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Biology of the Nass River Eulachon (Thaleichthys pacificus)

by
O. E. Langer, B. G. Shepherd, and P. R. Vroom

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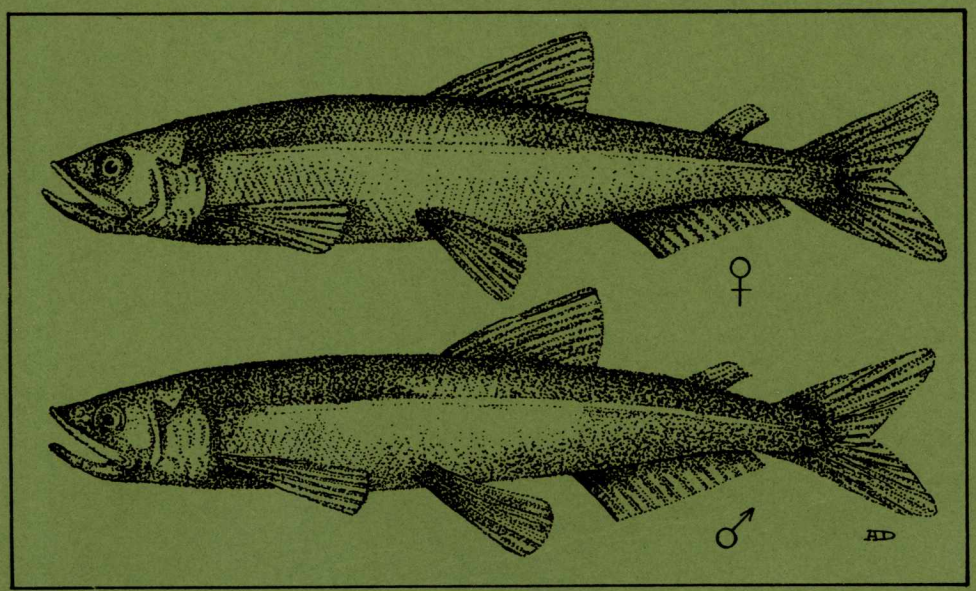

BIOLOGY OF THE
NASS RIVER EULACHON
(Thaleichthys pacificus)

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DEPARTMENT OF FISHERIES AND THE ENVIRONMENT
PACIFIC REGION

ABSTRACT

The upriver migratory and spawning activities of the Nass River eulachon (Thaleichthys pacificus) runs from 1969 to 1971 were examined in connection with possible detrimental effects from log driving. Echo-sounding, gillnetting, and dipnetting techniques were used to determine annual and seasonal variations in timing and distribution of adults and eggs. Catches of adults were sampled to determine sexual characteristics, sex ratios, age, and length. Results were compared with those available for other runs, and three possible impacts of the log drive on the Nass run were identified. An annotated eulachon bibliography has been appended to this report.

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I. INTRODUCTION

A. Purpose of Study:

Despite the importance of the eulachon, (*Thaleichthys pacificus* Richardson), to the native culture, very little attention has been devoted to the biology of British Columbia stocks north of the Fraser River. Biological information is generally sparse; only 13 of the 66 known papers on eulachons have contributed new information on eulachon biology, and seven of these are general data records compiled by researchers at the Pacific Biological Station of the Fisheries and Marine Service.

In 1968, a meeting was held between the Nishga Tribal Council and the Department of Fisheries to discuss fishery problems on the Nass River. At that time, the Council expressed the concern that current log driving practices might be harmful to the eulachon run into the Nass River (Figure 1). In 1969, the Fisheries and Marine Service initiated a program to achieve the following objectives:

1) To determine the timing, distribution, and relative abundance of the Nass River spawning stock.

2) To determine the environmental parameters that affect timing, distribution, and abundance of the stock.

3) To determine length, sex, and age compositions, and meristic characters of the stock.

4) To assess the impact(s) that log driving has on the stock.

