006 small-mesh cruise and the 2014 large-mesh cruise has high overlap because the spotted spiny dogfish fed mainly on cephalopods (> 37% WT) and Pacific herring (> 32% WT) in both cruises. Other high diet overlap values occurred between the 2010 and the 2014 large-mesh cruises because the Pacific herring comprised > 60% WT of the diet in both cruises. The rest of the high diet overlap values (between the cruises of 2008 small-mesh, 2009 small-mesh, 2011 small-mesh, and 2012 large-mesh) resulted from high (>70 % WT) consumption of walleye pollock (and other gadids) in all those cruises.

DISCUSSION

General Description of Diet

As top predator, spotted spiny dogfish ate mostly walleye pollock, eulachon, Pacific herring, and cephalopods from this study. Other top predators in the Gulf of Alaska area, like arrowtooth flounder, Pacific halibut, and sablefish, also consumed mostly walleye pollock and cephalopods (Yang et al. 2006). Other studies showed a similar diet for spotted spiny dogfish (Jones and Geen 1977, Feder et al. 1980, Sturdevant et al. 2012).

Predator Prey Size Relationship

Many studies have shown that there was a positive relationship between the body length of dogfish and the length of prey consumed (Alonso et al. 2002, Brodeur et al. 2009). In other words, small individuals were pelagic predators, and large individuals tended to reduce the consumption of gelatinous zooplankton, and increase the consumption of demersal and benthic species. However, this was not the case in this study. The total extended length of dogfish sampled in this study ranged from 56 to 101 cm and no juveniles were sampled. This was also the minimum size limitation of spotted dogfish in another study (Tribuzio et al. 2010).

Feeding Behavior

Feeding mechanism and feeding behavior were not in the scope of this study; however, some results from the stomach contents in this study can be helpful to understanding those aspects. Figure 10 shows the bite marks of spotted spiny dogfish on eulachon. It clearly shows that the prey (eulachon) is longer than the dogfish gape, but the prey width is shorter than the dogfish gape. This corresponded well with the description of Wilga and Motta (1998) that "the teeth of the spiny dogfish are inclined laterally and are effective at cutting long prey into two pieces." Figure 11 shows the pieces of different prey from one stomach. This is quite often seen in the stomachs of the spotted spiny dogfish. These small pieces are different from the usual fish offal (processed fish parts, fish head, fish tail, or visceral organs) found from other top predatory marine fishes Pacific cod, Pacific halibut. These small pieces have been bitten (pollock pieces, shrimp pieces). Figure 11 also shows two whole fish specimens (one capelin and one stichaeid) that were smaller than the dogfish gape and were swallowed whole, like the smaller euphausiids.

Scavenging behavior was found in lesser-spotted dogfish *Scyliorhinus canicula* studied by Kaiser and Spencer (1994). They found that *Pandalus* spp. and *Crangon* spp. only occurred in lesser-spotted dogfish stomachs after the area had been trawled by fishing vessels. In our study, fish offal comprised only a negligible proportion of the diet of spotted spiny dogfish. However, because of the special feeding behavior (biting, tearing, head-shaking, etc.), we need to be careful when we analyze the stomach contents of the spotted spiny dogfish. That is, to realize that the pieces of fish parts common in their stomach contents, are not necessarily fish offal scavenged from the sea floor, but were fresh prey masticated by the dogfish. Overall, the feeding behavior and feeding mechanism of the predators need to be taken into account when analyzing the sources of prey based on stomach contents.

ACKNOWLEDGMENTS

I thank Kally Spalinger, Dan Urban, and other scientists from ADF&G and NMFS on board the RV Resolution for collecting stomachs during the long period from 2006 to 2014. Kally Spalinger provided field data, haul information, and took care of the inventory of the stomach sampling equipment. Angie Greig was a great help on ArcMap issues, as was Geoff Lang with data analysis. Their help is much appreciated. Thanks also to Rick Hibpshman, Kim Sawyer, Caroline Robinson, and Sean Rohan for analyzing the stomach contents. I also would like to thank Michael Litzow who first suggested that we should collect dogfish stomachs from the Gulf of Alaska area for a diet study. I thank Tom Wilderbuer and Cynthia Yeung for comments on this manuscript.

