Fishery Data Series No. 04-06

Assessment of Dolly Varden Spawning Population in Kagvik Creek, Alaska

Final Report for Study 01-137
USFWS Office of Subsistence Management
Fishery Information Service Division

by
Brendan Scanlon

June 2004

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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by
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June 2004

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This document should be cited as:
Scanlon, B. 2004. Assessment of the Dolly Varden spawning population in Kagvik Creek, Alaska. Alaska Department of Fish and Game, Fishery Data Series No. 04-06, Anchorage.

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ABSTRACT

From June 2001 through June 2004, the Alaska Department of Fish and Game, Division of Sport Fish, conducted a study on Dolly Varden *Salvelinus malma* in northwestern Alaska to: 1) enumerate overwintering aggregations using aerial surveys in the Wulik, Kivalina, and Noatak drainages; 2) assess the accuracy of aerial counts of overwintering and spawning aggregations of Dolly Varden for a typical small-order spawning tributary in the Noatak River drainage, Kagvik Creek; and, 3) collect life history information on Dolly Varden returning to Kagvik Creek to spawn. Because of frequent rain and inclement weather during the study, most of the project objectives were not achieved. Only a few and mostly incomplete aerial survey counts of the Wulik, Kivalina, and Noatak drainages were conducted. During the summers of 2001 and 2002, a weir was constructed across Kagvik Creek to capture and enumerate Dolly Varden migrating upstream to headwater spawning areas and downstream to overwintering areas. The weir counts were also to provide a complete census of all fish in the system to compare against aerial survey counts. In 2001, the weir could not withstand repeated high water events, and only 63 fish (29 males, 19 females, 15 of unknown sex) were captured moving upstream and none were captured moving down before field operations ceased several weeks early (2 August). In 2002, a stronger weir was constructed, and consequently the field season lasted longer before the weir succumbed to high water on 31 August. In 2002, 342 fish (103 males, 236 females, 3 of unknown sex) were captured moving upstream; however, the weir was disabled before downstream movement had begun. Radio transmitters were fitted to 24 spawning Dolly Varden in 2002 to find overwintering locations during aerial tracking events conducted throughout the winter. Several overwintering locations were found and fish tended to aggregate near the outlet of tributary rivers in the mainstem Noatak. Two fish were found overwintering in the Wulik River the following year. Based upon results, it does not appear that weirs are an effective way to capture spawning Dolly Varden in small headwater streams in the Noatak drainage. Also, the inability to complete aerial surveys due to inclement weather further emphasizes the need to evaluate and develop other means of assessing Dolly Varden in northwestern Alaska, including sonar.

Key words: aerial survey, Dolly Varden, Kagvik Creek, Noatak River, overwintering, *Salvelinus malma,* spawning stock, weir, telemetry.

INTRODUCTION

The traditional subsistence economies of the villages of Kivalina and Noatak in northwestern Alaska are heavily dependent on harvests of anadromous Dolly Varden *Salvelinus malma*. Overwintering aggregations of anadromous Dolly Varden in northwestern Alaska are harvested in the Noatak, Kivalina, and Wulik River drainages and near Kotzebue. In addition, Dolly Varden in northwest Alaska are captured in a growing sport fishery, and fish migrating to overwintering areas in the Noatak River are captured incidentally in the Kotzebue-based commercial chum salmon fishery. Much of the subsistence and sport harvest occurs near critical spawning and rearing habitats located in tributaries of the Noatak River within the Noatak National Preserve, and in the Wulik and Kivalina rivers along the Chukchi Sea coast.

DESCRIPTION OF NORTHWEST ALASKA DOLLY VARDEN LIFE HISTORY

Anadromous Dolly Varden populations in northwestern Alaska have complex life history and movement patterns (DeCicco 1985, 1989, 1997). They spawn in freshwater streams, and juveniles rear for two to five years before first traveling to saltwater. Once Dolly Varden enter saltwater to feed, they still return to freshwater systems each fall to overwinter and, if mature, to spawn. Tagging studies have also shown Dolly Varden return to natal streams to spawn (DeCicco 1985 and 1992) but do not necessarily return to natal streams to overwinter. Therefore, various stocks mix in freshwater overwintering areas. DeCicco (1985 and 1989) demonstrated that overwintering aggregations in the Noatak, Wulik, and Kivalina rivers are composed of a mixture of stocks from the immediate area, Norton Sound, and as far as the Russian Far East.

Sexually-mature Dolly Varden in overwintering aggregations exhibit two different types of life histories strategies and are commonly referred to as summer and fall spawners (Armstrong and Morrow 1980). These two life history types differ greatly in the time they spend in freshwater: summer spawners remain in freshwater approximately 20 months, while fall spawners remain approximately nine months. Neither summer nor fall spawners feed while in freshwater. A typical summer spawner will enter a freshwater system in the fall, overwinter, remain in freshwater during summer, and move to upstream areas to spawn during late July or August. After spawning, summer spawners descend to lower-river overwintering areas where they join nonspawners returning from their summer marine feeding migration and remain for a second winter before finally migrating to saltwater during spring break-up (early June). If summer spawners do not winter in their natal river system, they move to sea with other Dolly Varden in June, travel directly to their natal river, and move upstream during July. Fall spawners feed at sea during summer, enter rivers in August, and travel directly to spring-fed areas in headwater streams where they spawn during September. After spawning, some of these fish remain near the spawning areas, while others move to wintering areas downstream. At spring break-up, fall spawners return to sea to feed.

Dolly Varden in northwestern Alaska can migrate vast distances. Immature Dolly Varden tagged in the Wulik River have been recovered in the Noatak, Kobuk, Wulik, and Kivalina rivers; near the village of Teller on the Seward Peninsula; near Unalakleet in Norton Sound; on St. Lawrence Island; and, at several locations in the Russian Far East. The movement of a Dolly Varden between North America and Russia (over 1,600 km) is the greatest distance documented (DeCicco 1989).

DESCRIPTION OF NORTHWEST ALASKA DOLLY VARDEN FISHERIES

Dolly Varden in northwestern Alaska are harvested in subsistence and sport fisheries throughout Northwest Alaska, and are taken incidentally in the Kotzebue-based commercial chum salmon fishery. Detailed annual harvest information for the subsistence Dolly Varden fishery in northwest Alaska is not available because there is no permit or harvest reporting requirements. The first documentation of subsistence fishing activities and harvests of Dolly Varden occurred from 1959 to 1961 (Wilimovsky and Wolfe 1966). Sarrio and Kessel (1966) estimated fall harvests of Dolly Varden from Kivalina residents to be 85,600 pounds in 1959 and 124,300 pounds in 1960. Estimates of total annual harvest of Dolly Varden by the residents of Kivalina from July 1964 to June 1965 were 33,845 and 14,087 the following year. During 1982 and 1983, Burch (1985) found that 76% of the Dolly Varden harvest in Kivalina was taken during the fall by seining, 6% was taken in the winter by through ice hooking, and 17% was taken in the spring by angling through the ice and using gill nets. The remaining 1% was taken in summer. DeCicco (1982, 1984, and 1985) estimated the fall subsistence harvest of Dolly Varden in the Wulik River at 14,600 fish in 1979, 15,000 to 18,000 fish in 1981, 16,270 in 1983, and 12,000 in 1984. Foote and Williamson (1966) estimated that the winter harvest of Dolly Varden from the Noatak River to be 10,500 pounds. Dolly Varden are the most important subsistence fish resource to the village of Kivalina, comprising 80% to 98% of their annual fish harvest, and second only to chum salmon to Noatak Village (Burch 1985).

Most sport fishing for Dolly Varden in northwestern Alaska occurs in the Noatak, Wulik, and Kivalina rivers. Anglers are attracted to the region because Dolly Varden in this area often reach large sizes; in 1991, an angler caught a 19 lbs, 12 oz Dolly Varden (a former state record fish) in

Kelly River, a tributary of the Noatak River (the new state record, a 27 lb, 6 oz fish, was caught from the nearby Wulik River in 2002). From 1990 to 2002, annual sport catches of Dolly Varden in these three rivers combined averaged 6,770 fish, and harvests averaged 1,180 fish (Mills et al. 1991–1994; Howe et al. 1995-1996, 2001a-d; Jennings et al. *In prep a-b*; Walker et. al 2003; Table 1).

Incidental harvests of Dolly Varden have occurred in the Kotzebue-based commercial chum salmon fishery since its inception in the early 1960s. Recorded annual harvests have averaged 1,580 fish since 1991 (Banducci et al. 2003), but records are limited to those years in which commercial fish buyers purchased Dolly Varden. In years without a market for Dolly Varden, no records of harvest exist although it is likely Dolly Varden were harvested and used locally to satisfy subsistence needs.

POPULATION MONITORING

Since the late 1970s, Dolly Varden stocks of northwestern Alaska have been monitored using aerial survey, and information for some areas dates back to the late 1960s. Most of surveys have been conducted on mixed-stock overwintering aggregations in the Wulik River and on spawning aggregations in major tributary streams of the Noatak River, including the Kelly, Kugururok, and Nimiuktuk rivers (Figure 1). Counts of overwintering Dolly Varden in the Wulik River have ranged from 5,600 in 1986 to 144,000 in 1993 (ADF&G *Unpublished*). Counts of spawning Dolly Varden in the three major spawning streams of the Noatak drainage combined have ranged from about 7,300 fish in 1990 to about 12,200 fish in 1996 (ADF&G *Unpublished*).

In the Wulik River, using mark-recapture techniques, the overwintering aggregation of Dolly Varden ≥ 400 FL was estimated to be 76,892 (SE = 16,811; DeCicco 1989) for the winter of 1988/89 and 361,599 (SE = 62,306; DeCicco 1996) for the winter of 1994/95. Corresponding aerial survey estimates were 80,144 for the fall of 1988 (DeCicco 1989) and 66,937 for the fall of 1994 (DeCicco 1996).The goal of this study was to improve the knowledge of Dolly Varden life histories and abundance trends for northwestern Alaska populations. Specifically, work was undertaken to: 1) enumerate overwintering aggregations using aerial surveys in the Wulik, Kivalina, and Noatak drainages; 2) assess the accuracy of aerial counts of overwintering and spawning aggregations of Dolly Varden for a typical small-order spawning tributary in the Noatak River drainage, Kagvik Creek; and, 3) for fish returning to Kagvik Creek to spawn, collect information on run timing, length and weight compositions, duration of time spent within the spawning stream, condition loss during spawning, time elapsed between spawning events (i.e., spawning interval), movement patterns, and overwintering locations.

