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Feasibility of Tagging Walleye Pollock, *Theragra chalcogramma*, Captured with Hook and Line using External Tags

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ABSTRACT

Walleye pollock (*Theragra chalcogramma*) were captured with jigs near Auke Bay, southeast Alaska, to determine the feasibility of tagging them with external tags. Most (92%) were < 40 cm fork length (juvenile size). The fish were tagged with either lock-on or internal T-bar anchor tags and held in live tanks. Two handling procedures, dipnet and non-dipnet methods, were used after capture had a marked effect on pollock survival. Sixty percent (N = 63) of the 105 fish transferred between live tanks with a dip net died, whereas only 12% (N = 16) of the 138 fish transferred without a dip net died. Overall, 50% of the deaths occurred within 7 days after capture and 89% within 10 days after capture. Of the dipnetted fish that died, 68% died from dermal infection due to scale loss compared to 30% of the non-dipnetted fish. Fin loss, torn jaws, internal dysfunction, and unknown factors were other suspected causes of mortality. All of the fish tagged with lock-on tags, and 93% of the fish tagged with anchor tags, developed an infection at the point of tag insertion. Tag retention rates of lock-on and anchor tags were 99% and 93%, respectively. Procedures for capturing and tagging walleye pollock are recommended.

CONTENTS

INTRODUCTION

Walleye pollock (*Theragra chalcogramma)* is the dominant species seen in the commercial groundfish catch in waters off of Alaska. In 2006, the eastern Bering Sea (EBS)-Aleutian Islands pollock catch (1.49 million metric tons) accounted for 68% of the total Alaskan groundfish catch. The ex-vessel value of the EBS-Aleutian Islands pollock catch ($357 million dollars) accounted for 47% of the total Alaskan groundfish ex-vessel value. (Hiatt et al. 2007). Despite the economic importance of pollock, many aspects of their biology, including migration, remain unknown and there is very little tagging information for walleye pollock that can be used to estimate the degree of interchange, if any, between spawning populations (Tsuji 1989).

We do not know, for instance, if pollock migrate between the Gulf of Alaska and the Bering Sea, or between U.S. and Russian waters. Results from tagging studies show there is some movement of pollock from the western Bering Sea into the international "doughnut hole" of the North Pacific and into the eastern Bering Sea. Five of the 20 tag returns in the Bering Sea have crossed international boundaries. In September 1982, the Northwest and Alaska Fisheries Center (NWAFC) tagged approximately 7, 000 trawl-caught pollock in the southeastern shelf of the Bering Sea, with 4 recoveries all from the same shelf/slope region (A. Shimada, NWAFC, Seattle, WA, pers. commun., 1987; as cited in Dawson 1989).

From 1966 to 1976, Japanese researchers tagged a minimum of 17,000 pollock in the Bering Sea with 15 of those fish recaptured (Yoshida 1979 as cited in Dawson 1989). Only two pollock tagged in the Bering Sea have been recovered in the basin.

One was a fish tagged on the Soviet shelf that was recovered 4 years later in the basin (Fisheries Agency of Japan 1977, as cited in Dawson 1989). The second basin recovery was also tagged in the Soviet portion of the Bering Sea and was recovered 8 years later (T. Sasaki, Japan Fisheries Agency, 7-1, 5 Chome Orido, Shimizu 424, Japan, pers. commun., 1987; as cited in Dawson, 1989). A third recovery from the basin was that of a pollock that had been tagged off Hokkaido Island. The vessel that reported the tag had shortly before been fishing near Hokkaido. (T. Sasaki, pers. commun., 1988; as cited in Dawson 1989).