The results of the program were immediately used to assess and minimize certain impacts of the log drive. It was recognized that these data should be summarized in a form useful for future possible protection

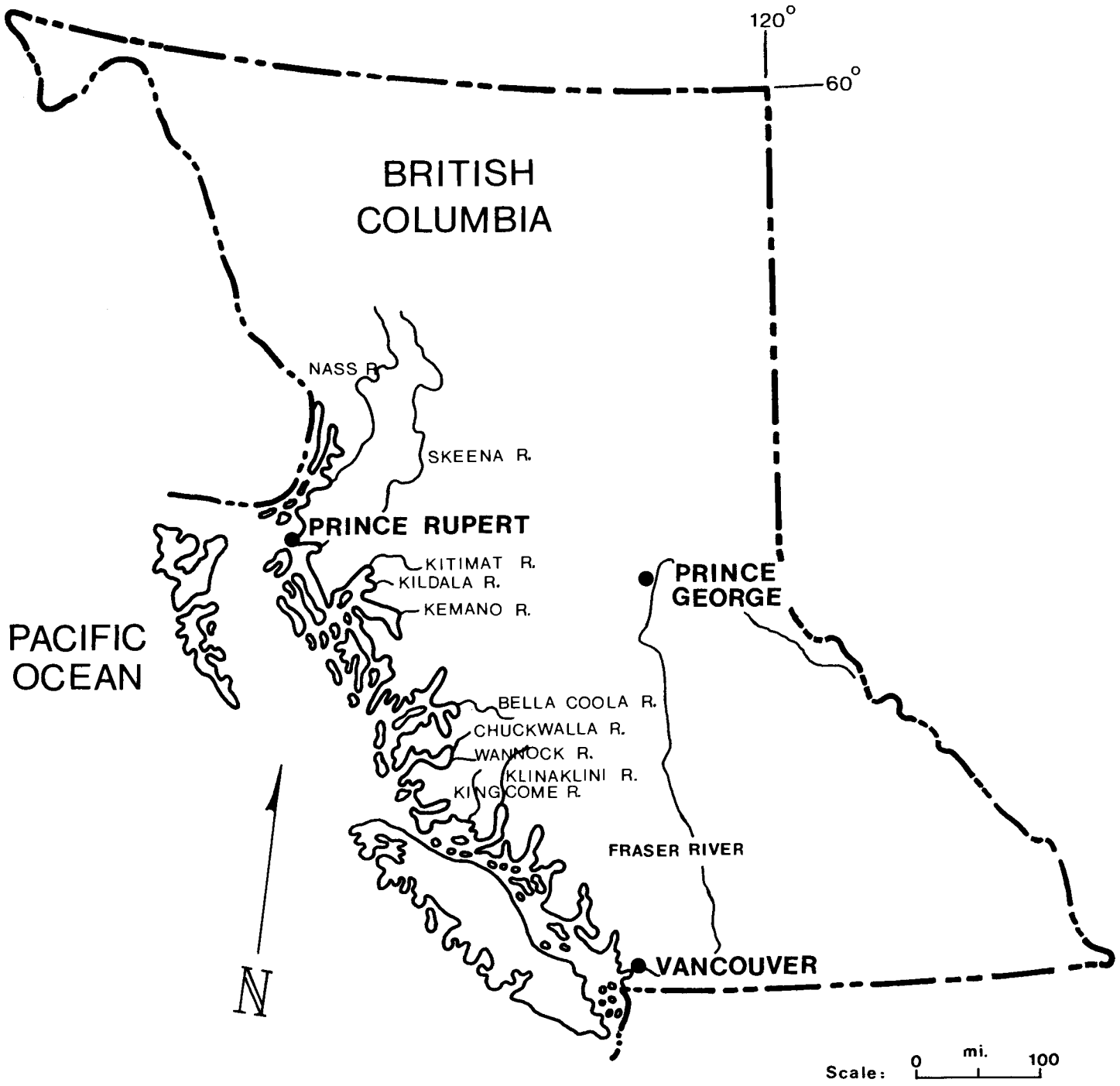


Figure 1: Location of known major eulachon spawning runs in British Columbia.

decisions, and that publication of the results would be a worthwhile contribution to eulachon biology.

B. History of Fishery:

1. Commercial

In British Columbia, the eulachon presently is fished commercially only on the Fraser River. However, commercial fishing for eulachons first began on the Nass River in 1877. The commercial catch of this species peaked in the early 1900's at about 900 metric tons, or fifth in market value among the fisheries of British Columbia. Since then, commercial catches have declined steadily, and non-Fraser stocks (see Figure 1) have been protected from commercial exploitation since the mid-1950's.