Table 1.–Estimated angler days expended; number of Dolly Varden harvested and caught; harvest per angler day and harvest per catch in Northwest Alaska, 1980-2002.

Year	Angler Days	Number Harvested	Number Caught	Harvest/ Angler Day	Harvest/ Catch
1980	4,042	327		0.08	
1981	5,284	1,231		0.23	
1982	6,906	1,531		0.22	
1983	7,963	2,192		0.28	
1984	7,791	4,842		0.62	
1985	6,701	1,557		0.23	
1986	6,313	1,529		0.24	
1987	10,221	1,520		0.15	
1988	5,279	983		0.19	
1989	4,932	999		0.20	
1990	3,782	806	3,747	0.21	0.22
1991	9,543	1,717	2,608	0.18	0.66
1992	6,145	682	7,054	0.11	0.10
1993	7,809	914	7,190	0.12	0.13
1994	6,036	2,365	10,733	0.39	0.22
1995	8,495	939	7,804	0.11	0.12
1996	5,571	913	5,376	0.16	0.17
1997	3,729	598	7,346	0.16	0.08
1998	3,801	440	8,606	0.12	0.05
1999	6,771	796	8,259	0.12	0.10
2000	7,056	1,590	7,965	0.23	0.20
2001	8,904	1,693	4,766	0.29	0.36
2002	6,417	1,884	6,552	0.29	0.29
			Average		
	6,318	1,393	6,770	0.21	0.21

OBJECTIVES

During 2001-2002, the project objectives were to:

1. conduct aerial surveys of spawning areas in the Wulik, Kivalina, and Noatak rivers to obtain a minimum estimate of the number of Dolly Varden spawning in these drainages
2. estimate the variability associated with aerial survey counts by conducting repeated surveys in Kagvik Creek, a tributary to the Kugururok River in the Noatak drainage
3. compare counts obtained by repeated aerial surveys with that obtained from a fish trap on Kagvik Creek in order to estimate the accuracy of aerial survey techniques
4. enumerate populations of fall and summer spawners in Kagvik Creek
5. measure the sex, size, and condition of spawning Dolly Varden passing through the trap at Kagvik Creek

Project objectives specific to 2002-2003 were to:

6. estimate condition loss during spawning for Dolly Varden spawning in Kagvik Creek
7. estimate the average time interval between spawning events for summer and fall spawning Dolly Varden in Kagvik Creek
8. determine overwintering locations of Dolly Varden that spawned in Kagvik Creek using radiotelemetry

METHODS

DESCRIPTION OF STUDY AREA

Kagvik Creek (68°17' N, 161°27' W) is approximately 16 km in length and is located in the Kugururok River drainage, which is part of the Noatak River drainage in northwest Alaska (Figures 1 and 2). The Noatak River is 640 km long, drains 31,000 km^2 of the western Brooks Range, is designated as a National Wild and Scenic River, and mostly lies within Gates of the Arctic National Park and Preserve. In addition to Dolly Varden, other species found in the Noatak drainage include Arctic grayling *Thymallus arcticus*, round whitefish *Prosopium cylindraceum*, humpback whitefish *Coregonus clupeaformis*, northern pike *Esox lucius*, burbot *Lota lota*, chum salmon *Oncorhynchus keta*, and pink salmon *Oncorhynchus gorbuscha*. Inconnu *Stenodus leucichthys* utilize the lower section of the river for seasonal feeding forays.

STUDY DESIGN AND SAMPLING METHODS

To enumerate and sample Dolly Varden returning to Kagvik Creek to spawn, a weir and trap were constructed across the stream to capture fish moving in either direction. The trap was constructed in lower Kagvik Creek, approximately 1,500 ft upstream from its mouth and was to be operated throughout the migratory period, which occurred from late June through the end of September (Figure 2). The location was selected because on an earlier survey on 7 July 2000, the water level, stream width, and flow appeared optimal for a weir site (the stream was

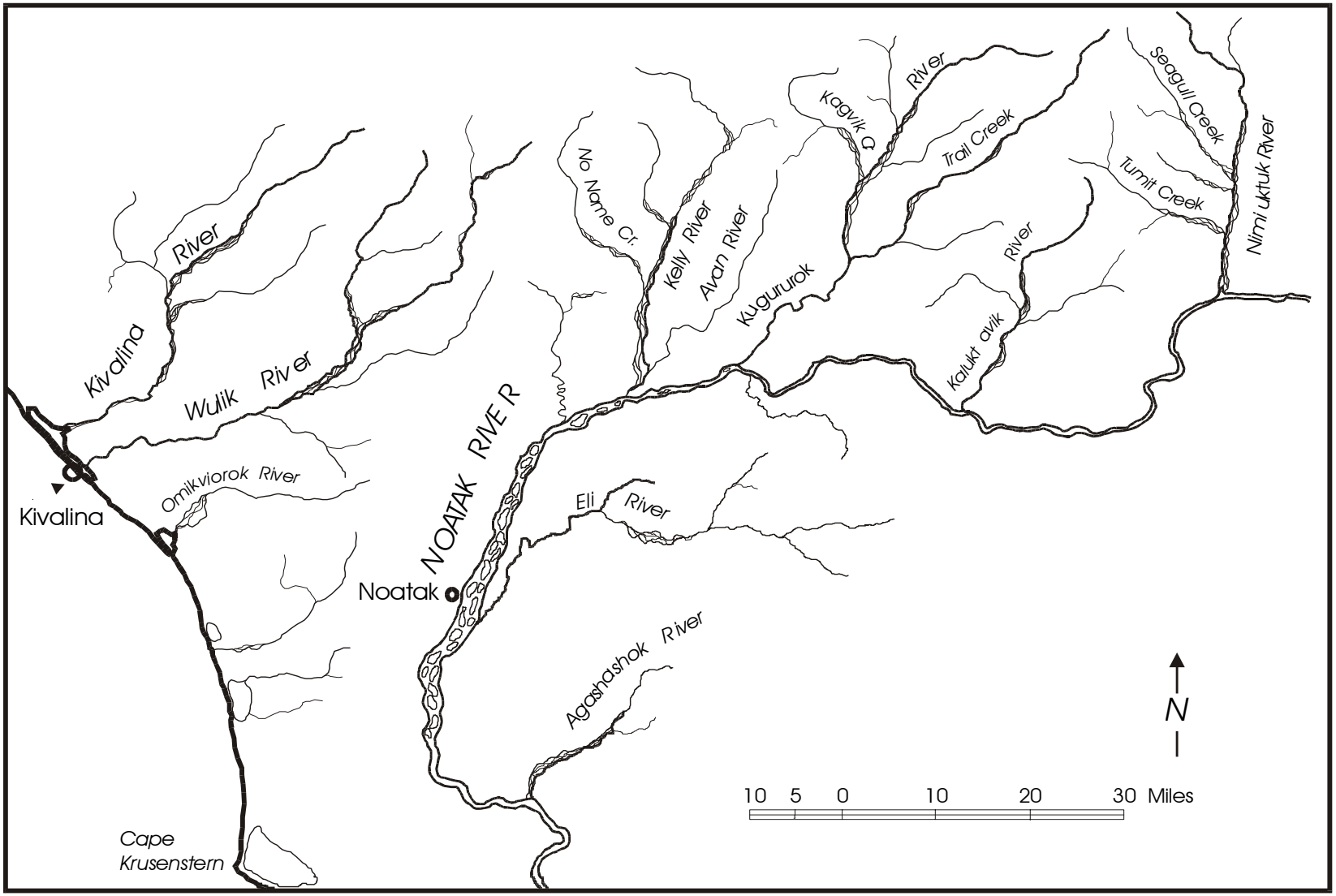

Figure 1.-The lower Noatak River with major Dolly Varden spawning streams**.**

approximately 20 m wide with a surface velocity of approximately 0.54 m/s and a maximum depth of 0.86 m; A. DeCicco, Alaska Department of Fish and Game, Fairbanks, personal communication). Also, from previous aerial surveys, both summer and fall type Dolly Varden were known to utilize this system.

The weir used in 2001 was approximately 75 ft long and 3.5 ft high, and was constructed of a tar-coated, 1-inch bar nylon mesh (4 ft tall) secured to 5/8-in rebar and duckbill anchors driven into the streambed. Maximum spacing between the 6-ft long rebar was two feet, and the duckbill anchors were attached to the rebar with 1-in nylon rope. The weir served to funnel fish into upstream and downstream fyke traps made of 1-inch nylon mesh with plastic, tubular frames 4 ft high by 4 ft wide. For sampling, fish were removed from an opening in the top of the trap using a dip net and placed into a plastic tote full of water. At the time of weir installation (25 June 2001), water depth at the study site was less than 1 m. Although the weir was operated from 25 June to 3 August, it was not tall or strong enough to withstand the large water-level increases (e.g., 1 meter) experienced after moderate rain events, and was inoperable throughout much of the sampling period.

To better withstand high-water events, a stronger picket-type weir was constructed and installed in 2002 using 4-in x 4-in timber tripods, 3-in angled aluminum rails, and steel conduit pickets, all of which were all anchored to the stream bottom with duckbill anchors. A seasonal camp was erected near the trap, and a three-person crew monitored the weir 24 hours a day in eight hour shifts from 30 June to 4 September.

Dolly Varden that entered the weir-trap counted, sampled, and released. Data collected included capture date, sampling time, sex, fork length (mm), weight (g), and spawning type (summer or fall). Spawning types were differentiated using capture date. Summer spawners typically enter spawning streams in July and early August, and generally are on the spawning grounds by 15 August. Fall spawners, that feed all summer before they return to spawn, typically do not enter spawning streams before 1 September. Therefore, all Dolly Varden captured after 1 September were considered to be fall spawners. Locally-hired technicians from Noatak Village were trained on site in proper sampling procedures. Fork length (tip-of-snout to fork-of-tail) was recorded to the nearest millimeter. Each fish was also given an individually-numbered Floy[1] FD-94 internal anchor tag, and the left axillary process was clipped to provide a secondary mark. Genetic tissue samples were collected from a subsample of Dolly Varden during July 2001 as part of a separate study (Crane et al. *In press*). After measuring and tagging, each Dolly Varden was placed in a net suspended from a fixed mechanical scale and weighed to the nearest gram. All data were recorded into field notebooks and then entered into a Microsoft Excel spreadsheet in the field using a laptop computer.

[1] Floy Tag Inc., 4616 Union Bay Place NE, Seattle, Washington, USA 98105. Product names used in this report are included for scientific correctness and do not constitute a product endorsement.