Unfortunately, most of the tagging in the Bering Sea had been completed long before there was any significant directed pollock fishery in the basin. Thus the absence of many tag returns from the basin may only indicate a lack of effort there. Two pollock tagged on the Soviet slope that were recaptured on the U.S. slope indicate that there is some interchange of fish between Soviet and U.S. waters, although it is unknown if those pollock spent any time in the basin. Within the U.S. Exclusive Economic Zone (EEZ) no pollock tagged on the continental shelf/slope regions has been recovered in the basin. One of four recaptured pollock, which had been tagged on the northeastern slope, was recovered on the U.S. southeastern slope, suggesting some movement between those areas. Northeastern and southeastern slopes refer to that portion of the eastern Bering with depths from 200 to 2,000 m that is northwest and southeast the Pribilof Islands, respectively.

Because of the ecological and economic importance of pollock, improved stock assessment models are being developed to incorporate movements and spatial variability. But adequate data on the spatial structure of pollock stocks are not currently available (Winter et. al. 2007). Past tagging studies in the Bering Sea have shown that individual adult walleye pollock undertake extensive seasonal feeding and spawning migrations (Dawson 1994, Bailey et al. 1999). Low (1989) cited discussions with Soviet scientists describing walleye pollock tagging studies that showed populations off Kamchatka, the northern Okhotsk Sea, and Sakhalin Island are intermixing even during spawning. Several tagging experiments summarized by Tsuji (1989) indicate extensive migration of walleye pollock during the feeding seasons in Japanese coastal waters and in the Sea of Okhotsk. Studies of tagged pollock can provide a means of determining the extent of migration and stock structure among North Pacific areas that is currently lacking. Miller et al. (2008) state that more in-depth information on pollock movements in the eastern Bering Sea is needed to develop an age-specific movement model. Having additional information from pollock tagging studies would help stabilize the model and allow for some assumptions to be relaxed.

Before large-scale tagging studies were undertaken, however, a pilot study was needed to determine the best method of capturing, handling, holding, tagging, and releasing pollock. Two pollock tagging feasibility studies using nets have been reported. In September 1982, a pilot pollock tagging experiment in the eastern Bering Sea was conducted using fish caught with bottom trawls (Shimada 1982). The feasibility of tagging pollock captured with a purse seine and tagged with coded wire tags was conducted near Unalaska Island, Alaska, during July 1996 (NRC and NMT 1996).

Unlike the studies previously reported, in the study presented here, pollock were caught with hook and line instead of nets; two types of tags were tested (Floy FT-4 lock and Floy FD-67 internal anchor: Floy Tag Inc., Seattle WA); and the effect of capture and handling procedures on pollock mortality was assessed over time.

METHODS

The study was done in the vicinity of Auke Bay, Alaska, (Fig. 1) 16 June through 4 December 1992. The NOAA ship *John N. Cobb* (28.4 m long) was used 16-17 June to locate schools of pollock and remain positioned over them for sampling. Most (92%) of the pollock captured for the experiment were < 40 cm in fork length (juvenile size; Fig. 2). The fish were not aged. Captured fish were carried to live tanks aboard the vessel by holding the fishing line (not the fish) which prevented the fish from touching any hard surface such as the side of the vessel. The hook was removed after the fish was placed in a live tank. Two methods were used during the handling procedures that later appeared to have a marked effect on pollock survival: use of a dip net to transfer the fish between containers, and transfer between containers without dipnetting the fish.

In the dip-net method, fish in the live tanks aboard the vessel were dipnetted twice: from a live tank for tagging and from a live tank to chest coolers for transfer to the holding tank at the laboratory. With the non-dipnet method, the fish were transported without using a dipnet; wet, bare hands were used to capture the fish and hold them for tagging. A crane was used to lift the live tanks off the vessel and then a forklift was used to carry them to the circular holding tank and place them in the water of the tank. The live tanks were then gently tipped over, allowing the fish to swim from the live tank into the holding tank.

The tagging procedure that took place on the vessel was identical for all fish tagged. The fish were removed from a live tank by carefully placing the bare left hand over their eyes and the bare right hand posterior to the first dorsal fin. During tagging, all surfaces including the hands were kept wet with seawater to prevent the fish from contacting a dry surface. Only fish that appeared viable were tagged; all others were discarded.

