15th Meeting of the
International Scientific Committee
for Tuna and Tuna-Like Species in the North Pacific Ocean
Kona, Hawaii, USA
15-20 July 2015

National Report of Canada (Canadian Tuna and Tuna-like Fisheries in the North Pacific Ocean in 2014)[1]

John Holmes and Evelyn Chen
Fisheries and Oceans Canada
Pacific Biological Station 3190 Hammond Bay Road
Nanaimo, BC, Canada, V9T 6N7

July 2015

[1]Prepared for the Fifteenth Meeting of the International Scientific committee on Tuna and Tuna-like Species in the North Pacific Ocean (ISC), 15-20 July, 2015, Kona, Hawaii, USA. Document should not be cited without permission of the authors.

SUMMARY

Canada has one fishery for highly migratory species in the Pacific Ocean, a troll fishery targeting juvenile north Pacific Albacore Tuna (*Thunnus alalunga*). Category I, II, and III data from the 2014 fishing season are summarized in this report. The Canadian fleet consisted of 160 vessels and operated exclusively within the eastern Pacific Ocean. Provisional 2014 estimates of catch and effort are 4,781 metric tonnes (t) and 4,747 vessel-days, respectively, which represent a 6% decrease in catch and 27% decrease in effort relative to 2013. Catch and effort were split primarily between Canadian waters (55% of the catch and 62% of the effort) and US waters (45% of the catch and 37% of the effort) while the remaining catch and effort occurred in adjacent high seas waters. Roughly 85% of the catch was made in sea surface temperature band of 16-18 °C. Fifty-seven (57) vessels participated in the on-board size sampling program and measured 11,208 fish on 137 trips for a sampling rate of 1.6% of the reported catch. Fork lengths (FL) were dominated by fish between 65-71 cm FL corresponding to 2-year old fish, and fish between 76-80 cm FL, which are 3-years old. The Canadian troll fishery exhibited a discernible shift in fishing operations towards the North American coast in 2014, fishing almost exclusively within the Canada and US EEZs. In addition, there was pronounced northward shift in Albacore Tuna distribution within Canadian waters in the latter part of the fishing season (September). Very little catch and effort occurred outside the Canadian and United States EEZs in 2014.

1.0 INTRODUCTION

The Canadian fishery for highly migratory species uses troll gear with jigs to target juvenile north Pacific Albacore Tuna (*Thunnus alalunga*) in the surface waters of the Pacific Ocean. The majority of catch and effort by the Canadian fleet occurs within the exclusive economic zones (EEZ) of Canada and the United States. Access to the United States EEZ is permitted through a bilateral Treaty, which provides for access by Canadian-flagged and US-flagged vessels licensed to fish for albacore and for the landing of Albacore Tuna catches at designated ports within each country. Some of the larger Canadian vessels follow Albacore Tuna concentrations into offshore waters and into the central and western Pacific Ocean. Management regulations for Canadian vessels fishing Albacore Tuna from 01 April 2014 to 31 March 2015 are documented in the Albacore Tuna Integrated Fisheries Management Plan (IFMP) http://www.dfo-mpo.gc.ca/Library/353288.pdf. Historically the majority of catch and effort for north Pacific Albacore Tuna has occurred in a four month period from early July to the end of October**.**

This report summarizes Category I (annual catch and effort), Category II (annual 1° x 1° catch and effort data), and Category III (bycatch, catch size composition) data for vessels active in the Canadian north Pacific Albacore Tuna troll fishery in 2014. This report also provides information on scientific research conducted by Fisheries and Oceans Canada (DFO) in support of resource conservation and management both domestically and internationally, including stock assessment, biological and oceanographic studies.

2.0 DATA SOURCES

Data on Albacore Tuna catch and effort from 1995 through to the present are compiled from hail records, logbooks, and sales slips and stored in the Canadian Albacore Tuna Catch and Effort Relational Database (Stocker et al. 2007). This database generates the best available estimates of total annual catch and effort by geographic zone (Canadian, US, and high seas waters) for the Canadian fishery. All Canadian fishing vessels are required to hail (call) a third party service provider when they intend to start fishing and stop fishing, and when they change fishing zones. Canadian vessels must also carry logbooks in which daily position, catch and effort (latitude, longitude, number of fish, estimated weight) are recorded for Albacore Tuna and non-target species. These data have the highest temporal and spatial resolution and are obtained when logbooks are returned in November after the fishing season is completed. The third data source, sales slips, record the weight of Albacore Tuna landed and bought by domestic buyers and provide the most accurate estimates of Albacore Tuna catch in weight since these data are the basis for payment to harvesters (Stocker et al. 2007). Logbooks and sales slips from domestic buyers (plus trans-shipment slips if applicable) are forwarded for entry into the Albacore Tuna catch database (Stocker et al. 2007).

Fork length data are collected by fishermen through an on-board sampling program initiated in 2009, with a sampling goal of 1% of the reported catch. Harvesters record the lengths of the first 10 Albacore Tuna landed on a daily basis in their logbooks to randomize measurements. Size composition data were collected by US port samplers from a portion of the Canadian catch landed in United States ports specified in the bilateral Canada-United States Albacore Tuna Treaty between 1981 and 2008. Fork length data reported by Canada since 2009 to the present are from the domestic on-board sampling program only.

The fishery data provided in this report were taken from Canadian tuna database version 15.02.17. Figures up to and including 2013 are considered definitive and are derived from a reconciliation of logbook data (best estimates of effort, catch in pieces, and geographic location) and sales slip (best estimate of catch weight) data (Stocker et al. 2007). The 2014 catch and effort data are preliminary at this time.