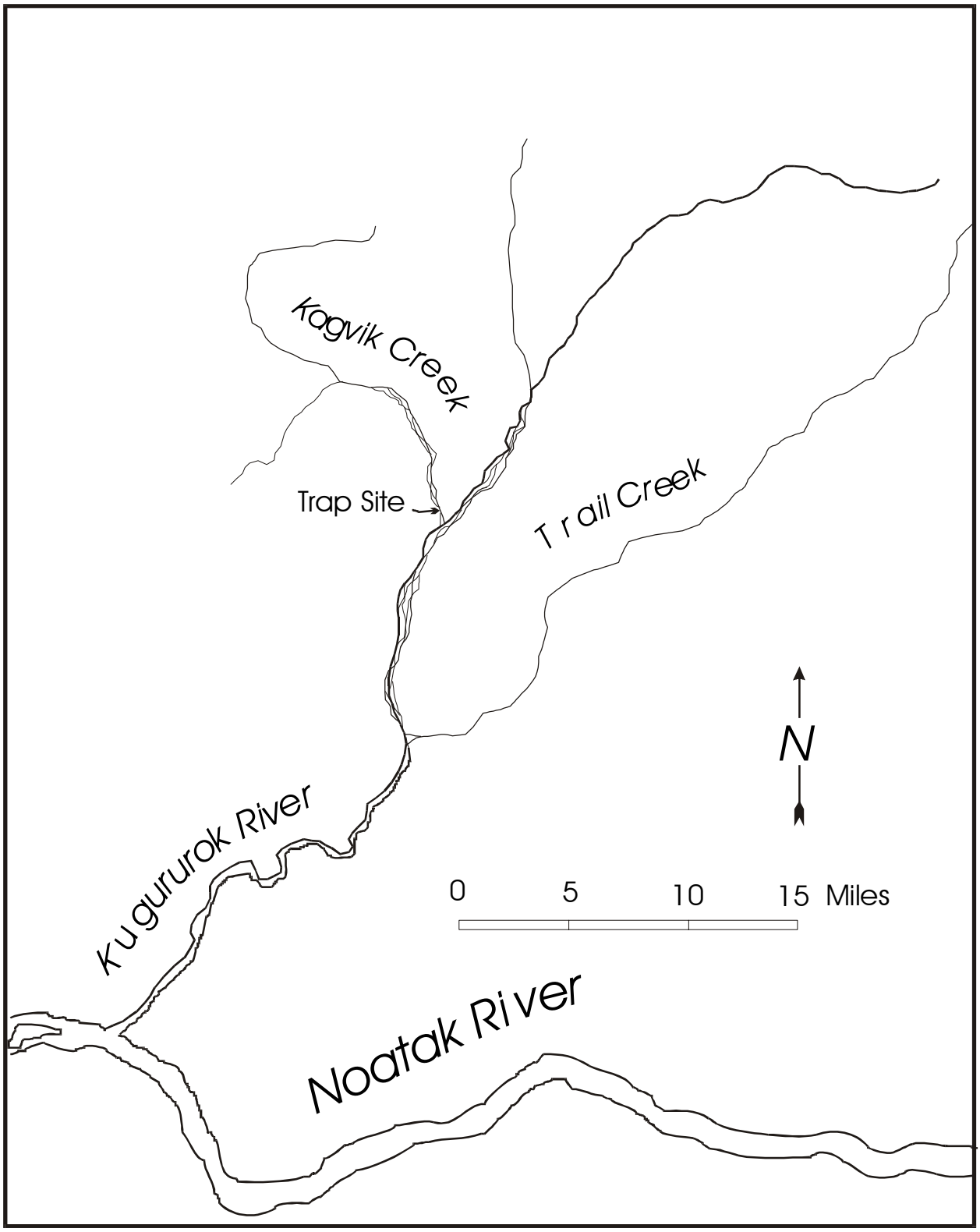

Figure 2.-The Kugururok River with study site location on Kagvik Creek.

ASSESSMENT OF AERIAL SURVEYS COUNT VARIATION

To assess the variability associated with aerial surveys in Kagvik Creek (Objectives 2 and 3), aerial survey counts of Dolly Varden in Kagvik Creek upstream of the weir were compared to the number passed upstream of the weir. Three aerial survey events were planned for each field season, each event consisting of three separate flights and counts. Aerial counts were considered "blind counts" because the observer recorded counts into a microcassette recorder and did not know either count totals or weir counts until after all flights were completed. In this way independence between counts could be approximated (Bevan 1961).

The same surveyor was used for all events and polarized glasses were worn to help reduce glare from sun and wind. A Piper PA-18 Super Cub was used for all surveys, and was flown at an altitude of 100 m and at an air speed of approximately 100 km/hr, which is common practice for aerial surveys (Jones et al. 1998). Attempts were made to conduct aerial surveys in similar weather and water conditions (i.e., relatively calm winds, clear skies or minimal cloud cover, and clear water). On the day of each aerial survey no fish were allowed to pass through the weir to ensure that the number in the survey area did not change. Efforts were made to ensure that at least one survey event was completed prior to the onset of seasonal rains, which typically begin in August, because of the potential for reduced visibility.

RADIOTELEMETRY

During the 2002 field season, 24 summer-spawners were fitted with radio tags. Although we planned to place radio tags in 20 summer and 20 fall spawners, field operations ended before fall spawners arrived at the weir. Radio tags were manufactured by Advanced Telemetry Systems[2] (model *F-1850*), had individual frequencies, operated continuously for two years, and were labeled with tag return information.

Dolly Varden to be tagged were anesthetized in water and clove oil as described by Anderson et al. (1997), and radio transmitters were surgically implanted within the coelomic cavity through a 2-3 cm incision along the linea alba, anterior to the pelvic girdle (Hart and Summerfelt 1975). Three to five sutures were used to close the incision. The outlet incision for the trailing antenna was posterior to the pelvic girdle. All Dolly Varden fitted with a radio tag were also marked with a Floy FD-94 internal anchor tag to help identify any later captured in subsistence, commercial, or sport fisheries. Prior to release, all tagged fish were held in a shallow pen for up to one hour to ensure recovery from surgery.

Radio-tagged Dolly Varden were located by flying the mainstem and major tributaries of the Noatak drainage downstream of the capture site in a systematic manner while listening for transmitter signals with a five-element Yagi antenna having 9 dB gain mounted on a fixed-wing aircraft (Cessna 206) five times during the project: 23 November 2002, 11 April 2003, 4 June 2003, and 23 June 2003, and 18 April 2004. Each survey took approximately four hours to complete and covered the lower Kugururok, Kelly, Avan and Eli rivers, as well as No Name Creek. Areas upstream of the capture site were not surveyed, due to the unlikelihood of upstream movement of postspawning fish. All collected data were entered into spreadsheet files for analysis and archival (Appendix A).

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[2] Advanced Telemetry Systems, 470 First Avenue North, P.O. Box 398, Isanti, MN, 55040 USA. Product names used in this report are included for scientific correctness and do not constitute a product endorsement.

RESULTS

2001

In 2001, light to moderate rain events resulted in two-foot increases in stream levels in less than four hours. These flows were sufficient to bend the rebar frame, lift the duckbill anchors out of the streambed, and cover the weir with gravel and cobble. It required one to three days to remove, repair, and reset the weir after each high-water event. After unsuccessful attempts to strengthen the weir, repeated repairs during which the rebar often snapped from repeated bending, and the anticipation of more frequent and intense rain events in August, we decided to discontinue field operations on 2 August. Of the 35 days the field camp was in operation, the trap was not functional for at least seven days.

Due to the unanticipated weather events, most project objectives were not met in 2001. Heavy and frequent rains during most of July and August coupled with subsequent high, turbid water prevented us from obtaining reliable aerial surveys of the Noatak, Kivalina, and Wulik drainages, as well as of Kagvik Creek. The continued failure of the weir did not allow us to count all Dolly Varden migrating into or out of Kagvik Creek. When the weir was not operational, Dolly Varden were observed moving both up and downstream past the weir site, and weir operations were terminated before most fall spawners arrived. Only 63 summer spawners were captured and sampled between 25 June and 3 August (Figure 3), and no fall spawners were captured since weir operations were suspended before they arrived. Of the 63 Dolly Varden sampled in 2001, 29 were males, 19 were females, and the sex of 15 individuals could not be determined visually. The mean length of sampled males was 699 mm FL (SD = 127), and their average prespawning weight was 3,920 g (SD = 1,978; Figure 4). The mean length of sampled females was 631 mm FL (SD = 87), and their average prespawning weight was 2,695 g (SD = 975). Finally, no information on post-spawning weight or condition loss could be collected due to early termination of work.

2002

During 2002, the fixed-picket weir was operated from 9 July until 31 August when it was breached and destroyed by high water from frequent rains. Sampling was continued until 4 September (Figure 5). A high water event on 17 August caused water to flow over and around the weir for two days, but did cause substantial damage to the weir. While it is likely that some Dolly Varden passed over or around the weir during these two days, some were captured in the trap (Figure 5). However, heavy rains during most of July and subsequent high, turbid water again prevented conducting reliable aerial surveys. Aerial surveys were attempted several times, but no counts of Dolly Varden were made for spawning areas on the Kivalina or Wulik rivers. Although a count of spawning Dolly Varden was conducted of the Noatak River on 13 August 2002, poor water conditions prevented surveys of three major tributaries where known spawning sites are located: Nimiuktuk and Kaluktavik rivers, and Nunaviksak Creek, a small tributary of the Kugururok River 5 km upstream from Kagvik Creek (Figure 1). A total of 3,646 Dolly Varden were counted during this survey. While this was a minimum count of spawners, it was less than counts observed in previous years that included similar survey areas (Appendix B1). The mean count for 11 previous surveys that included the Kelly and Kugururok rivers, but not the Eli, Kaluktavik, and Nimiuktuk rivers, (1981, 1982, 1984, 1985, 1990-1993, 1995, 1996, and 1999) was 8,577 Dolly Varden. Only one of these 11 surveys (1992) resulted in a lower count (2,745) than the 2002 survey.