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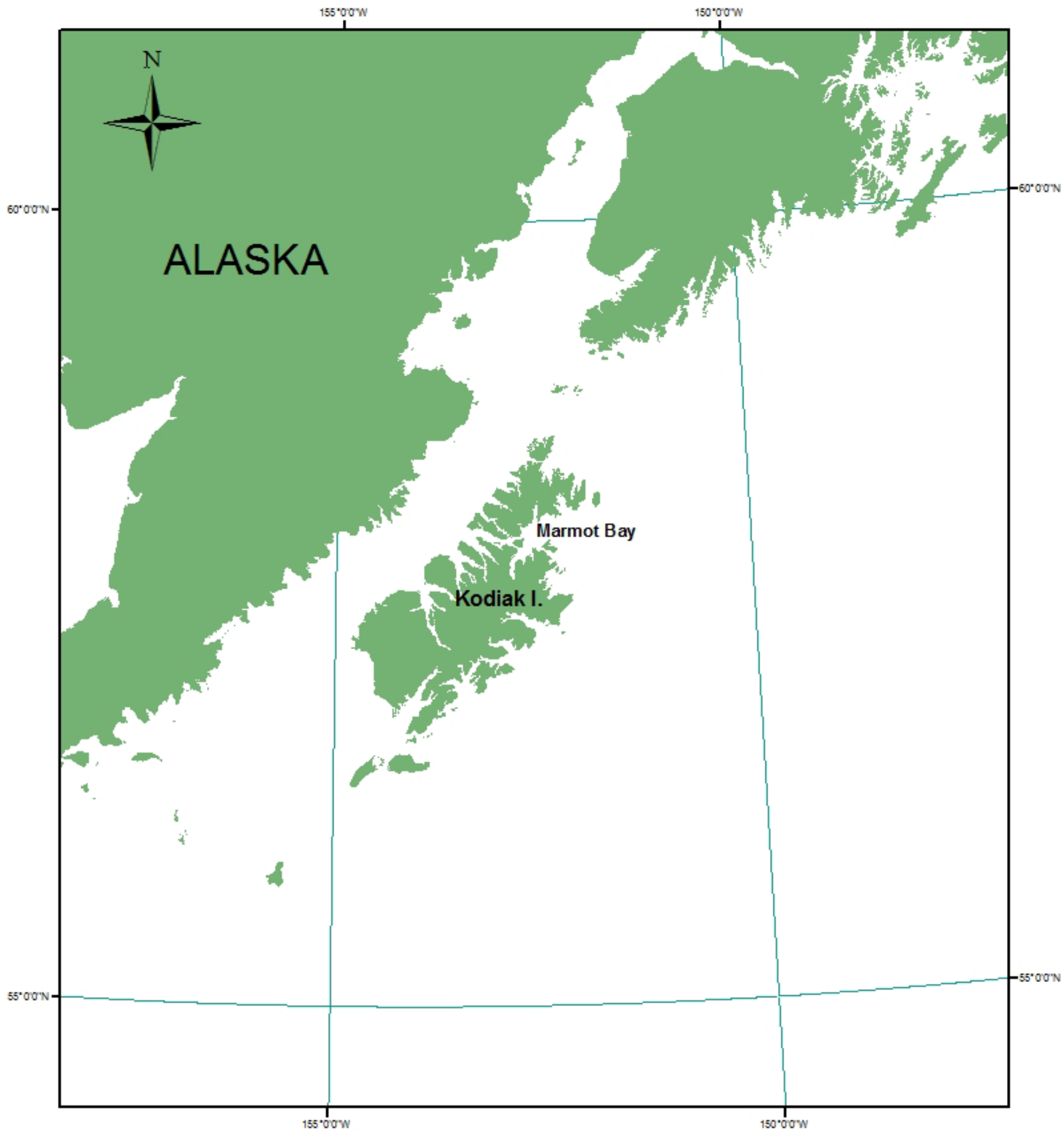

Figure 1. -- Study area of stomach sampling in Marmot Bay Between 2006 and 2014.