2. Native

The Nass River has supported a concentrated native fishery since before earliest records. Quoting Scott and Crossman (1973, p. 323):

> The native eulachon fishery was extensively governed by ritual, traditional ownership of good sites, rivalry, and an extensive trade network to the interior of British Columbia. The name of the Nass River is supposed to be a Tlingit word meaning food depot. The oil or "grease" (kleena) from the eulachon was held in high regard as a food item for cooking and as a curative.... Trails used by Indians to get to the coastal fishing grounds, and over which the oil was carried for trade, were known as "grease trails." Around 1881, 5000 members of the Tsimshian tribe alone moved annually to fishing locations on the coast. Between 1935 and 1940, crude statistics were kept of the Indian fishery, which exceeded the commercial catch in those years by as much as 7,000 cwt (300 metric tons). Lord (1866) and Swan (1881) both described in interesting detail the pole, basket, and net fishery, some of the ritual associated with pacifying the eulachon so it would come again, and the drying, smoking, and preparation of oil by the Indians.

The Nass River native food fishery still exists, although effort has dropped. During the 1970 and 1971 surveys, about 25 natives fished during weekends, and 10 during weekdays. Since 1971, the numbers involved have remained relatively constant at 20 or 30 families from Greenville to Canyon City, with a few others from Port Simpson participating (L.J. Gray, Upper Nass Fishery Officer, pers. comm.). The main type of gear used at the traditional fishing site at Fishery Bay (Figure 2) is a modified beam trawl, which is usually set through the ice and held stationary by poles (Figures 3-5). Similar trawl nets are used at the mouth of the Nass, but are tended from boats. If break-up is early, the Fishery Bay trawls also are tended from boats (Figure 6). Trawls also are towed behind boats if ice floes allow. Stationary trawls are fished during ebb tides. Dipnets with a hoop diameter of roughly two feet are used in the upper tidal reaches of the river. Gillnets are used only occasionally, and beach seines are not used at all on the Nass, despite their reported use in other eulachon fisheries (Ricker et al., 1954; Smith and Saalfied, 1955; MacNair, 1971). Effort has remained concentrated in Fishery Bay (Figure 2 and Table 1). Annual total food catches in 1970-71 were in the order of 135 to 180 metric tons, a third of the Nass catch reported for 1940 (Larkin and Ricker, 1964). Catches to 1974 have remained constant or slightly increased to those of 1970-71; L.J. Gray (pers. comm.) estimated annual catches of 180 to 225 metric tons. Catches in 1975 were lower, due to early break-up (W. MacKenzie, Upper Nass Fishery Officer, pers. comm.). Catches are consumed or traded locally as fresh fish, as dried and smoked fish, or as rendered oil. MacNair (1971) has described the present-day rendering process. The oil remains in high demand among coastal natives. In 1975, one gallon could be traded for the equivalent of $40 in other goods (W. MacKenzie, pers. comm.).

C. Log Drive Operations:

Log driving began on the Nass River in 1962, and rapidly intensified. The quantity of logs released annually has averaged 275,000 cunits since 1967 (Columbia Cellulose, Canadian Cellulose representatives, pers. comm.):