3.0 AGGREGATED CATCH AND EFFORT DATA

3.1 Catch

The preliminary estimate of the Canadian Albacore Tuna catch in 2014 is 4,781 metric tons (t) and is a 6% decrease relative to 2013, but a 92% increase relative to catch in 2012 (Table 1; Figure 1). The total catch by the Canadian troll fishery has ranged from 1,761 t in 1995 to 7,857 t in 2004 and averaged 5,570 ± 1,316 (± sd) t since 2003, the period when logbook coverage has exceeded 90% of all vessels participating in this fishery. The 2014 catch was distributed among Canadian coastal waters (55%) and United States coastal waters (45%), while catch in adjacent high seas waters was minimal (0.1%). Forty-five (45) Canadian vessels were permitted to fish in the coastal waters of the United States in 2014, but only 44 vessels entered the US EEZ and fished.

3.2 Effort

The Canadian Albacore Tuna troll fleet consisted of 160 unique vessels in 2014, a decrease of about 13% in participation relative to 2013 and below the average participation rate of 178 vessels since 2003 (Table 1). The 2014 estimate of fishing effort is 4,747 v-d and is a 27% decrease in effort relative to 2013 (Table 1; Figure 1). Fishing effort in 2014 was split between Canadian coastal waters (62%), United States coastal waters (37%), and adjacent high seas waters (1%). Annual fishing effort has ranged between 4,320 v-d in 1997 and 10,021 v-d in 2001, averaging 7,119 ± 1,483 v-d since 2003.

4.0 SPATIAL DISTRIBUTION OF CATCH AND EFFORT DATA

The Canadian troll fleet operated in a latitudinal band between 41 and 54°N and from the west coast of North America to 137° W in 2014 (Figure 2a,b). This spatial distribution is more compressed longitudinally than in 2013 and was more coastally oriented in the waters of Canada and the United States than in previous years. The Canadian fishery operated within the Inter-American Tropical Tuna Commission (IATTC) convention area east of 150°W and north of the equator. No effort or catch were made in the Western and Central Pacific Fisheries Commission (WCPFC) convention area west of 150°W in 2014, continuing a trend that began in 2005 of concentrating effort and catch in the eastern Pacific Ocean (EPO). Approximately 99% of the fishing effort and catch occurred within the coastal waters of Canada and the United States in 2014, although the proportion of effort and catch occurring within United States waters is lower (37% and 45%, respectively) than average (66% of effort and catch) for the 1995 to 2011 period. This change in the fishing pattern in which more effort and catch occurred in Canadian waters than occurred historically prior to 2012, is the result of the fishing regime in the bilateral Albacore Tuna treaty negotiated for 2013 and adopted for a three-year period beginning in 2014.

Monthly effort and catch shifted from waters in the Canadian and US EEZs south of 50°N in June and July to waters in the Canadian EEZ north of 50°N in August and September (Figures 2 and 3). September fishing effort and catch was notably focused on northern waters along the northwest coast of Haida Gwaii (Figures 2d and 3d).

Albacore were caught in waters with sea surface temperatures ranging between 12 and 21 °C in 2014, but 99% of the fish were harvested in waters within a narrow temperature band of 15-19 °C (Figure 3).

Nominal catch rates peaked in mid-July and then exhibited a sharp decline through late July and August and were below average for the rest of the season (Figure 4). A small secondary peak in mid-September may be due to the northward shift in catch and effort near the BC-Alaska border. During the latter part of the season, there were reports that Albacore Tuna were further north into the coastal waters of southeast Alaska. The pattern of CPUE changes is superficially similar to the average pattern, with two differences: (1) the well above average short duration peak in July and below average CPUE thereafter, and (2) the small secondary peak in September, consistent with a northward shift in distribution.

5.0 BIOLOGICAL DATA

5.1 By-Catch

Reported by-catch was 21 fish and five species in 2014 (Table 2), of which 38% were retained. Pacific Bluefin Tuna (*Thunnus orientalis*) had the highest amount of retained by-catch with five individuals, followed by Yellowtail (*Seriola lalandi*) with three individuals. Other by-catch species that were released include Coho Salmon (*Oncorhynchus kisutch*), Steelhead Trout (*O. mykiss*) and Shortfin Mako Shark (*Isurus oxyrinchus*). Total weight of all retained by-catch is estimated to be approximately 50 kg, of which Pacific Bluefin Tuna accounted for more than 60%.

5.2 Biological

Fifty-seven (57) vessels measured 11,208 fork lengths on 137 trips in 2014 (Figure 5), representing a sample rate of 1.6% of the reported catch. This sampling rate is above the target of 1.0% of the reported catch. The amount of length sampling in the three fishing zones (Canada - 79%; United States waters - 20%; high seas - 1%) was not proportional to the effort in each zone.

Albacore in the Canadian catch ranged from 43 cm to 102 cm fork length (FL) in size (Figure 5), which is slightly larger than the size range reported in previous years (see Holmes 2011, 2012, 2013). The dominant mode in these data corresponds to 2-year old fish at 65-71 cm FL. A significant number of fish formed a less prominent second mode between 76-80 cm FL, corresponding to 3-year old fish (Figure 5). Although the size range reported is somewhat larger than in previous years, the pattern of two modes corresponding to 2- and 3-yr old fish is consistent with previously reported size composition data for this fleet.

Mixture analysis was conducted on the July and September size distribution data (Figure 6) corresponding to periods when the fishery was operating south and north of 50°N, respectively. Based on the mixture analysis results, the 2-yr old age group (mean ± sd; 67.5 ± 2.9 cm) comprised 61% of the July catch south of 50N and 3-yr old fish (77 ± 3.9 cm) comprised 39% of the catch. In contrast, the September catch was dominated by 3-yr old fish (78.9 ± 4.6 cm) which comprised 64% of the catch and 2-yr old fish (69.04 ± 3.09 cm) accounted for 34% of the catch. A small mode at 57 cm fork length, perhaps corresponding to 1-yr old fish was not well estimated in September 2014 data (Figure 6B).