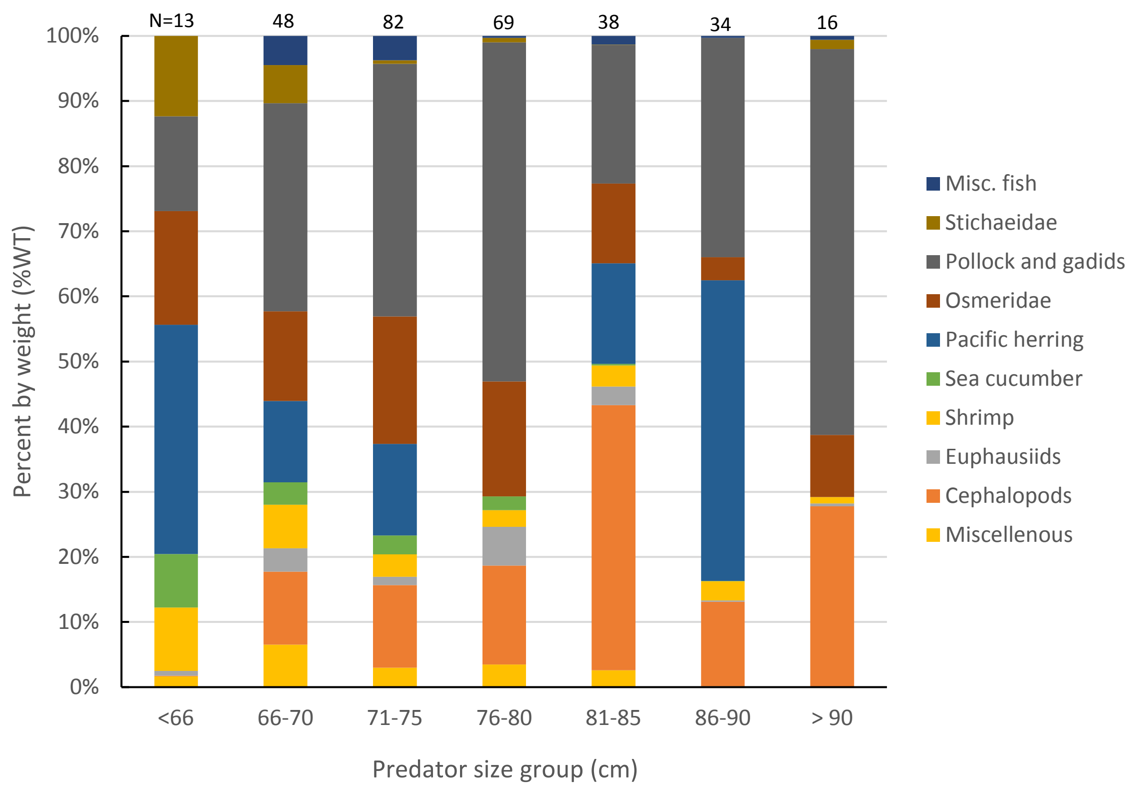

Figure 2. -- Variations in the main prey of spotted spiny dogfish, by predator size, in the Marmot Bay between 2006 and 2014. N= sample size.

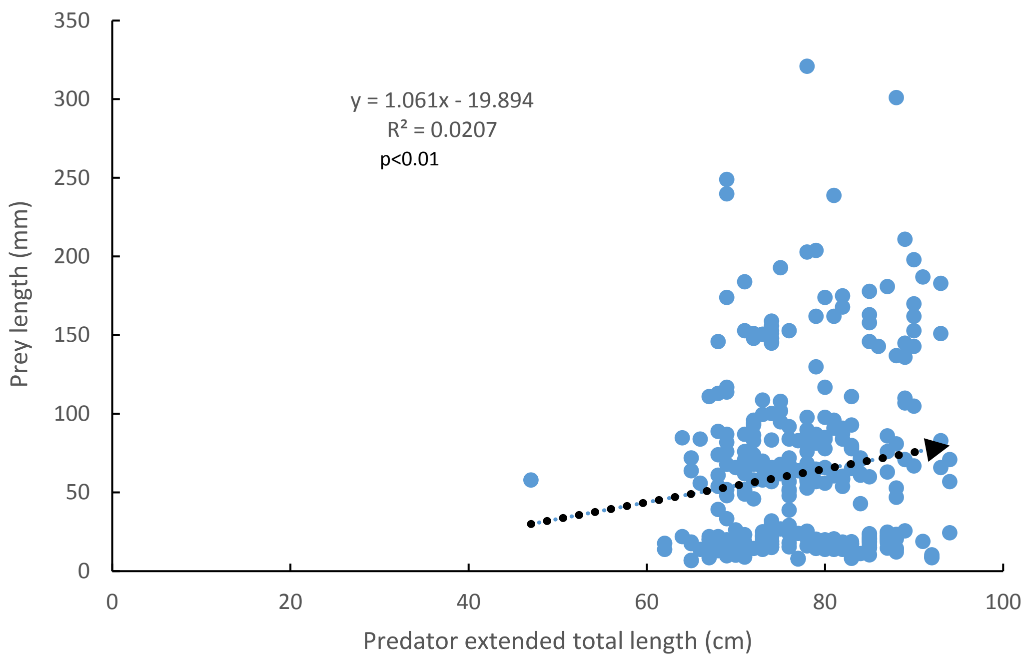

Figure 3.-- Relationship between predator size and prey size of the spotted spiny dogfish collected in Marmot Bay from 2006 to 2014.

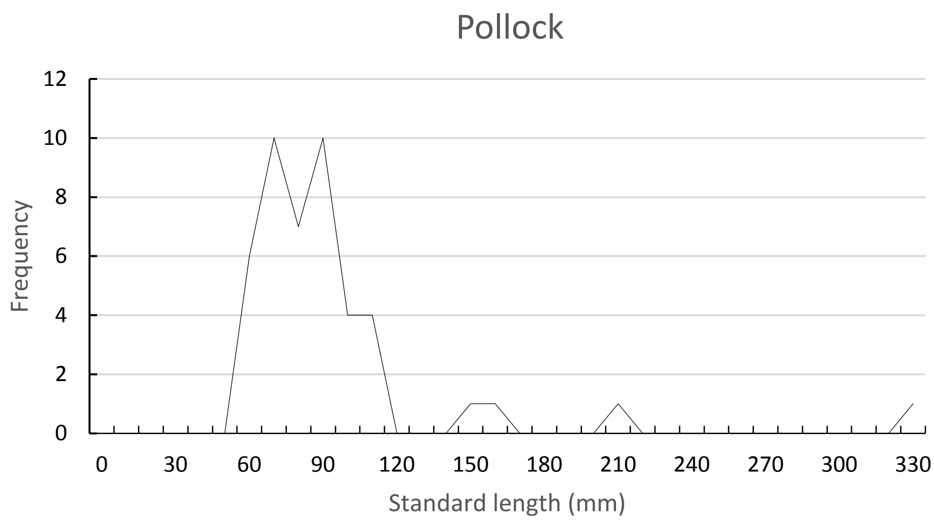

Figure 4. -- Size frequency distribution of pollock consumed by spotted spiny dogfish in Marmot Bay between 2006 and 2014.