Two types of tags were used: the Floy FT-4 lock-on tag and the Floy FD-67 internal anchor tag. The FT-4 tag was tested because it is more visible than a smaller tag. The study showed, however, that the hole made by the FT-4 tag did not heal readily and may contribute to fish mortality. To avoid this possibility, the FD-67 anchor tag was used for about one half of the tagged fish.

The FT-4 tag is about 137 mm long, 2 mm in diameter, and designed so that the two ends lock together. The FD-67 tag is 65 mm long, about 0.3 mm in diameter, and is designed to anchor in the fish by a "T" at one end. The tags are attached differently. The FT-4 tag is inserted using a hollow stainless steel needle 3 mm in diameter. The needle containing the tag is pushed into the body below the first dorsal fin and pulled through the fish until several inches of tag show behind the needle. The tag is held stationary and the needle removed. Then the tag ends are locked together over the dorsal fin. The FD-67 tag is inserted using a Floy tagging gun. A plunger in the gun pushes the "T" of the tag through a slotted, hollow, 2 mm diameter needle that has been inserted into the fish beneath the first dorsal fin. The FD-67 tag has a tab at the exposed end; this tab was cut off in case it might resemble a food item and stimulate another pollock to try to ingest it. The needle and tagging gun were cleaned before tagging. For non-dipnetted fish, the needle was rinsed in 37% isopropyl alcohol before insertion. All dip-netted pollock were tagged with lock-on tags.

The fish were held in a single 26,495 L circular wooden holding tank 4.7 m in diameter. Seawater for the tank was pumped from Auke Bay from a depth of 25.9 m at 49.2 l per minute. Tagged pollock were held in the tank which allowed easy access to them for feeding and monitoring their condition. The tank was covered with black polyethylene overlaid with a blue polyethylene tarp which prevented direct sunlight from reaching the water surface, although indirect lighting probably reached the water surface from spaces between the cover and the tank. The pollock were fed pieces of 1 cm cubed squid, *Loligo* sp., daily and any excess food was siphoned from the tank at feeding time.

Sea water temperature in the holding tank gradually increased from 7.3°C in June to 9.5°C in August . No temperature spikes were recorded, which might have affected the survival of the fish. Water temperatures at the depth pollock were caught during 16-17 June ranged from 6.9° to 7.6°C. Water salinity and dissolved oxygen concentration in the holding tank were recorded only once, on 10 July: 31.59 ‰ and 3.96 ml/L, respectively. At the depth pollock were caught, salinity and dissolved oxygen concentrations were 28.8-32.0‰ and 2.3-8.7 ml/L, respectively. The experiment ended 4 December 1992 when the tagged pollock in the holding tank were released into Auke Bay.

RESULTS

Effect of the Different Handling Procedures

The dip-net and non-dipnet methods gave markedly different results. Sixty percent (63 of 105) of the dip-netted fish died compared to only 12% (17 of 138) of the non-dipnetted fish (Table 1). Clearly, survival was much greater using the non-dipnet method than the dipnet method. However, the dipnetted fish were all tagged with lock-on tags, which caused a larger wound.

Mortality

Fifty percent of the mortality occurred within the first week, regardless of whether the dipnet or non-dipnet method was used (Table 2). For fish with anchor tags, 50% (4 of 8) had died by day 5. For both dip-netted fish and non-dipnetted fish with lock-on tags, 89% (8 of 9) of the deaths had occurred by day 10. For both tag types, mortality then declined and remained low until the last two deaths of fish (one each, dipnetted and non-dipnetted) on day 105.