6.0 DISCUSSION

The 2014 Canadian troll fishery exhibited a discernible shift in fishing operations towards the North American coast, fishing almost exclusively within the Canada and US EEZs. In addition, there

was pronounced northward shift in Albacore Tuna distribution within Canadian waters in the latter part of the fishing season (Figures 2a, 2b), assuming that the distribution of effort and catch is somewhat representative of the underlying fish distribution. This northward change in fish distribution is supported by mixture analysis results (Figure 6), which show that late season (September) catches when the fishery was operating in northern waters were dominated by older and larger fish by a 2:1 margin, relative to earlier in the season when the fishery was operating primarily off of Oregon, Washington, and the southwest coast of Vancouver Island, and younger and smaller fish dominated the catch by a similar 2:1 ratio. The seasonal changes in location of fishery operations and the results of the mixture analysis on the size distribution data support the hypothesis that a substantial northward shift in the distribution of juvenile Albacore Tuna may have occurred in 2014.

The terms of the fishing regime in the Canada-United States bilateral Pacific Albacore Tuna Treaty continue to influence Canadian fishery operations. The fishing regime currently in effect limits the number of Canadian vessels in US waters to 45 for a defined period from June 15 to September 15 annually for 2014 to 2017. The reductions to the number of vessels permitted to access US waters and length of the fishing period relative to previously negotiated fishing regimes, has resulted in more effort and catch by Canadian vessels in the Canadian EEZ. In 2014, this increased emphasis on fishery operations in Canadian waters appears to have coincided with a northward shift in fish distribution into Canadian waters. Hypotheses to address this distributional change are under investigation.

There is anecdotal evidence of a growing recreational fishery for Albacore Tuna off the west coast of Vancouver Island as technology improves and as migratory conditions bring the fish within Canadian waters and relatively close to shore for longer periods of time. At present, this sport fishery consists of both charter-boat and private boat components. Information on catch and effort in this sport fishery has been collected by two methods: (1) a logbook program for the major charter-boat operators and fishing lodges along the west coast of Vancouver Island, and (2) a web-based survey of recreational anglers that purchased a tidal waters licence. The estimated catches and effort for 2013 and 2014 are under investigation to resolve differences between methods. The preliminary estimates for the sport fishery are that at least 1,600 juvenile Albacore Tuna were caught in 2014 with an estimated total weight of about 10.6 t. The majority of fishing effort and catch appear to occur in the June to September period (consistent with the commercial fishery) and most of the effort occurs in areas offshore of the southwest coast of Vancouver Island. The recreational catch and effort data are not included in the tables and figures in this report because they are highly uncertain. Once the differences in methodology and resulting estimates are resolved satisfactorily, these data will be incorporated into Canada's data reporting.

7.0 RESEARCH

Canadian highly migratory species research in the Pacific Ocean has focused on improving understanding of the biology and ecology of north Pacific Albacore Tuna to enhance assessments of the effects of fishing and the environment on stock dynamics and status. The studies highlighted below have recently been completed or are ongoing and are conducted largely in cooperation with stakeholders and in collaboration with both Canadian and international colleagues.

The Canadian Space Agency has sponsored research to develop simple predictive metrics of juvenile Albacore Tuna distribution and abundance in Canadian waters based on remotely sensed data (sea surface temperature, sea surface height, temperature fronts, chlorophyll fronts) that could be used operationally for resource management. Proximity to frontal structures within the thermal

niche for juvenile Albacore Tuna (estimated to be 15-19°C) is the most promising result. This association between juvenile Albacore Tuna and frontal structures is not a new finding, but it appears to increase in strength from June through to August-September, based on the results of Mantel tests. These results are unlikely to be used to develop an operational product for resource management at present.

A simple modeling exercise was conducted to evaluate the potential effects of anthropogenically caused warming on Albacore Tuna habitat in Canadian waters of the north Pacific Ocean. Albacore habitat was defined as waters between 14 and 19 C, based on logbook records of catch, effort, and sea surface temperature made the Canadian troll fleet from 1995 to the present. Thirty-five coupled models for which SST data from the historical, no mitigation (atmospheric CO_2 concentration increases rapidly through the 21st century) and moderate mitigation (atmospheric CO_2 emissions peak around 2040 and concentrations stabilize in the late 21st century) scenarios were examined. The expansion of potential habitat is large by 2065, regardless of emission scenario, covering the entire Gulf of Alaska in no mitigation scenario and only slightly less in the moderate mitigation scenario. The greatest expansion is in July and September, with smaller increases in June and October, but large relative to the baseline. Since Albacore Tuna in the northeastern North Pacific are strongly associated with a fairly narrow thermal niche, and the amount of potential habitat within this niche could expand substantially under anthropogenic warming, an increase in Albacore Tuna productivity may occur, other factors such as food availability and oxygen being equal or not limiting. Anthropogenic warming and ocean acidification together result in CO_2 concentrations increasing and O_2 concentrations declining, even in the surface mixed layer. The tolerance of Albacore Tuna for increased CO_2 concentrations is unknown and the synergistic effects of increasing CO_2 and decreasing O_2 might have unexpected negative consequences. Both changing ocean chemistry and inadequate food supplies potentially limit colonization of habitat that is within the thermal niche of Albacore Tuna.