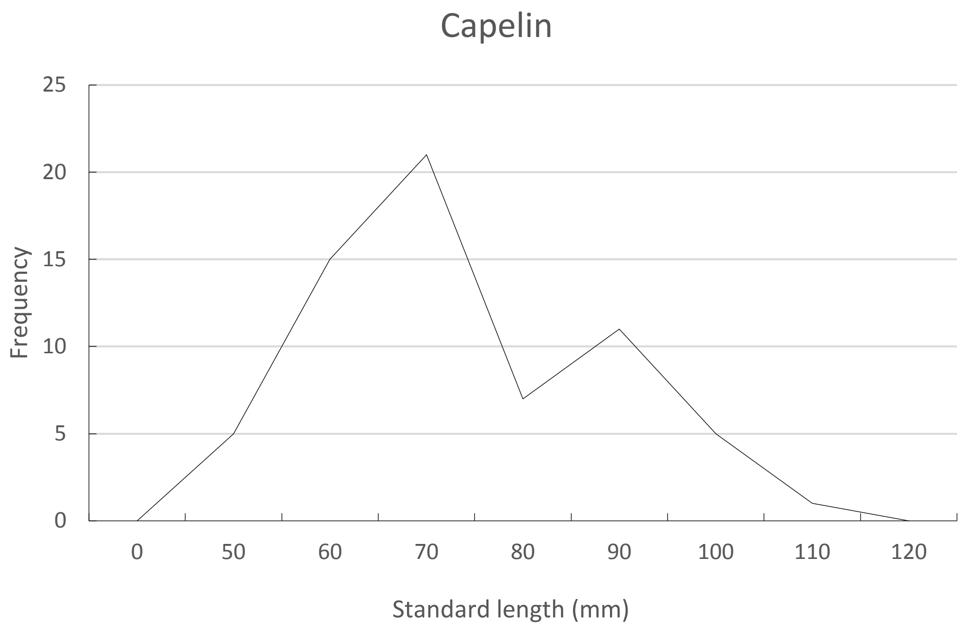

Figure 5 .--Size frequency distribution of capelin consumed by spotted spiny dogfish in Marmot Bay between 2006 and 2014.

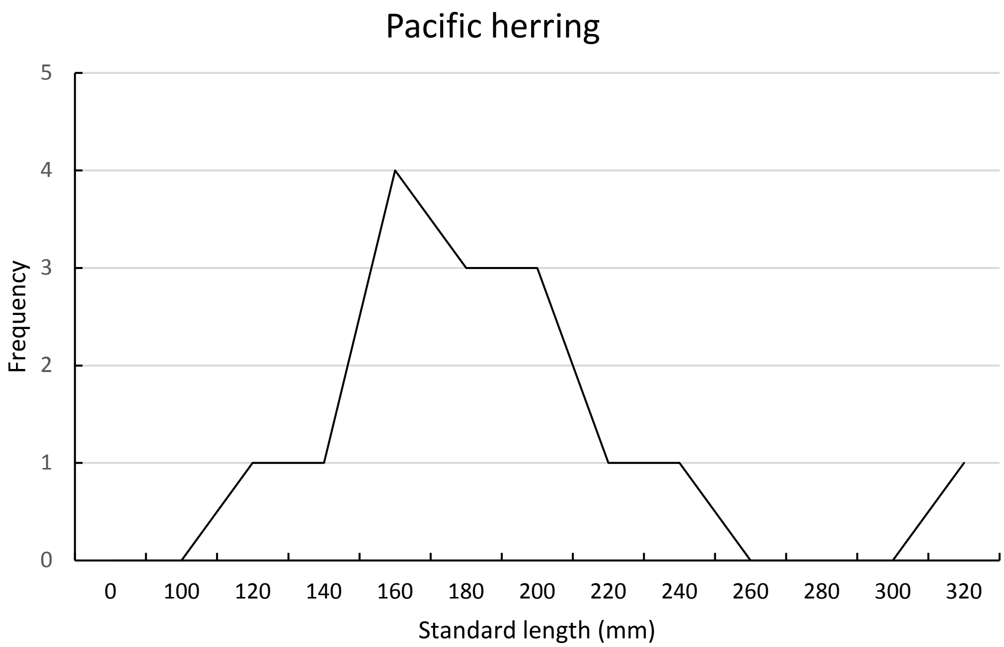

Figure 6.-- Size frequency distribution of Pacific herring consumed by spotted spiny dogfish in Marmot Bay between 2006 and 2014.