Of the 243 pollock in the holding tank, 80 (33%) died before the end of the experiment. The dead fish were examined and injuries classified into five categories: dermal infection due to scale loss, fin loss, torn jaws, internal dysfunction, and unknown (Table 3). Most fish had more than one type of injury. For instance, several fish in the dermal infection category also showed fin loss. Conversely, the fin loss category included fish with dermal infections. Thus, although fish were placed in categories based on what was considered the main cause of death, the assignments are somewhat arbitrary. The category "unknown" includes seven fish with no visible evidence of cause of death. Dermal infection from scale loss caused the death of 68% (43 of 63) of dip-netted fish that died and about 30% (5 of 17) of non-dipnetted fish. This rate of infection emphasizes the need to minimize scale loss to prevent high mortalities. Fin loss is the decay and loss of the fin rays and soft tissue at the base of the fin. Several fish lost their entire caudal fin before dying. Fin loss probably is related to embolism resulting from the rapid change in pressure during capture.

Death from torn jaws includes infection and starvation. Care needs to be exercised during removal of the hook to prevent tearing the flesh. Tag only healthy fish, none with torn jaws. Internal examination showed that five of the dip-netted fish may have died from suspected internal causes possibly malfunctioning of internal organs. This handling procedure may cause internal injuries. Seven fish showed no evidence of cause of death either internally or externally.

Several of these fish died within the first two days; their death may have been due to capture stress.

Tag Injuries

Pollock tagged with lock-on tags showed raw tissue and infection at each tag hole. So, about half the fish were tagged with anchor tags in an attempt to reduce the amount of injured tissue. The extent of tissue damage at the time of release was assigned to one of four categories:

1. no infection.
2. flesh off-color, but no open wound.
3. flesh infected and wound around tag $\leq$5 mm diameter.
4. flesh infected and wound around tag >5 mm diameter.

At time of release, all pollock with lock-on tags and 93% of those with anchor tags were infected at the point of tag insertion (Table 4). Tag wound and infected tissue at the point of tag insertion (category 3) was the most common injury, regardless of tag type. Results of other pollock tagging studies suggest the tags do not significantly impact pollock survival. Infection of the tag wound and lack of healing may be common in tagged fish. Many tagged sablefish have open wounds at the location of tag insertion when recovered (D. Clausen, AFSC, pers. commun., 2008). Winter et al. (2007) stated that neither tagging by coded-wire tags or T-bar anchor tags had a significant impact on the survival of pollock captured in Alaska.

Tag Retention

Retention of lock-on tags was excellent. Of 180 lock-on tags used, only 1 tag became unlocked; it was found on the bottom of the holding tank. Of 63 pollock tagged with anchor tags, 4 lost the tag.

DISCUSSION

Tagging studies of walleye pollock have been limited but also indicate the feasibility of using tagging methods to identify their seasonal feeding and spawning migrations Several tagging experiments summarized by Tsuji (1989) indicate extensive migration of walleye pollock during the feeding seasons in Japanese coastal waters and in the Sea of Okhotsk. However, only two of these studies appear to have included fish tagged on the spawning grounds. Walleye pollock tagged just after the spawning season in April of 1968 in Ishikari Bay off western Hokkaido were recaptured in the next spawning period at locations in a wide range up to the southern Sakhalin coast (Tsuji 1989, p. 168), although the majority of recaptures appear to have occurred in Ishikari Bay during the 1969 and 1970 spawning seasons (Tsuji 1989: fig. 19). A second tagging experiment summarized by Tsuji (1989) involved walleye pollock tagged during the spawning season in the Nemuro Strait (a known spawning ground), between Hokkaido and the southernmost Kurile Islands. Nine tagged walleye pollock were recaptured during successive spawning seasons in Nemuro Strait, while all recaptures in other areas (Sea of Okhotsk) occurred during the feeding migration and not during spawning (Tsuji 1989).

Gong and Zhang (1986) reported that of over 47,000 walleye pollock tagged off the coast of Korea from 1931-1936, 226 were recaptured off Korea and 13 were recaptured off the west coast of Hokkaido (Tsuji 1989). Further details of this tagging program are provided in Tsuji (1989), and it is apparent that recaptures of Korean tagged walleye pollock off Hokkaido occurred in only one year (1935 fishing season) of the study, during the active feeding period, which was not during the spawning season. Tsuji (1989) suggested that this one-time migration of Korean walleye pollock to Hokkaido may have resulted from straying of an exceptionally large year class.