A technical report documenting best practices for age determination of Albacore Tuna is under development. This manual is based on discussion and advice provided by fish age experts during the Joint Pacific Bluefin Tuna and North Pacific Albacore Tuna Age Determination Workshop, held November 13-16, 2013, at the National Research Institute of Far Seas Fisherys Research laboratory in Shimizu, Shikuoka, Japan. The workshop was sponsored by the ISC and the Fisheries Research Agency of Japan.

Research Manuscripts

Christian, J.R., and Holmes, J.A. Expansion of albacore tuna habitat in the northeast Pacific Ocean under anthropogenic warming. Fish. Oceanogr. (in prep).

Chen, E., and Holmes, J.A. 2015. Manual of best practices for age determination of north Pacific Albacore Tuna. Can. Tech. Rep. Fish. Aquat. Sci. XXXX.

8.0 LITERATURE CITED

Kleiber, P., and Perrin, C. 1991. Catch-per-effort and stock status in the U.S. north Pacific albacore fishery: reappraisal of both. Fish. Bull., US. 89: 379-386.

Stocker, M., H. Stiff, W. Shaw, and A.W. Argue. 2007. The Canadian albacore tuna catch and effort relational database. Canadian Technical Report of Fisheries and Aquatic Sciences 2701: vi+76 p.

Table 1. Fishery statistics from the Canadian troll fishery for north Pacific Albacore Tuna tuna, 1995-2014. Catch and effort data are expanded or raised to account for vessels that do not report logbook data. The level of expansion can be determined by the logbook coverage figures.

Year	Total Catch (t)	Effort (vessel-days)	Total Vessels	Logbook Coverage[2] (%)
1995	1,761	5,923	287	18%
1996	3,321	8,164	295	24%
1997	2,166	4,320	200	30%
1998	4,177	6,018	214	50%
1999	2,734	6,970	238	71%
2000	4,531	8,769	243	68%
2001	5,249	10,021	248	81%
2002	5,379	8,323	232	74%
2003	6,847	8,428	193	96%
2004	7,857	9,942	221	92%
2005	4,829	8,564	213	94%
2006	5,833	6,243	174	95%
2007	6,040	6,902	207	92%
2008	5,464	5,774	137	93%
2009	5,693	6,540	138	97%
2010	6,527	7,294	161	96%
2011	5,385	8,556	176	99%
2012	2,484	5,974	174	100%
2013	5,088	6,465	183	99%
2014[1]	4,781	4,747	160	100%

1. 2014 data are preliminary based on Ver.15.02.17 of the *Canadian Albacore Tuna Catch and Effort Relational Database*.
2. Logbook coverage = Number of vessels reporting logbooks/Total number of vessels fishing based on all data sources (sales slips, logbooks, hail records) in database Ver. 15.02.17 for all years.

Table 2. Reported catch of non-target species (by-catch) by the Canadian Albacore Tuna troll fishery in 2014.

			Catch (Number of fish)	
Month	Common name	Scientific Name	Retained	Released
July	Pacific Bluefin Tuna	*Thunnus orientalis*	3	4
	Shortfin Mako Shark	*Isurus oxyrinchus*		1
	Yellowtail	*Seriola lalandi*	2	1
August	Pacific Bluefin Tuna	*Thunnus orientalis*	2	
	Yellowtail	*Seriola lalandi*	1	
	Steelhead	*Oncorhynchus mykiss*		1
	Coho salmon	*Oncorhynchus kisutch*		6
		TOTALS	8	13