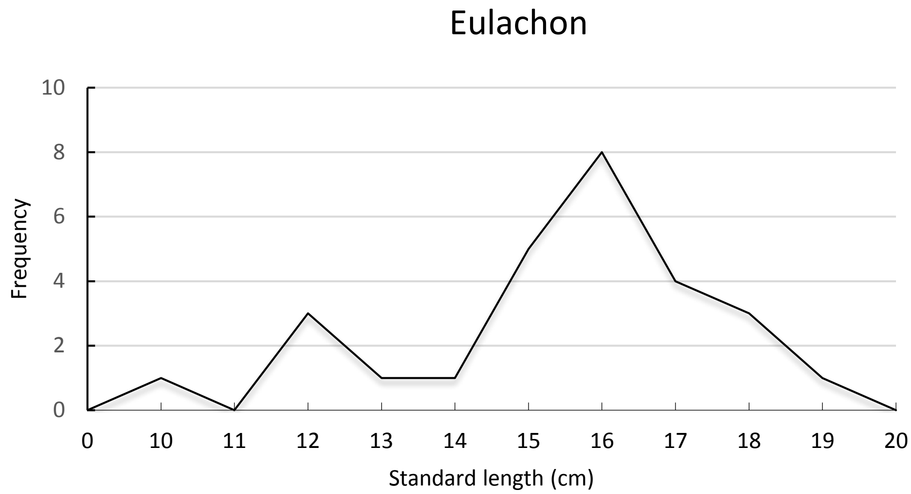

Figure 7 .-- Size frequency distribution of eulachon consumed by spotted spiny dogfish in Marmot Bay between 2006 and 2014.

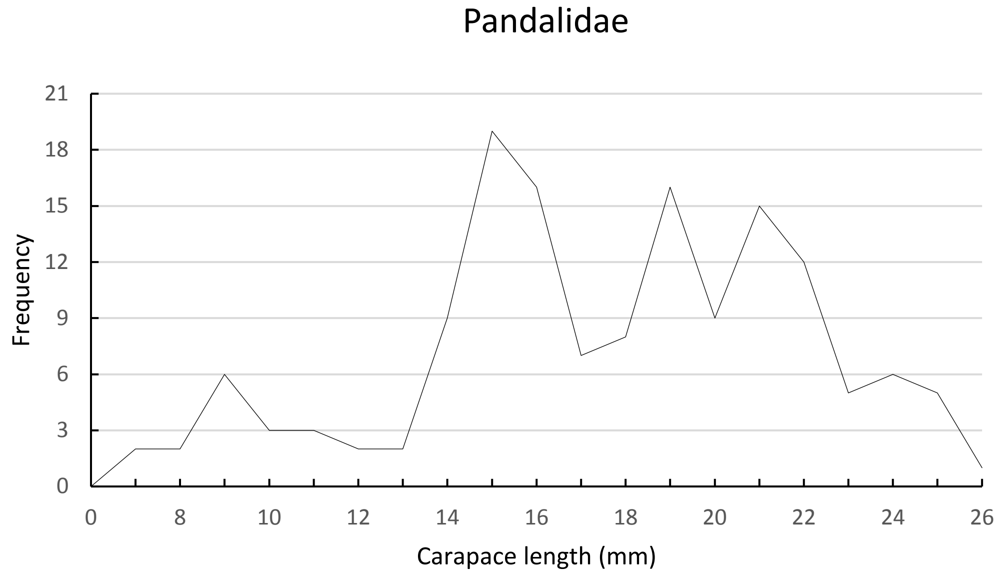

Figure 8.-- Size frequency distribution of Pandalidae consumed by spotted spiny dogfish in Marmot Bay between 2006 and 2014.

	2006 s	2007 l	2007 s	2008 l	2008 s	2009 s	2010 l	2010 s	2011 s	2012 l	2012 s	2014 l
2006 s		7	46	57	18	18	40	40	14	12	13	71
2007 l			36	2	83	75	4	19	73	72	12	0
2007 s				7	45	57	47	35	46	38	25	38
2008 l					15	17	9	35	9	6	14	0
2008 s						87	11	33	84	79	20	6
2009 s							10	43	82	75	31	5
2010 l								14	5	2	9	63
2010 s									28	27	57	28
2011 s										91	17	4
2012 l											14	4
2012 s												0
2014 l												

Figure 9.-- Diet overlap (expressed as the Percent Similarity Index, PSI) of the spotted spiny dogfish in Marmot Bay between the cruises from 2006 to 2014.

<30	30-60	>60

Diet Overlap

Figure 10.-- Eulachon found in the stomachs of spotted spiny dogfish.
Note the bite marks.

Figure 11.-- Stomach contents of spotted spiny dogfish in Marmot Bay.
1. Pandalidae; 2. Euphausiids; 3. Capelin; 4. Pollock;
5. Stichaeidae.

Table 1.-- Percent frequency of occurrence (%FO), and percent weight (%WT) of the main prey items in the diet of spotted spiny dogfish (*Squalus suckleyi*) collected in Marmot Bay, Alaska, from 2006 to 2014. Prey items with < 0.01 %WT were excluded in this table.