CONCLUSIONS

The results of this study demonstrate that using a dip net to handle pollock resulted in a higher mortality rate than not using the net to handle the fish. Of the dipnetted fish that died dermal infection due to scale loss was the primary cause of mortality. Winter et al. (2007) reported that the survival rate of pollock caught in trawls and placed on live tanks via dip nets was low due to scale loss. Therefore the following procedures are recommended for capturing and tagging walleye pollock:

1. Pollock should be captured using hook and line.
2. Hold the line (not the fish) and carry the fish to the live tank, which should be small enough so that the fish can be captured later with bare hands - chest coolers (94.6 l) are an appropriate size. The fish should not be tagged if it touches a hard surface, such as the side of the vessel, or is dropped on the deck of the vessel.
3. Remove the hook carefully, using pliers. Don't jerk the fish off the hook.
4. Wait at least 15 minutes before tagging. Discard any pollock that has unexpelled gas, bleeds from the anus or gills, has torn jaws or cannot orient itself.

5. Wet the measuring board. Capture fish in the chest cooler using bare wet hands. Measure length and tag the fish. Use a needle that has been wiped clean and then passed through an alcohol bath.
6. Discard any fish that falls out of the tagging cradle or twists while being held (loses scales).
7. Place tagged fish into live tank using bare hands. When releasing tagged fish, lower live tank into sea and tip carefully so fish can swim out without contacting a hard surface.

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Table 1.-- Survival of walleye pollock using the dip-net and non-dipnet procedures.

Method	Live	Dead	Total
Dip-netted	42	63	105
Non-dipnetted			
Lock-on tag	66	9	75
Anchor tag	55	8	63
Total	163	80	243

Table 2. -- Observed mortality of tagged walleye pollock in holding tank.

	Dip-net Lock-on tag			Non-dipnet Lock-on tag			Non-dipnet Anchor tag		
	No. of	Accum. mort.		No. of	Accum. mort.		No. of	Accum. mort.	
Day	deaths	no.	%	deaths	no.	%	deaths	no.	%
<1	--	--	---	-	--	---	1	1	12
1	--	--	---	3	3	33	2	3	38
3	2	2	3	-	--	---	-	--	---
4	9	11	17	-	--	---	-	--	---
5	3	14	22	1	4	44	1	4	50
6	11	25	40	-	--	---	-	--	---
7	7	32	51	-	--	---	-	--	---
8	19	51	81	2	6	67	-	--	---
9	--	--	---	1	7	78	-	--	---
10	5	56	89	1	8	89	-	--	---
12	2	58	92	-	--	---	-	--	---
13	1	59	94	-	--	---	-	--	---
15	1	60	95	-	--	---	-	--	---
19	1	61	97	-	--	---	1	5	62
32	--	--	---	-	--	---	1	6	75
33	--	--	---	-	--	---	1	7	88
45	--	--	---	-	--	---	1	8	100
50	--	--	---	-	--	---	-	--	---
69	1	62	98	-	--	---	-	--	---
82	--	--	---	-	--	---	-	--	---
105	1	63	100	1	9	100	-	--	---
Total		63			9			8	

Table 3. -- Captivity (days) until death and number of dead walleye pollock for each category of mortality.

Mortality Category	Dip-netted No.	Dip-netted Days alive	Non-dipnetted No.	Non-dipnetted Days alive
Dermal infection due to scale loss	43	3-19	5	5-9
Fin loss	15	4-15	2	10-32
Torn jaws	0	-	3	45-82
Internal	5	4-105	0	-
Unknown	0	-	7	< 1-50
Total	63		17	

Table 4. -- Number of walleye pollock in each tag-infection category at time of release. Categories: (1) no infection, (2) flesh off-color but no open wound, (3) tag hole ≤5mm diameter, (4) tag hole > 5 mm diameter. ( ) = %.