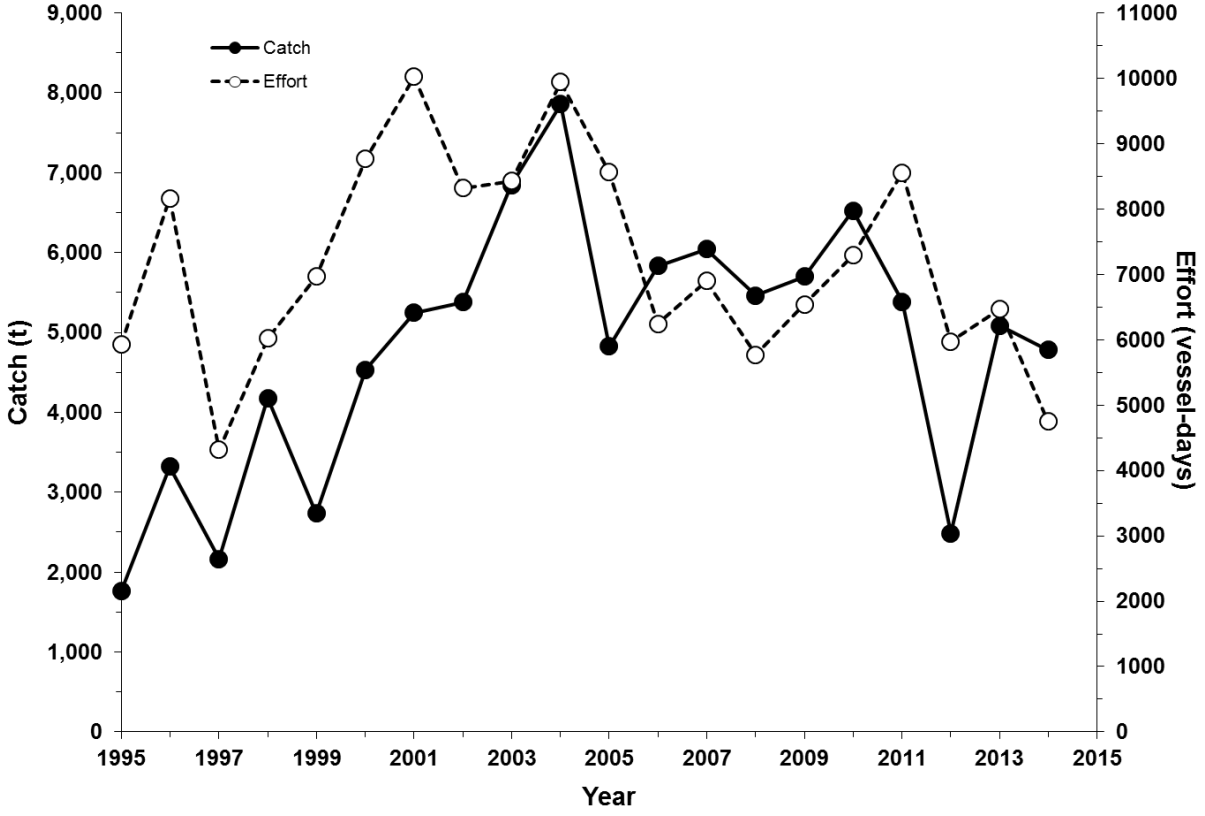

Figure 1. Historical trends in expanded catch and effort in the Canadian troll fishery for north Pacific Albacore Tuna from 1995 to 2014.

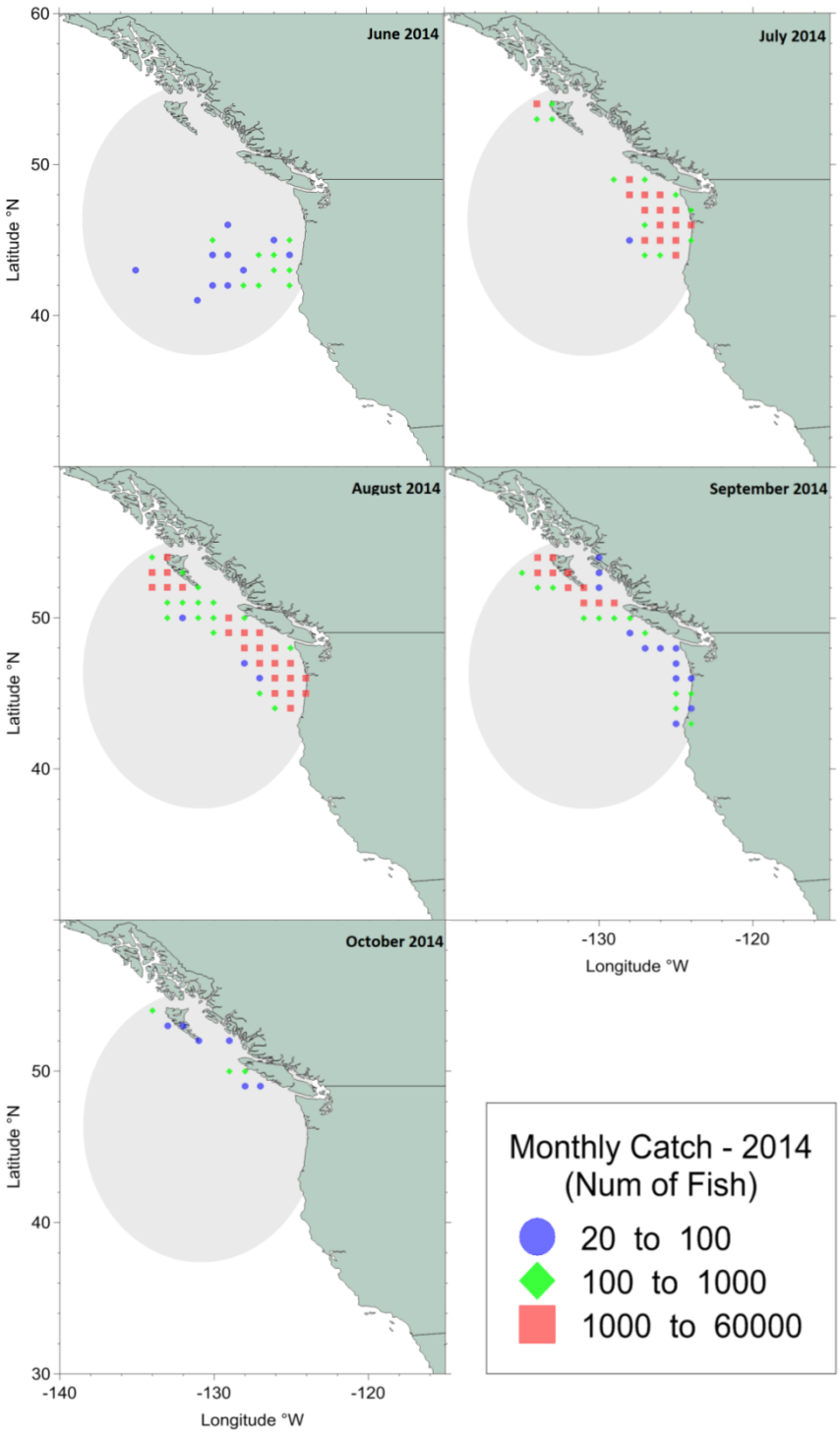

Figure 2a. Monthly spatial distribution of reported catch in Canadian Albacore Tuna troll fishery in 2014. Data are plotted on a 1° x 1° grid with symbols located on the bottom-right

corner of each cell. Cells in which fewer than three vessels reported are not shown. Grey area is the approximate operational area of the Canadian fishery in 2014.