Prey Name	%FO	%WT
Scyphozoa (jellyfish)	2.67	0.29
Polychaeta (polychaete)	1.00	0.13
Unidentified cephalopods (squid and octopus)	12.67	11.69
Rossia pacifica (North Pacific bobtail squid)	0.33	0.01
Teuthida (squid)	1.33	1.02
Octopoda (octopus)	2.00	2.58
Octopodidae (octopus)	0.33	0.04
Enteroctopus dofleini (Pacific giant octopus)	3.33	4.95
Unidentified euphausiids (euphausiid)	31.00	1.73
Thysanoessa sp. (euphausiid)	6.33	0.54
Thysanoessa inermis (euphausiid)	2.67	0.01
Caridea (shrimp)	4.33	0.02
Pandalidae (shrimp)	26.00	3.09
Crangonidae (shrimp)	5.33	0.07
Reptantia (crab)	0.67	0.12
Chionoecetes bairdi (Tanner crab)	3.67	0.49
Sipuncula (peanut worm)	2.00	0.07
Echiura (marine worm)	0.67	0.07
Holothuroidea (sea cucumber)	9.00	1.38
Copelata (larvacea)	0.67	0.04
Rajidae (skate)	0.33	0.07
Non-gadoid fish remains	0.67	0.04
Clupea pallasii (Pacific herring)	5.00	18.32
Salmonidae (salmon, whitefish)	0.67	0.31
Osmeridae (smelt)	5.33	0.50
Mallotus villosus (capelin)	15.67	2.23
Thaleichthys pacificus (eulachon)	5.00	9.00
Gadidae (gadid fish)	1.67	3.32
Gadus macrocephalus (Pacific cod)	0.33	0.21
Gadus chalcogrammus (walleye pollock)	22.67	32.93
Zoarcidae (eelpout)	0.33	0.02
Cottoidei (sculpin)	0.67	0.07
Dasycottus setiger (spinyhead sculpin)	1.00	0.52
Stichaeidae (prickleback)	2.00	1.14
Lumpenella longirostris (longsnout prickleback)	0.67	0.64
Leptoclinus maculatus (daubed shanny)	0.33	0.01
Ammodytes sp. (sand lance)	1.33	0.10
Pleuronectidae (flatfish)	1.33	1.00
Hippoglossoides elassodon (flathead sole)	0.33	0.02
Unidentified organic material	3.00	1.10
Unidentified worm-like organism	0.67	0.04

Total number of stomachs analyzed = 333
Total non-empty stomachs = 300
Number of hauls = 119
Average predator length = 76.9 cm
Standard deviation of predator length = 8.1 cm
Length range of predators : 47 -101 cm

Table 2.-- Mean prey length (SL, CL, CW), minimum size (Min), maximum size (Max), standard deviation (SD), and the number (N) of some miscellaneous prey consumed by spotted spiny dogfish in Marmot Bay between 2006 and 2014.

Prey name	Mean (mm)	Min (mm)	Max (mm)	SD (mm)	N
Ammodytes sp.	62.4	53.0	72.0	7.5	5
Chionoecetes bairdi	31.0	23.4	39.4	5.9	8
Clupea pallasii	177	105.0	301.0	47.7	15
Cottoidei	79.9	60.0	108.0	18.5	5
Gadus chalcogramma	88.9	54.0	321.0	44.8	45
Gadus macrocephalus	148.0	148.0	148.0	0.0	1
Hippoglossoides elassodon	61.9	61.9	61.9	0.0	1
Mallotus villosus	68.7	43.0	107.0	14.5	65
Osmeridae	68.0	48.0	111.0	21.1	9
Pandalidae	17.2	6.8	25.7	4.4	148
Pleuronectidae	60.8	25.5	96.0	49.9	2
Salmonidae	99.5	53.0	146.0	65.8	2
Stichaeidae	152.2	65.3	249.0	68.5	10
Thaleichthys pacificus	149.8	97.8	183.0	21.1	27
Zoarcidae	63.0	63.0	63.0	0.0	1

Table 3.-- Percent weight of the main prey items in the diet of spotted spiny dogfish (*Squalus suckleyi*) collected in Marmot Bay from 2006 to 2014. S, small-mesh survey; L, large-mesh survey.

	2006 S	2007 L	2007 S	2008 L	2008 S	2009 S	2010L	2010 S	2011 S	2012 L	2012 S	2014 L
Cephalopods	53.1	0.0	0.0	86.8	6.4	4.8	0.3	23.1	3.9	3.7	0.0	37.4
Euphausiids	0.0	0.0	11.9	0.1	2.0	1.4	0.0	0.0	4.7	0.0	0.4	0.0
Pandalids	2.6	0.0	5.9	0.0	1.0	3.8	1.4	4.7	0.7	0.0	6.8	0.0
Crabs	0.8	1.0	0.0	0.0	1.0	0.9	0.7	0.0	0.6	0.0	5.1	0.0
Sea cucumber	0.0	24.2	0.0	2.1	9.6	1.3	3.0	0.7	0.0	0.0	0.0	0.0
Pacific herring	32.4	0.0	32.9	0.0	0.0	0.0	79.0	4.3	0.0	0.0	0.0	62.6
Osmeridae	3.8	0.0	6.0	5.8	6.3	14.2	6.3	34.8	4.5	2.2	75.2	0.0
Pollock and gadids	5.6	31.9	30.7	0.0	70.7	69.5	0.0	15.8	85.4	91.3	11.3	0.0
Misc. fish	1.5	40.4	11.6	5.2	2.7	3.1	6.0	9.8	0.0	0.0	0.0	0.0
Sample size	56	5	38	3	25	48	17	52	36	6	11	3

APPENDIX

Appendix Table 1.-- Haul information of spiny dogfish collected in Marmot Bay between 2006 and 2014. x represents no data.