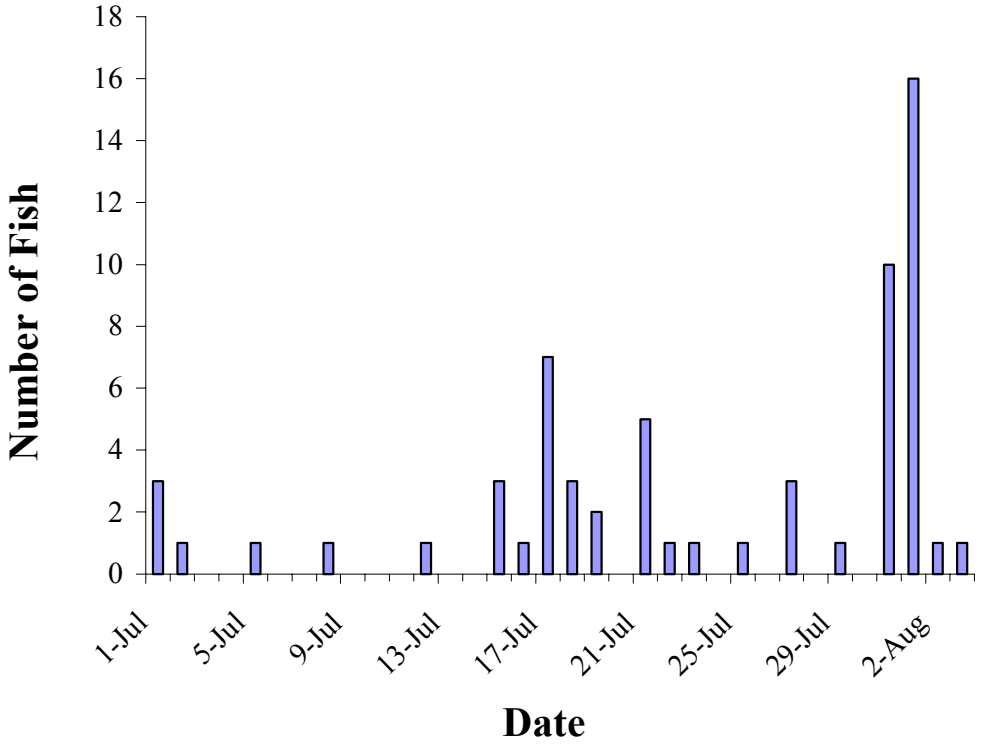

Figure 3.-Number of Dolly Varden sampled in Kagvik Creek by day from 1 July to 4 August, 2001.

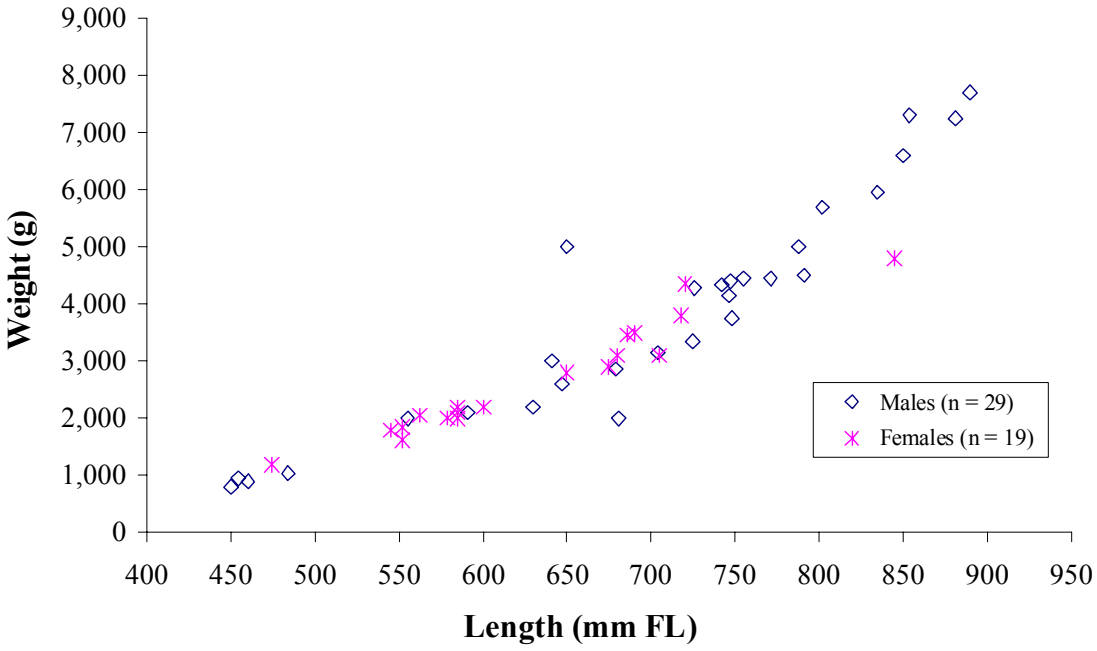

Figure 4.-Length-weight relationship of male and female summer-spawning Dolly Varden captured in Kagvik Creek from 25 June through 3 August, 2001.

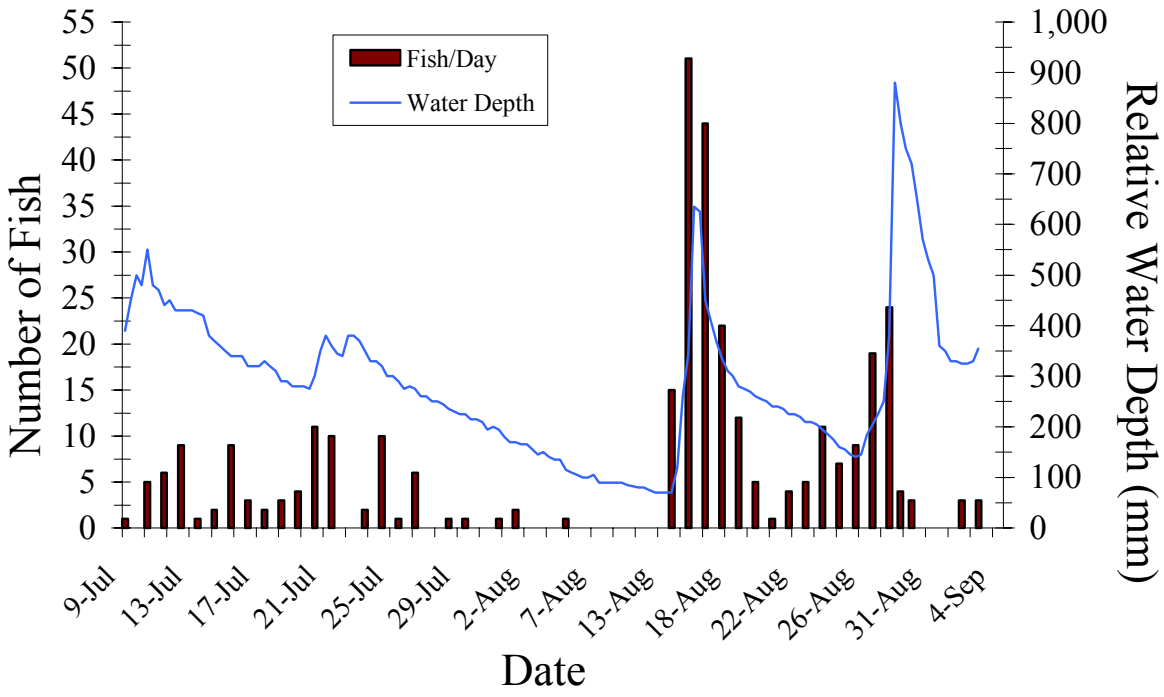

Figure 5.-Number of Dolly Varden sampled and relative water depth at the weir site on Kagvik Creek, 9 July through 4 September 2002. Relative water depth was measured as the distance above the level at the time the weir was put in.

Because only a single aerial count was completed on 3 August due to frequent inclement weather, the variability of aerial survey counts could not be effectively examined (Table 2). However, the three aerial surveys of Kagvik Creek conducted on 3 August were all similar to the number of summer spawners that had passed the weir, which was assumed to be an accurate count (Table 2).

Table 2.–Number of Dolly Varden counted on three aerial surveys and the number of fish passed through the weir in Kagvik Creek as of 3 August, 2002.

Count	Aerial Survey Count	Weir Count
1	99	97
2	106	97
3	89	97

No Dolly Varden were observed upstream of the weir when it was installed on 30 June based on aerial and foot surveys. From 9 July through 4 September, 342 Dolly Varden passed upstream through the weir. Dolly Varden upstream movement appeared to coincide with high water events (Figure 5). Six Dolly Varden were caught in the trap during the time the weir was breached at the end of August, but we do not know how many more may have passed the site without being captured. No Dolly Varden were observed moving downstream during the period of weir operations.

All but one of the Dolly Varden counted at the weir site were sampled for length, weight, and sex information (Figure 6). Of these, 103 were males, 236 were females, and the sex of two could not be determined. Mean length of sampled males was 677 mm FL (SD = 123), and mean weight was 3,213 g (SD = 1,688). Mean length of sampled females was 642 mm FL (SD = 71), and mean weight was 2,769 g (SD = 883). None of the 63 Dolly Varden sampled from Kagvik Creek in 2001 was recaptured in 2002. No information on post-spawning weights of fish was obtained since the project ended earlier than planned when the weir was destroyed by high water.

Twenty-four radio tags were deployed between late August and 4 September, and all tagged were considered to be summer spawners. On 11 November 2002, 19 of these Dolly Varden were located during an aerial tracking survey of the Noatak River drainage (Appendix C1). Three tagged Dolly Varden were found in Kagvik Creek, six miles above the study site, five were found near the mouth of the Kugururok River, and 11 were spread throughout the lower 100 miles of the Noatak River from the confluence of the Kugururok and Noatak rivers to Noatak Village. One of these Dolly Varden had traveled 130 miles downstream of the weir site, and was located at the confluence of the Agashashok and Noatak rivers.