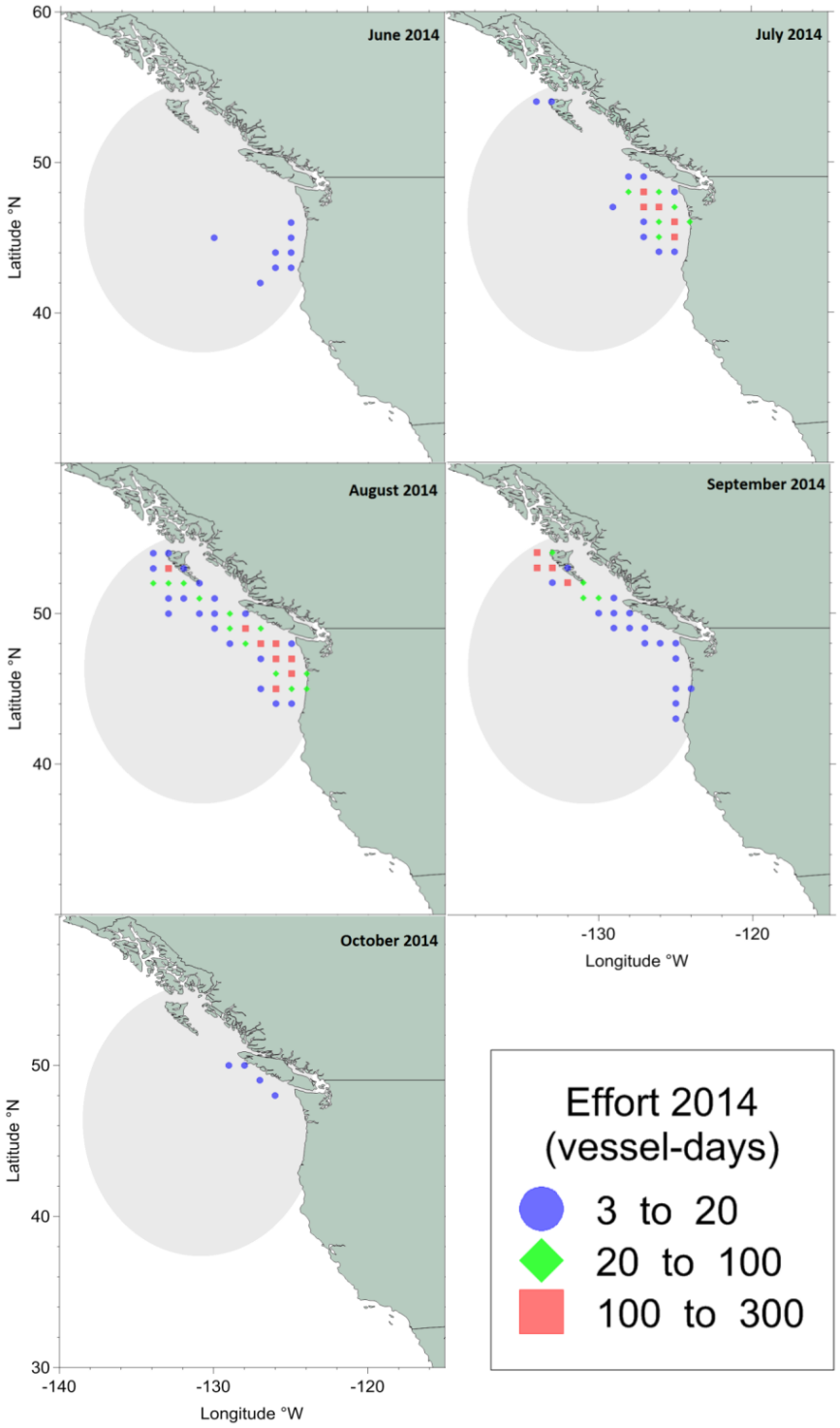

Figure 2b. Monthly spatial distribution of effort by the Canadian Albacore Tuna troll fishery in

2014. Data are plotted on a 1° x 1° grid with symbols located on the bottom-right corner of each cell. Cells in which fewer than three vessels reported are not shown. Grey area is the approximate operational area of the Canadian fishery in 2014.