Year	Vessel	Cruise	Haul	Lat.	Long.	Depth (m)	Temp (°C)	Haul Date
2006	41	200602	73	57.94	-152.08	88	6.70	10/19/2006
2006	41	200602	74	58.02	-152.13	84	6.60	10/19/2006
2006	41	200602	75	58.08	-152.14	115	6.70	10/19/2006
2006	41	200602	77	58.11	-152.17	102	6.80	10/20/2006
2006	41	200602	78	58.02	-151.93	80	6.70	10/20/2006
2006	41	200602	79	57.99	-152.06	90	6.70	10/20/2006
2006	41	200602	80	57.92	-151.96	102	6.70	10/20/2006
2006	41	200602	81	57.87	-151.96	64	6.90	10/20/2006
2006	41	200602	82	58.14	-152.23	91	6.80	10/21/2006
2006	41	200602	83	58.09	-152.27	82	6.80	10/21/2006
2006	41	200602	84	58.07	-152.29	96	6.80	10/21/2006
2006	41	200602	85	58.12	-152.58	60	7.20	10/21/2006
2006	41	200602	86	58.11	-152.58	63	7.20	10/21/2006
2006	41	200602	88	57.99	-152.52	97	6.70	10/21/2006
2006	41	200602	94	57.89	-152.77	48	7.00	10/22/2006
2007	41	200701	16	58.07	-151.93	65	5.71	6/19/2007
2007	41	200701	17	58.07	-151.82	72	5.30	6/19/2007
2007	41	200701	19	58.00	-151.75	77	4.53	6/19/2007
2007	41	200701	24	58.14	-152.22	90	5.08	6/20/2007
2007	41	200701	26	58.02	-151.93	80	4.59	6/20/2007
2007	41	200701	28	58.02	-151.86	83	4.48	6/20/2007
2007	41	200701	39	57.95	-152.66	68	5.42	6/22/2007
2007	41	200702	89	57.97	-152.57	93	6.90	10/17/2007
2007	41	200702	90	58.02	-152.55	100	6.80	10/17/2007
2007	41	200702	91	58.00	-152.59	83	7.00	10/17/2007
2007	41	200702	95	57.95	-152.61	70	7.00	10/18/2007
2007	41	200702	96	58.15	-152.58	52	6.60	10/18/2007
2007	41	200702	97	58.13	-152.59	65	6.60	10/18/2007
2007	41	200702	99	58.11	-152.25	86	6.40	10/18/2007
2007	41	200702	100	58.13	-152.19	102	6.20	10/19/2007
2007	41	200702	101	58.08	-152.09	85	6.30	10/19/2007
2007	41	200702	103	57.99	-151.86	84	6.10	10/19/2007
2007	41	200702	104	57.98	-151.95	98	6.00	10/19/2007
2007	41	200702	105	57.97	-152.00	107	6.00	10/19/2007
2007	41	200702	108	58.21	-152.25	82	6.40	10/20/2007
2008	41	200801	16	58.05	-152.08	84	5.08	6/17/2008
2008	41	200801	29	57.98	-152.10	96	4.95	6/18/2008
2008	41	200801	44	57.97	-152.62	72	5.32	6/20/2008
2008	41	200802	107	57.98	-151.81	72	6.80	10/21/2008
2008	41	200802	111	58.11	-152.19	108	6.60	10/22/2008
2008	41	200802	112	58.10	-152.15	105	6.60	10/22/2008
2008	41	200802	116	58.08	-152.25	91	6.60	10/23/2008
2008	41	200802	120	58.03	-152.55	104	6.60	10/23/2008
2008	41	200802	121	58.00	-152.56	103	6.60	10/23/2008

Appendix Table 1. -- Cont.