Category	Lock-on tag Dip-net	Lock-on tag Non-dip-net	Combined	Anchor tag
1	0 (0)	0 (0)	0 (0)	4 (7)
2	8 (19)	20 (30)	28 (26)	21 (38)
3	29 (69)	28 (42)	57 (53)	27 (49)
4	5 (12)	18 (28)	23 (21)	3 (6)
Total	42	66	106	55

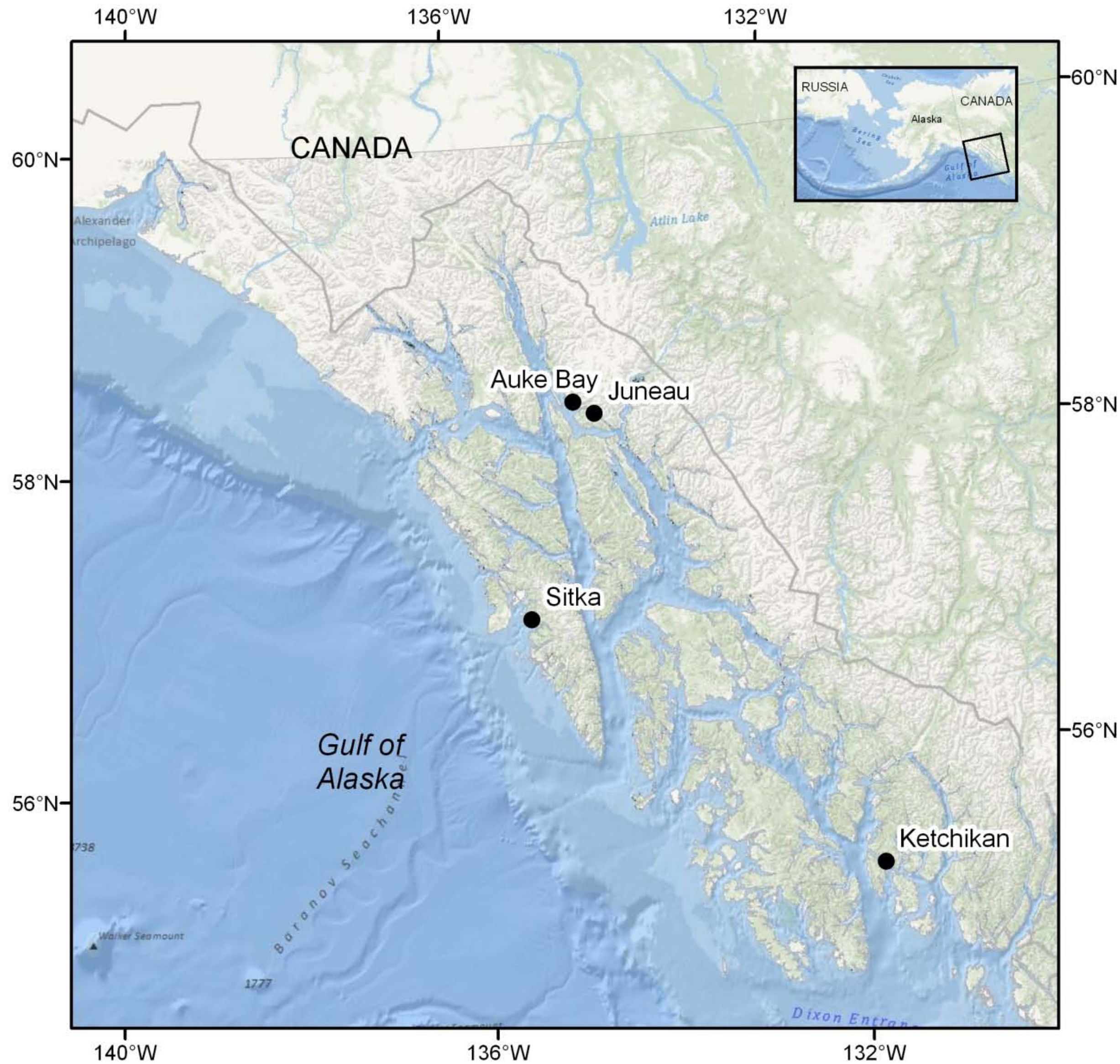

Figure. 1. -- Study location in southeastern Alaska of tagging walleye pollock with external tags.