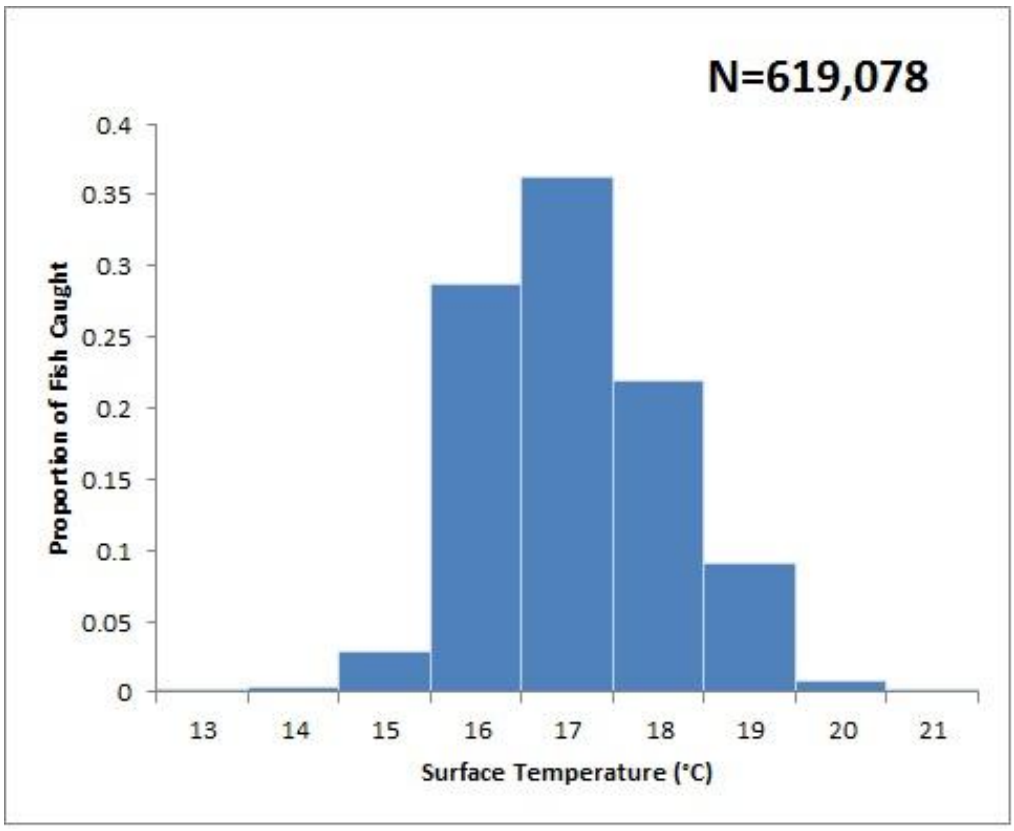

Figure 3. Sea surface temperatures at which Albacore Tuna were caught by the Canadian troll fishery in 2014. N = fish with associated water temperature data reported in logbooks.

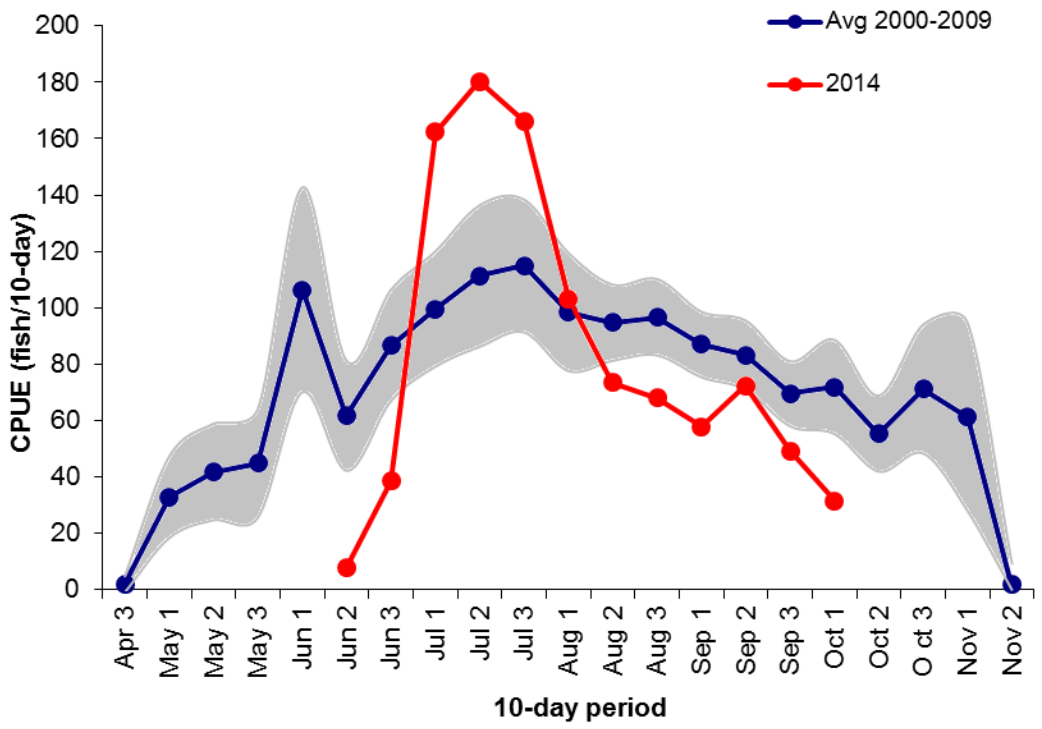

Figure 4. Nominal catch per unit effort for 10-day periods of the Canadian fleet averaged for 2000-2009 compared to the 2014 fishing season. Each data point is the average of all 1°x1° spatial strata in which effort occurred during one of three 10-day periods in a month. The grey area is the 95% confidence interval around the CPUE "climatology". See Kleiber and Perrin (1991) for CPUE calculation details.