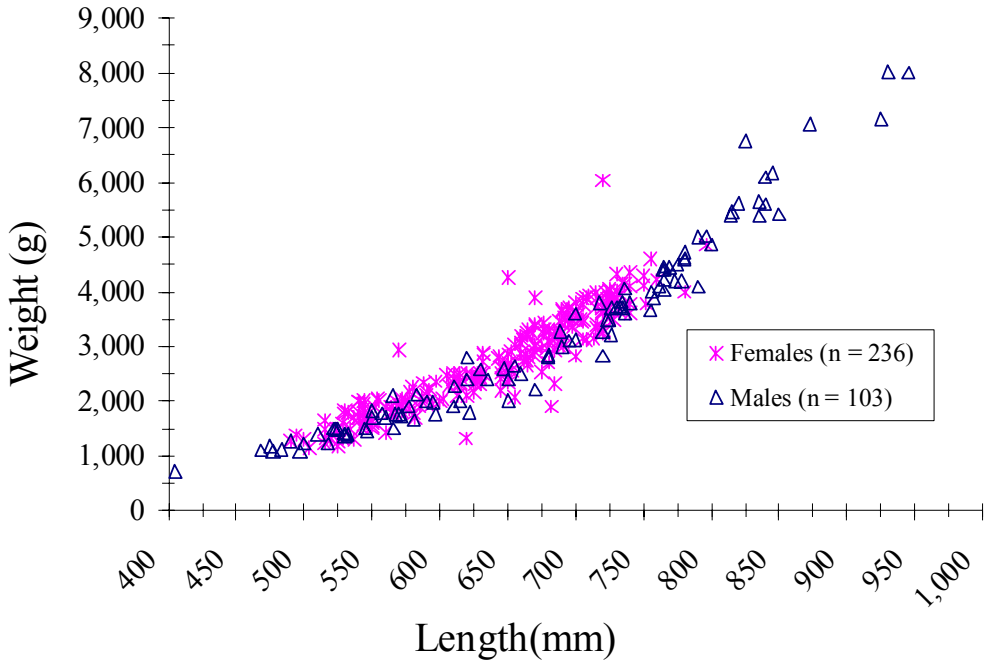

Figure 6.-Lengths and weights of male and female Dolly Varden sampled in Kagvik Creek from 9 July through 4 September 2002.

2003

During 2003, work consisted of one aerial survey to count spawning Dolly Varden and three aerial surveys to locate individuals tagged with radio transmitters in 2002 (Appendices B1, B2, and D). The aerial survey of spawning areas was conducted on 20 August 2003 for the Noatak and Wulik rivers. Due to poor water conditions, the survey of the Noatak River did not include counts from Nimiuktuk and Kaluktavik rivers. The count of spawners for the remainder of the Noatak River surveyed was 2,836 Dolly Varden. The count for the Wulik River, considered a complete survey, was 1,500 Dolly Varden. Due to helicopter unavailability, the Kivalina River was not surveyed. The 2003 Noatak River count was similar to that obtained in 2002, and less than counts observed in previous years that included similar survey areas (Appendix B1). The 2003 Wulik River count was greater than the mean count of 1,096 (range, 418-1,978) obtained during eight past surveys (1982-1986, 1991, 1995, and 1999; Appendix B2).

On 11 April 2003, 21 radio-tagged Dolly Varden were located in the Noatak River drainage during aerial tracking (Appendix C2). Two of these individuals had not been located during the November 2002 survey. One of these was found eight river miles upstream of Noatak Village, and the other was located at the outlet of the Noatak River, just inside Hotham Inlet. The Dolly Varden at the Noatak River outlet may have been harvested, because its radio signal was associated with a group of 10 anglers fishing at this location. Only three tagged Dolly Varden had moved more than 2 km since they were first located during November 2002. All three of these ascended 5 km into Evaingiknuk Creek, just upstream of Noatak Village (Figure 1; Appendix C2). The other 16 Dolly Varden either had no measurable movement between

tracking events or had only moved less than 2 km between Noatak Village and the outlet of the Kugururok River.

On 4 June 2003, 21 radio-tagged Dolly Varden were located during aerial tracking event, and three of these had not been located during the April 2003 survey (Appendix C3). Therefore, all 24 Dolly Varden fitted with radio tags were located at least once since the date of release. Two of the three newly located Dolly Varden were in the Noatak River between the mouth of the Kugururok River and the Kelly River, and the third was found up an unnamed creek that flows into the lower Kelly River. The Dolly Varden assumed to have been harvested during the previous tracking event was not located either in the river or in Kotzebue. Four of the 21 Dolly Varden located had moved less than 2 km from the tagging site since they were released, and were presumed to be dead since there did not appear to sufficient water in this area to support overwintering fish. At the time of the 4 June survey, the lower Noatak River was ice-free from the outlet up to Agashashok River, and several open leads were seen in the upper Noatak, Kelly, and Kugururok rivers.

On 23 June 2003, 19 radio-tagged Dolly Varden were located during aerial tracking (Appendix C4). Five Dolly Varden located during the 4 June survey were not found, and, since they were between the outlet of the Kugururok and Noatak Village, may have entered saltwater. Three of four tagged Dolly Varden located in the lower 10 km of the Noatak River had moved approximately 150 km downriver from the confluence of the Kugururok and Noatak rivers since the 4 June survey, and were probably on their way to saltwater. The fourth had moved downstream since the 4 June survey from the outlet of the Kelly River to a spot 5 km upstream of Noatak Village. A fifth Dolly Varden had moved 6 km down the Noatak River to a spot 3 km upstream of Noatak Village. The remaining 14 Dolly Varden had not moved since the previous tracking event and were assumed to be dead. At the time of the 23 June survey all rivers were entirely ice-free, except for a few small backwater sloughs and headwater creeks. Due to poor weather and pilot unavailability, no further tracking events were conducted in 2003.

2004

On 18 April 2004, 17 radio-tagged Dolly Varden were located during aerial tracking (Appendix C5). Fifteen fish, including the four assumed to be dead near the tagging site, were found in the Noatak River drainage, spread out between the Agashashok River and the middle reaches of Kagvik Creek. None of these had moved appreciably since the previous survey on 23 June 2003, and were assumed to be dead. Two Dolly Varden were located in the Wulik River, where they may have overwintered (Appendix C5). The remaining seven tagged Dolly Varden were not located. One of these was probably harvested 4 June 2003, but the fate of the remaining six could not be determined.

DISCUSSION

Failure of the weirs to withstand high-water events during both the 2001 and 2002 field seasons prevented at least portions of all eight project objectives from being achieved. Kagvik Creek is a first order, headwater stream in a mountainous valley characterized by high velocity flows, alluvial substrate, and large and rapid fluctuations in water level. In times of even moderate rains, the inability of the soil to absorb surface flow led to rapid increases in water level of the creek. Neither of the two weir designs was strong enough to withstand the rise in water levels, which brought not only higher flows but also lots of woody debris downstream. In addition,

stream substrate (cobbles and gravels) was displaced downstream in times of high flow; covering the weir wings, bending rebar, and lifting duckbill anchors out of the streambed. The stronger weir used in 2002 was in operation almost one month longer (until August 31) than the weir used in 2001 (until August 2), and allowed us to sample many more Dolly Varden (2002: 342; 2001: 63). However, the duration of operation was still insufficient to provide counts and samples of fall spawning and spent Dolly Varden. Additionally, fish were able to pass the site uncounted for periods of two to three days whenever the weir needed to be repaired. So counts that were obtained for this project did not represent a census of Dolly Varden for the total period of weir operations. Because of this, we were only able to obtain one early season comparison of aerial surveys and weir counts for Kagvik Creek. However, even without enough data to examine aerial survey accuracy, we feel that aerial surveys are not an effective method to obtain information on population abundance, distribution, or run timing for Dolly Varden in northwestern Alaska due to the frequent occurrence of storms, which limit flying and reduce water clarity.

Our radiotelemetry data suggest that Dolly Varden move very little during the winter months, although some individuals may undertake fairly long journeys, like the three which ascended Evaingiknuk Creek. It is unlikely that their movements were associated with feeding since adult Dolly Varden from northwest Alaska do not appear to eat much while in freshwater (Armstrong and Morrow 1980). It is more likely that these Dolly Varden were searching for better oxygenated water, which could be provided by springs in headwater areas.

Although radio-tagged Dolly Varden were found throughout the Noatak River drainage during the winter, two locations seems to be particularly attractive as overwintering locations. During all our tracking surveys, groups of radio-tagged Dolly Varden were found at the mouths of the Kugururok and Kelly rivers (Appendix C1–C4). Both locations have deeper water than most other sites within the Noatak drainage, and both probably contain reliable and sufficient levels of oxygen. These two locations are also popular winter subsistence fishing sites for the residents of Noatak Village, and a substantial proportion of the winter harvest is said to occur at these two locations (A. DeCicco, Sport Fish Area Manager, ADF&G, Fairbanks; personal communication).

By the end of our tracking study 16 of the 24 radio-tagged Dolly Varden appeared to have died, with most mortality probably occurring by 23 June 2003. One of these individuals was probably harvested, while the others were assumed to be dead since they did not show appreciable movement between tracking events. By 23 June all of the Dolly Varden we tagged, since they were adults, should have either left freshwater or at least begun moving downstream on their way to saltwater (Armstrong and Morrow 1980). Four Dolly Varden appear to have died in Kagvik River shortly before or after spawning, and may have succumbed to infection or other effects due to surgical implantation of radio tags. However, the other 11 Dolly Varden likely died only after they had reached their overwintering areas, and many of these may have died of natural causes rather than from effects of tagging. The maximum number of tagged Dolly Varden that could have survived through 18 April 2004 was 8, assuming that, along with the two located in Wulik River, six Dolly Varden not located during the last survey had migrated to saltwater and were still alive. This would result in an overwintering morality of 58% (11 dead in overwintering areas, 2 alive in Wulik River, 6 alive in saltwater). This level of mortality is somewhat greater than that reported by Craig (1977), who estimated that northern form adult Dolly Varden from the Canning River, Alaska, had an average annual natural mortality of 49%

for age-8 to -14 individuals. Therefore, it is possible that tagging may have increased overwintering mortality of Dolly Varden in our study.

CONCLUSIONS

1. It does not appear that a weir can be used to count Dolly Varden on small-order streams in the Noatak drainage due to the magnitude of water level fluctuations throughout the migration season of July through September.
2. Aerial surveys, while commonly used, probably do not provide accurate counts of spawning Dolly Varden in northwestern Alaska due to the common occurrence of turbid water and storms.
3. Alternatives to weirs and aerial surveys need to be developed to enumerate Dolly Varden spawning in northwestern Alaska drainages.

RECOMMENDATIONS

Recent advances in sonar technology may offer an alternative to aerial surveys and weirs for counting Dolly Varden entering freshwater to spawn and overwinter. In 2004, researchers at the U.S. Fish and Wildlife Service will conduct a feasibility study on the Hulahula River using dual frequency identification sonar (DIDSON®) to count Dolly Varden migrating into this system (Fisheries Resource Monitoring Program Study 04-103, Enumeration of Dolly Varden using Dual Frequency Identification Sonar (DIDSON) in the Hulahula River, Alaska.). Didson® equipment appears to be an improvement over single, dual, and split beam sonar equipment being used to count salmon because it produces images of fish that are easier to see, has a wider viewing angle with better water column coverage, is easier to aim and operate, makes it easier to determine up- and downstream fish movement, and may provide reasonably accurate measures of fish length (Maxwell and Grove 2004).