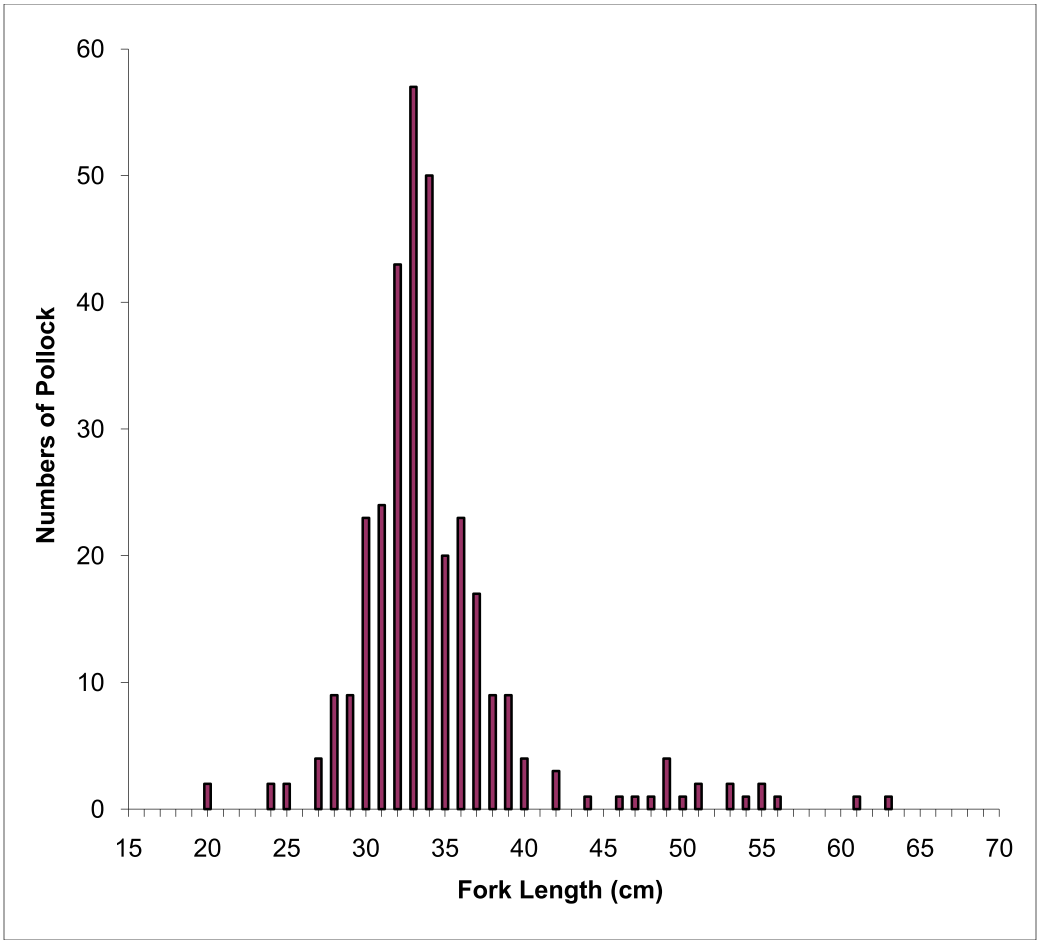

Figure. 2. -- Length frequency distribution of walleye pollock used in the feasibility tagging study.