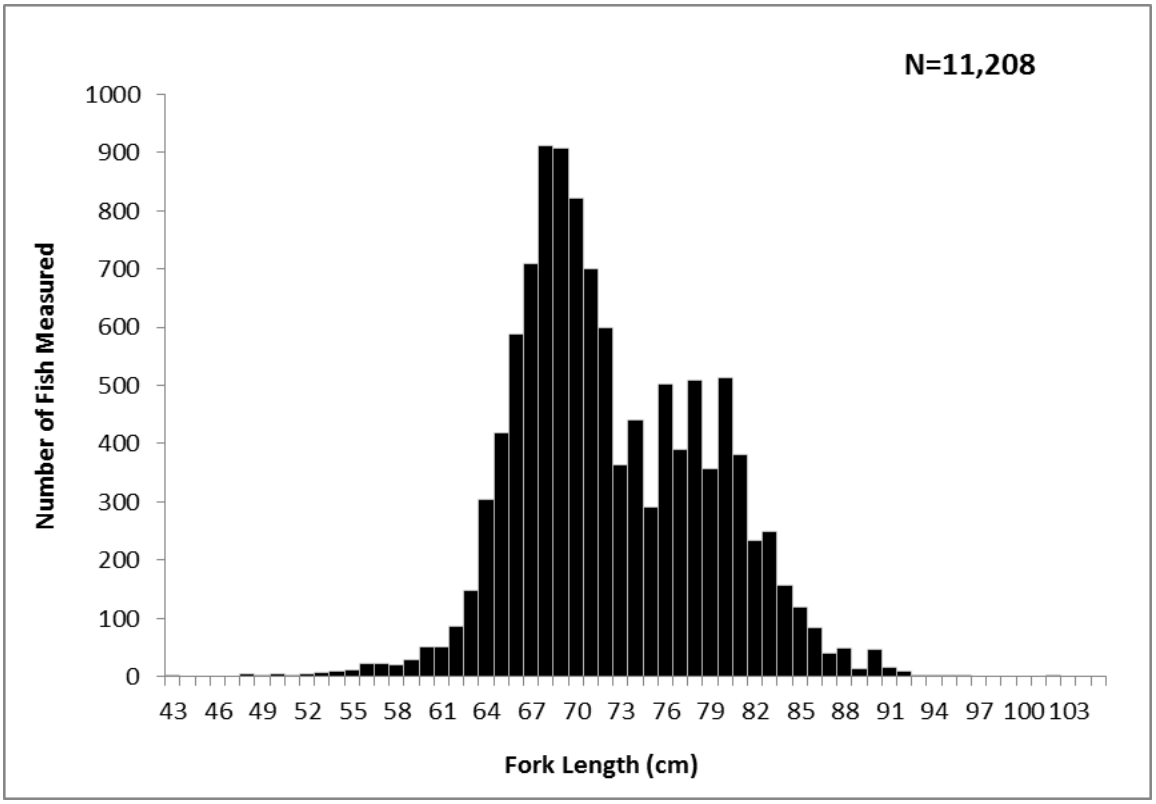

Figure 5. Fork lengths of North Pacific Albacore Tuna harvested by the Canadian troll fishery in 2014. The 11,208 measurements represent a sampling rate of 1.6% of the reported 2014 catch.

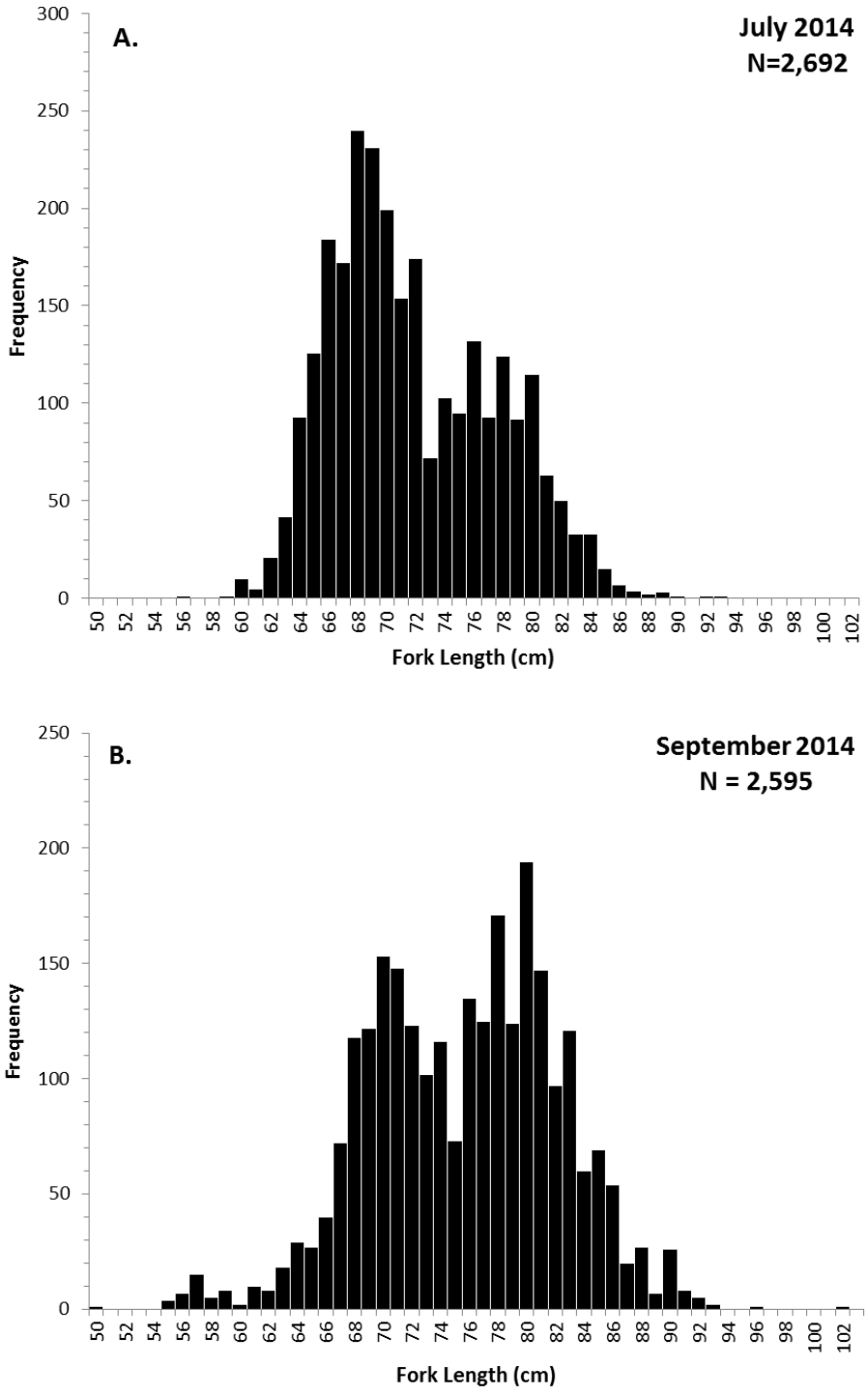

Figure 6. Fork lengths of north Pacific Albacore Tuna harvested by the Canadian troll fishery in July (A) and September (B) 2014.