ACKNOWLEDGMENTS

The U.S. Fish and Wildlife Service, Office of Subsistence Management, provided $737,800.00 in funding for this project through the Fisheries Resource Monitoring program, under agreement number 701811J333. The author appreciates the help and comments from those who reviewed and edited this report as well as its operational plan, Matt Evenson as research coordinator, Brian Taras for biometric review, Fred DeCicco as Northwest Alaska Area Manager, and Sara Case for the preparations necessary for publication. Thanks are also given to Klaus Wuttig and Don Roach for supervisory support and encouragement. Additionally, special thanks go to those who helped collect the data: Phil Joy, Fred Luther, Floyd Wesley, Ralph Archuleta, Jerry Shy, Duke Burns, and Caleb Sage.

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APPENDIX A:
Data File Listing

Appendix A1.-Data files of the Kagvik Creek Dolly Varden spawning population in 2001 and 2002.

Data File[a]	Description
Bscanlon2001kagvikdv.xls	Population and marking data for Kagvik Creek Dolly Varden captured 11 September through 19 August, 2001.
Bscanlon2002kagvikdv.xls	Population and marking data for Kagvik Creek Dolly Varden captured 11 September through 19 September, 2002, and radio-tracking data from 2002 and 2003.

[a] Data files were archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, 1300 College Road, Fairbanks, Alaska 99701.

APPENDIX B:
Historical Data Summaries

Appendix B1.-Summary of aerial surveys of summer-spawning Dolly Varden in the Noatak drainage, 1981-2003.

Year	Date	Weather/ Water Conditions	Noatak River Tributary Surveyed					Total
			Kelly River	Kugururok River	Eli River	Kaluktavik River	Nimiuktuk River	
1981	8/16-19	Overcast	2,616	3,284	NS[a]	NS	2,022	7,922
1982	8/3-6	Good	2,244	3,861	NS	NS	2,170	8,275
1983	8/24-25	Poor	2,924	NS	NS	NS	NS	2,924
1984	8/26-27	Fair	2,618	4,591	NS	NS	1,921	9,130
1985	7/24-26	Good	3,875	4,973	NS	NS	2,131	10,979
1986	8/24-25	Poor	NS	NS	NS	NS	NS	NS
1987			NS	NS	NS	NS	NS	NS
1988			NS	NS	NS	NS	NS	NS
1989			NS	NS	NS	NS	NS	NS
1990	8/18-19	Good	2,682	2,802	NS	386	1,777	7,647
1991	8/26	Good	3,293	3,915	NS	455	2,397	10,060
1992	8/23-25	Poor	990	1,755	NS	NS	NS	2,745
1993	8/16-17	Good	4,595	3,635	NS	NS	1,330	9,560
1994	7/27	Poor	NS	NS	NS	NS	NS	NS
1995	8/20-21	Good	2,906	2,228	289	NS	1,364	6,787
1996	8/27-28	Good	4,942	3,434	NS	943	2,865	12,184
1997			NS	NS	NS	NS	NS	NS
1998			NS	NS	NS	NS	NS	NS
1999	7/22-23	Good	5,673	3,386	NS	NS	NS	9,059
2000			NS	NS	NS	NS	NS	NS
2001			NS	NS	NS	NS	NS	NS
2002	8/13	Overcast	1,604	812	NS	NS	NS	2,416
2003	8/20	Good	1,671	1,165	NS	NS	NS	2,836

[a] NS indicates no survey was conducted.

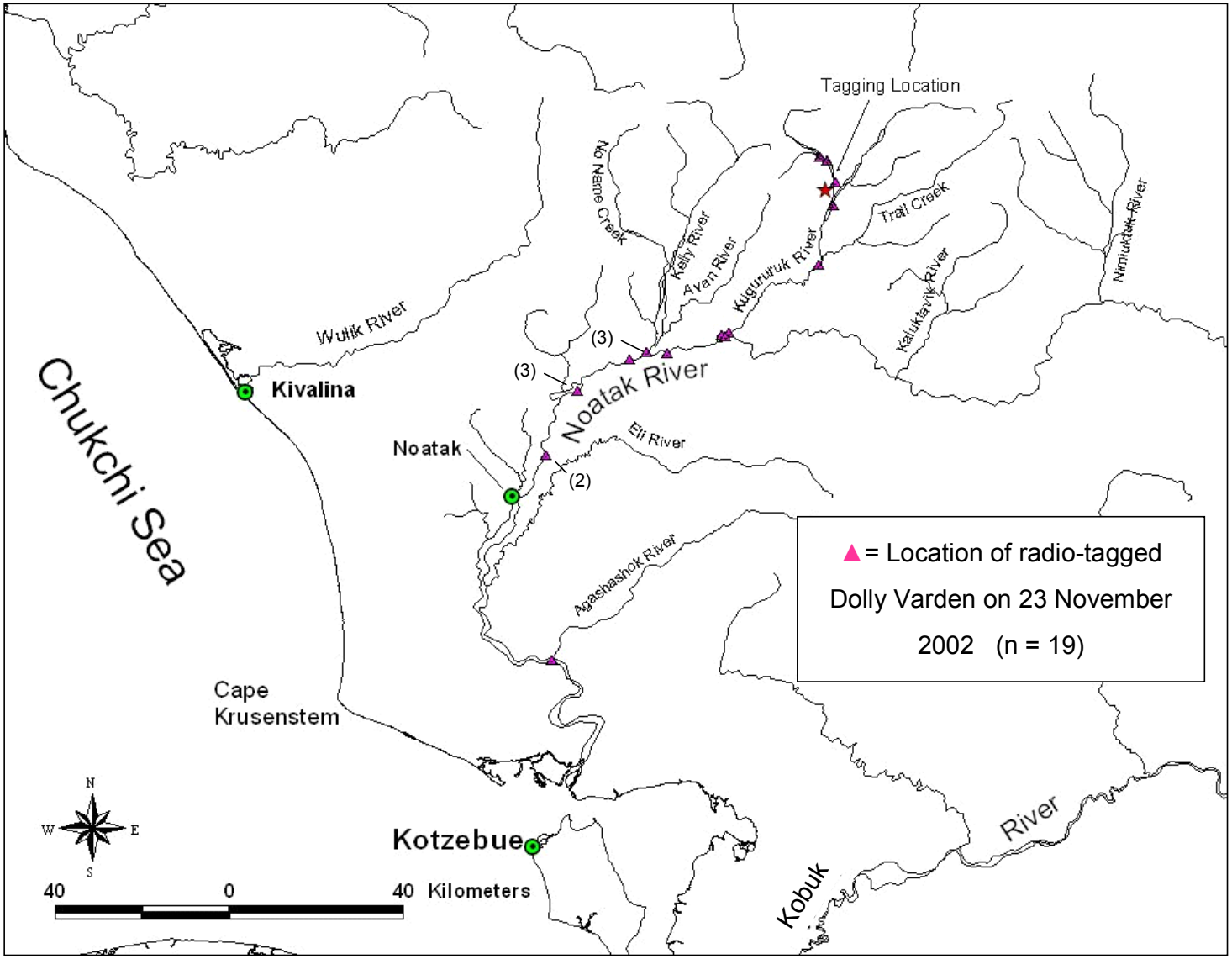
Appendix B2.-Summary of aerial surveys of spawning Dolly Varden in the Wulik and Kivalina drainages, 1981-2003.

Year	Date	Weather/Water Conditions	Drainage Surveyed		Total
			Wulik River	Kivalina River	
1981	8/20	Good	NS[a]	561	561
1982	8/8	Good	418	375	793
1983	8/24-25	Good	1,137	685	1,822
1984	8/28	Good	1,492	652	2,144
1985	7/24	Good	1,615	1,780	3,395
1986	8/25	Good	1,232	527	1,759
1987			NS	NS	NS
1988			NS	NS	NS
1989			NS	NS	NS
1990			NS	NS	NS
1991	8/26	Good	115	NS	115
1992			NS	NS	NS
1993			NS	NS	NS
1994			NS	NS	NS
1995	8/20	Good	781	997	1,778
1996			NS	NS	NS
1997			NS	NS	NS
1998			NS	NS	NS
1999	7/27	Good	1,978	NS	1,978
2000			NS	NS	NS
2001			NS	NS	NS
2002			NS	NS	NS
2003	8/20	Good	1,500	NS	1,500

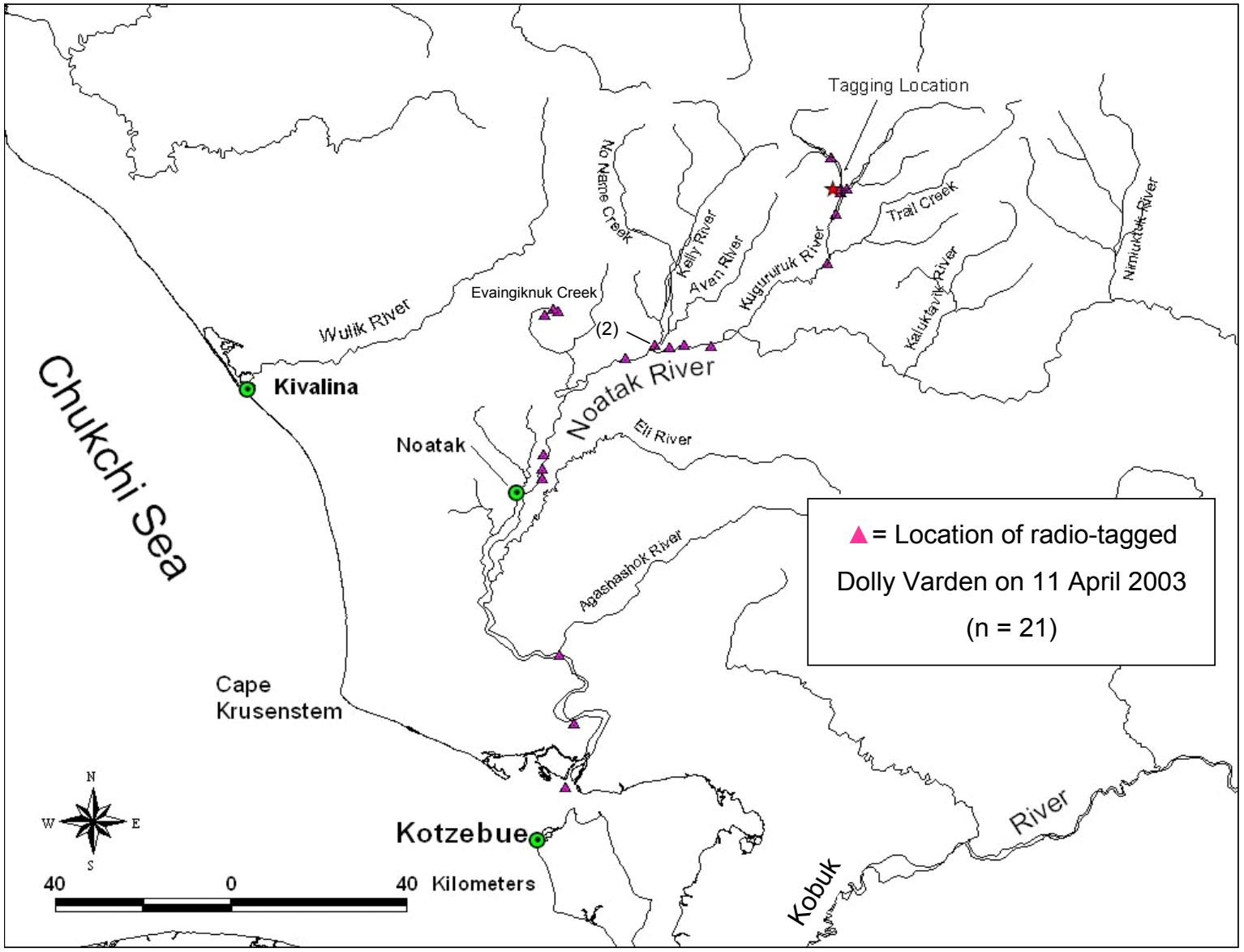
[a] NS indicates no survey was conducted.