2008	41	200802	122	57.97	-152.55	82	6.50	10/23/2008
2008	41	200802	123	58.00	-152.61	80	6.60	10/24/2008
2008	41	200802	127	57.96	-152.59	86	6.50	10/24/2008
2008	41	200802	128	57.97	-152.17	95	6.40	10/24/2008
2008	41	200802	129	58.01	-152.14	94	6.40	10/24/2008
2009	41	200902	114	57.96	-152.59	84	6.66	10/26/2009
2009	41	200902	115	57.99	-152.55	99	6.04	10/26/2009
2009	41	200902	117	58.04	-152.13	84	5.73	10/27/2009
2009	41	200902	118	58.05	-152.08	81	6.51	10/27/2009
2009	41	200902	119	58.06	-151.95	75	6.27	10/27/2009
2009	41	200902	120	58.04	-151.95	80	6.21	10/27/2009
2009	41	200902	122	58.00	-152.03	90	6.36	10/27/2009
2009	41	200902	124	58.21	-152.25	75	5.31	10/28/2009
2009	41	200902	125	58.16	-152.25	84	5.95	10/28/2009
2009	41	200902	126	58.13	-152.19	100	5.63	10/28/2009
2009	41	200902	127	58.12	-152.21	98	6.27	10/28/2009
2009	41	200902	130	58.03	-152.55	103	6.15	10/28/2009
2009	41	200902	131	58.00	-152.59	85	4.17	10/29/2009
2009	41	200902	132	57.95	-152.62	70	5.35	10/29/2009
2010	41	201001	11	57.97	-152.04	96	5.61	6/21/2010
2010	41	201001	14	58.09	-152.16	106	5.88	6/22/2010
2010	41	201001	16	58.05	-151.96	70	6.26	6/22/2010
2010	41	201001	17	58.06	-151.82	76	6.01	6/22/2010
2010	41	201001	18	58.07	-151.65	88	5.98	6/22/2010
2010	41	201001	19	57.98	-151.69	59	6.35	6/22/2010
2010	41	201001	23	58.19	-152.25	80	5.96	6/23/2010
2010	41	201001	24	58.14	-152.22	89	5.93	6/23/2010
2010	41	201001	25	58.07	-151.93	72	6.43	6/23/2010
2010	41	201001	26	58.06	-151.93	76	5.92	6/23/2010
2010	41	201001	33	57.95	-152.34	68	6.40	6/24/2010
2010	41	201001	42	57.91	-152.70	58	6.68	6/25/2010
2010	41	201002	134	58.07	-151.65	87	6.43	10/26/2010
2010	41	201002	136	58.02	-151.86	87	6.54	10/26/2010
2010	41	201002	137	57.97	-151.97	104	6.46	10/26/2010
2010	41	201002	138	57.92	-152.05	105	6.50	10/26/2010
2010	41	201002	139	57.94	-152.12	88	6.75	10/26/2010
2010	41	201002	141	58.21	-152.28	72	7.03	10/27/2010
2010	41	201002	142	58.21	-152.25	82	7.11	10/27/2010
2010	41	201002	143	58.16	-152.23	108	6.72	10/27/2010
2010	41	201002	144	58.11	-152.19	102	x	10/27/2010
2010	41	201002	145	58.10	-152.15	120	6.63	10/27/2010
2010	41	201002	146	58.03	-152.08	87	6.64	10/27/2010
2010	41	201002	147	58.05	-152.10	86	6.67	10/27/2010
2010	41	201002	148	58.08	-152.29	97	6.75	10/27/2010
2010	41	201002	150	57.92	-152.73	70	7.07	10/28/2010
2010	41	201002	152	57.91	-152.68	58	7.11	10/28/2010
2010	41	201002	153	57.98	-152.52	85	6.82	10/28/2010

2010	41	201002	154	58.01	-152.58	82	6.80	10/28/2010
2010	41	201002	156	58.00	-152.59	86	6.82	10/28/2010
2010	41	201002	157	57.97	-152.64	69	6.95	10/28/2010
2010	41	201002	158	57.94	-152.59	66	6.90	10/29/2010
2010	41	201002	159	57.96	-152.58	83	6.80	10/29/2010
2011	41	201102	10	57.94	-151.95	102	5.97	9/27/2011
2011	41	201102	13	58.14	-152.20	99	6.10	9/28/2011
2011	41	201102	14	58.12	-152.19	106	6.11	9/28/2011
2011	41	201102	16	58.06	-152.01	71	6.08	9/28/2011
2011	41	201102	17	58.04	-151.96	82	6.00	9/28/2011
2011	41	201102	18	58.04	-151.89	85	5.93	9/28/2011
2011	41	201102	19	58.03	-151.77	82	5.96	9/28/2011
2011	41	201102	20	58.01	-151.62	58	6.45	9/28/2011
2011	41	201102	21	58.20	-152.25	95	6.25	9/29/2011
2011	41	201102	23	58.10	-152.28	89	6.23	9/29/2011
2011	41	201102	25	58.00	-152.12	97	6.01	9/29/2011
2011	41	201102	26	58.00	-152.04	97	5.97	9/29/2011
2011	41	201102	27	57.98	-152.06	97	6.07	9/29/2011
2011	41	201102	35	58.02	-152.56	102	6.23	9/30/2011
2011	41	201102	37	57.98	-152.61	77	6.34	9/30/2011
2012	41	201201	11	57.93	-151.77	33	5.63	6/19/2012
2012	41	201201	13	58.06	-151.70	86	4.88	6/19/2012
2012	41	201201	15	58.05	-151.96	70	4.90	6/20/2012
2012	41	201201	17	58.06	-151.84	75	5.08	6/20/2012
2012	41	201201	18	58.05	-151.75	90	4.15	6/20/2012
2012	41	201201	19	58.02	-151.86	85	4.63	6/20/2012
2012	41	201202	100	58.01	-151.87	87	6.51	10/14/2012
2012	41	201202	103	57.94	-152.03	106	6.31	10/14/2012
2012	41	201202	105	57.89	-152.04	88	6.43	10/15/2012
2012	41	201202	108	57.99	-152.11	97	6.30	10/15/2012
2012	41	201202	112	58.02	-152.00	83	6.45	10/15/2012
2012	41	201202	114	58.21	-152.28	78	6.64	10/16/2012
2012	41	201202	116	58.16	-152.23	108	6.51	10/16/2012
2012	41	201202	117	58.15	-152.21	99	6.52	10/16/2012
2014	41	201401	24	57.97	-151.66	55	6.00	6/19/2014
2014	41	201401	29	58.05	-151.99	70	6.01	6/19/2014
2014	41	201401	35	57.95	-152.35	63	6.42	6/20/2014