APPENDIX C:
Telemetry Mapping Summaries

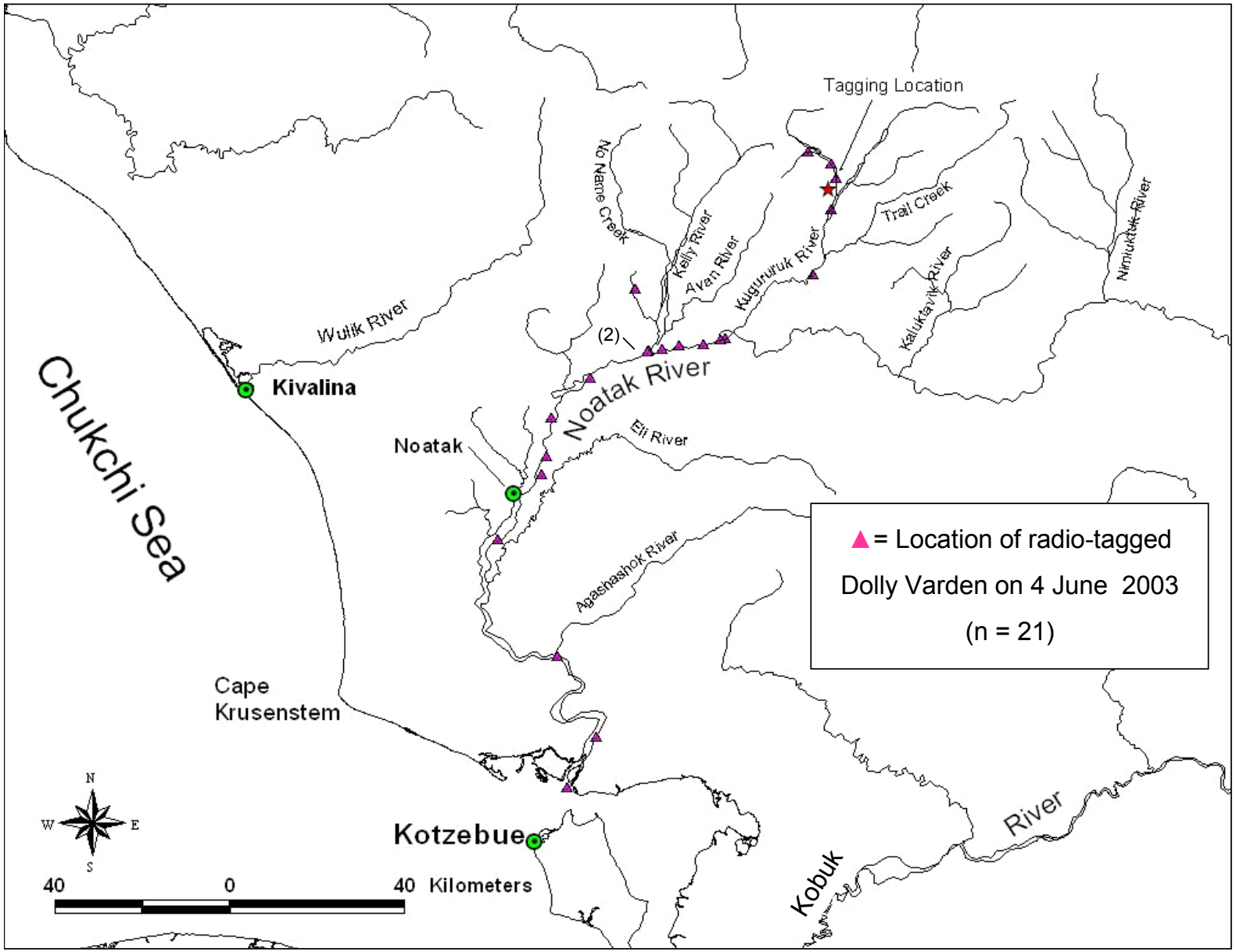
Appendix C1.–Locations of radio-tagged Dolly Varden in the Noatak River drainage on 23 November 2002.



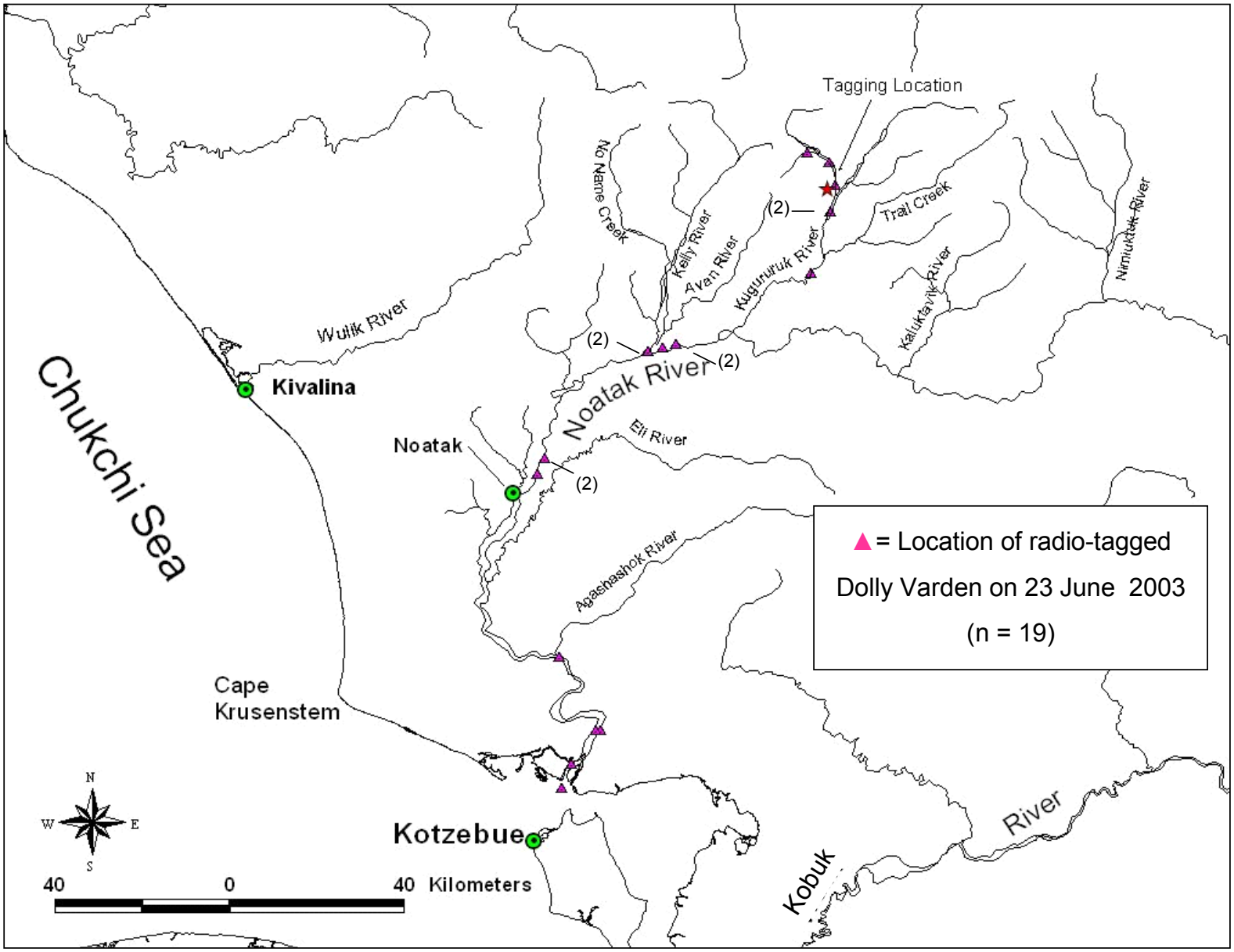
Appendix C2.-Locations of radio-tagged Dolly Varden in the Noatak River drainage on 11 April 2003.



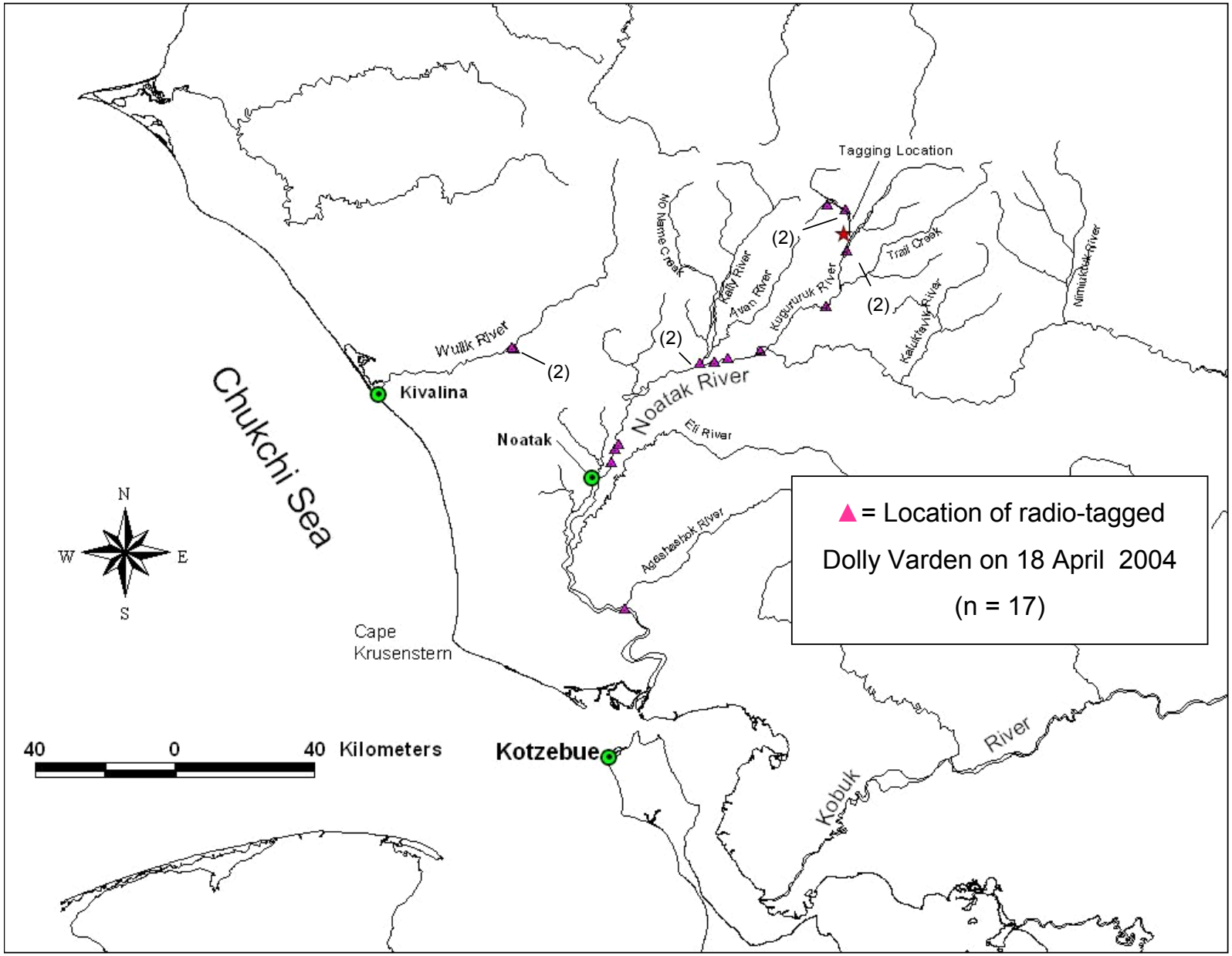
Appendix C3.-Locations of radio-tagged Dolly Varden in the Noatak River drainage on 4 June 2003.



Appendix C4.-Locations of radio-tagged Dolly Varden in the Noatak River drainage on 23 June 2003.



Appendix C5.-Locations of radio-tagged Dolly Varden in the Noatak River drainage on 18 April 2004.



APPENDIX D:
Telemetry Data Summaries

Appendix D1.-Locations of radio-tagged Dolly Varden in the Noatak River drainage for the period 11 November 2002 through 23 June 2003.

Frequency	Survey Date	Latitude (north)		Longitude (west)	
		Degrees	Minute	Degrees	Minute
165.304	Released 15 Aug	68	17.00	161	27.00
	23 Nov	67	97.17	161	96.65
	11 Apr	67	94.17	162	04.85
	4 Jun	67	91.77	162	36.18
	23 Jun	nf [a]			
	18 Apr	nf			
165.444	Released 23 Aug	68	17.00	161	27.00
	23 Nov	67	04.42	162	48.43
	11 Apr	nf			
	4 Jun	68	04.27	162	47.80
	23 Jun	67	02.65	162	29.05
	18 Apr	nf			
165.453	Released 15 Aug	68	17.00	161	27.00
	23 Nov	67	98.03	161	92.70
	11 Apr	67	97.32	162	89.02
	4 Jun	67	94.42	162	07.02
	23 Jun	68	35.30	161	50.42
	18 Apr	nf			
165.464	Released 15 Aug	68	17.00	161	27.00
	23 Nov	68	35.67	161	50.52
	11 Apr	68	36.17	161	52.42
	4 Jun	68	34.97	161	49.57
	23 Jun	nf			
	18 Apr	68	21.47	161	30.15
165.484	Released 20 Aug	68	17.00	161	27.00
	23 Nov	68	36.32	161	54.63
	11 Apr	68	36.17	161	52.42
	4 Jun	68	34.97	161	49.57
	23 Jun	68	35.30	161	50.42
	18 Apr	68	21.47	161	30.15

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Frequency	Survey Date	Latitude (north)		Longitude (west)	
		Degrees	Minute	Degrees	Minute
165.493	Released 3 Sept	68	17.00	161	27.00
	23 Nov	68	13.92	161	48.45
	11 Apr	68	14.03	161	48.12
	4 Jun	68	84.62	162	65.40
	23 Jun	nf			
	18 Apr	nf			
165.514	Released 15 Aug	68	17.00	161	27.00
	23 Nov	nf			
	11 Apr	nf			
	4 Jun	68	36.93	161	62.97
	23 Jun	68	36.63	161	62.68
	18 Apr	68	21.80	161	37.69
165.533	Released 15 Aug	68	17.00	161	27.00
	23 Nov	67	89.98	162	44.89
	11 Apr	67	89.38	162	49.75
	4 Jun	67	75.20	162	83.47
	23 Jun	67	93.78	162	21.62
	18 Apr	67	53.42	163	38.13
165.543	Released 15 Aug	68	17.00	161	27.00
	23 Nov	67	97.05	161	95.00
	11 Apr	67	96.15	161	95.75
	4 Jun	67	96.30	161	95.65
	23 Jun	68	25.00	161	46.80
	18 Apr	67	58.01	161	57.83
165.554	Released 23 Aug	68	17.00	161	27.00
	23 Nov	68	26.55	161	44.73
	11 Apr	68	24.58	161	46.88
	4 Jun	68	25.43	161	47.12
	23 Jun	67	66.62	162	83.70
	18 Apr	68	15.12	161	27.73
165.564	Released 23 Aug	68	17.00	161	27.00
	23 Nov	nf			
	11 Apr	67	67.23	162	86.42
	4 Jun	67	67.33	162	83.20
	23 Jun	nf			
	18 Apr	67	40.06	162	27.73

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Frequency	Survey Date	Latitude (north)		Longitude (west)	
		Degrees	Minute	Degrees	Minute
165.584	Released 26 Aug	68	17.00	161	27.00
	23 Nov	67	82.18	162	70.47
	11 Apr	67	62.20	162	85.57
	4 Jun	67	63.43	162	84.50
	23 Jun	67	63.42	162	86.07
	18 Apr	67	38.06	162	51.18
165.592	Released 23 Aug	68	17.00	161	27.00
	23 Nov	67	97.17	161	96.62
	11 Apr	67	97.60	162	91.92
	4 Jun	67	95.83	161	98.28
	23 Jun	nf			
	18 Apr	67	53.42	163	38.13
165.614	Released 21 Aug	68	17.00	161	27.00
	23 Nov	68	31.48	161	44.88
	11 Apr	68	29.17	161	45.40
	4 Jun	68	32.17	161	46.47
	23 Jun	68	30.68	161	45.88
	18 Apr	68	15.12	161	27.73
165.634	Released 24 Aug	68	17.00	161	27.00
	23 Nov	68	31.48	161	44.88
	11 Apr	68	29.83	161	45.40
	4 Jun	68	32.17	161	46.47
	23 Jun	68	30.66	161	45.88
	18 Apr	68	15.12	161	27.73
165.644	Released 16 Aug	68	17.00	161	27.00
	23 Nov	67	97.05	161	95.00
	11 Apr	67	93.67	162	19.35
	4 Jun	67	93.72	162	19.90
	23 Jun	67	93.78	162	21.62
	18 Apr	67	56.24	162	10.46
165.653	Released 20 Aug	68	17.00	161	27.00
	23 Nov	67	26.35	162	64.90
	11 Apr	67	26.35	162	64.08
	4 Jun	67	26.43	162	63.55
	23 Jun	67	26.17	162	62.02
	18 Apr	67	15.75	162	38.73

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Frequency	Survey Date	Latitude (north)		Longitude (west)	
		Degrees	Minute	Degrees	Minute
165.663	Released 16 Aug	68	17.00	161	27.00
	23 Nov	67	92.14	162	24.81
	11 Apr	67	92.80	162	26.87
	4 Jun	67	92.32	162	29.12
	23 Jun	67	92.68	162	28.07
	18 Apr	67	55.42	162	15.96
165.684	Released 24 Aug	68	17.00	161	27.00
	23 Nov	67	67.97	162	82.75
	11 Apr	67	64.43	162	85.98
	4 Jun	67	48.88	163	02.78
	23 Jun	67	66.62	162	83.70
	18 Apr	67	40.95	162	50.59
165.714	Released 4 Sept	68	17.00	161	27.00
	23 Nov	68	13.92	161	48.45
	11 Apr	67	12.60	162	51.37
	4 Jun	68	11.62	161	52.57
	23 Jun	68	11.85	161	53.73
	18 Apr	68	06.10	161	33.19
165.804	Released 4 Sept	68	17.00	161	27.00
	23 Nov	nf			
	11 Apr	nf			
	4 Jun	nf			
	23 Jun	67	12.20	162	35.30
	18 Apr	nf			
165.834	Released 4 Sept	68	17.00	161	27.00
	23 Nov	nf			
	11 Apr	68	29.93	161	42.28
	4 Jun	67	10.78	162	37.45
	23 Jun	67	11.87	162	37.87
	23 Jun	68	30.68	161	45.88
	18 Apr	nf			

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Frequency	Survey Date	Latitude (north)		Longitude (west)	
		Degrees	Minute	Degrees	Minute
165.855	Released 4 Sept	68	17.00	161	27.00
	23 Nov	67	91.93	162	36.03
	11 Apr	67	92.82	162	35.07
	4 Jun	67	91.50	162	36.78
	23 Jun	67	91.52	162	36.28
	18 Apr	67	54.99	162	21.59
165.864	Released 4 Sept	68	17.00	161	27.00
	23 Nov	68	31.48	161	44.88
	11 Apr	68	29.17	161	45.40
	4 Jun	68	32.17	161	46.47
	23 Jun	68	30.68	161	45.88
	18 Apr	nf			

[a] nf means the fish could not be found or located during an aerial tracking survey.