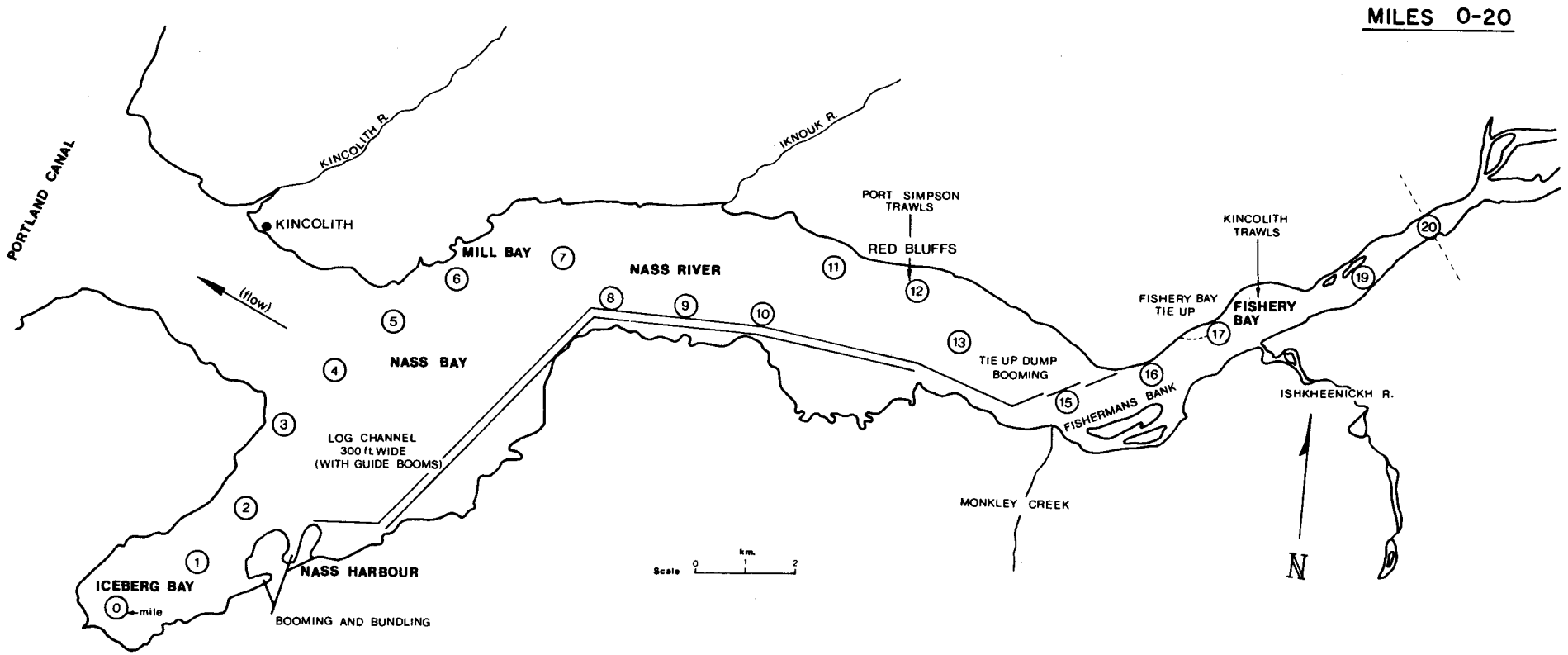
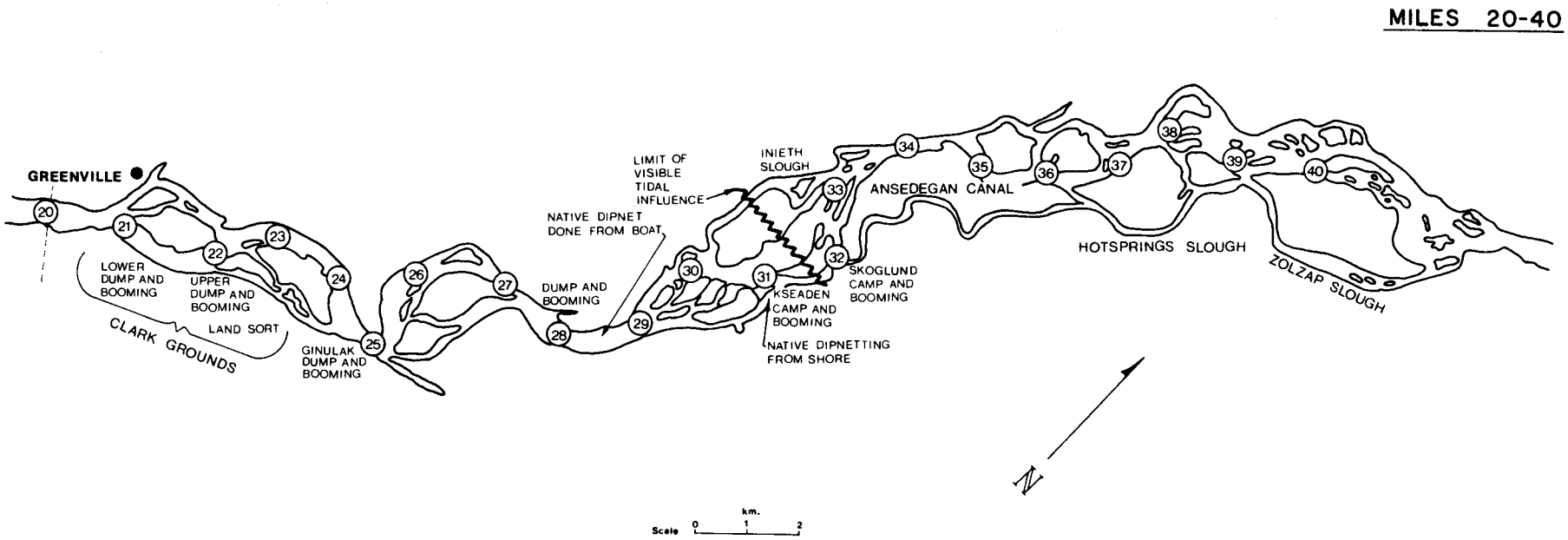


Figure 2: Log drive facilities and distribution of native fishing in 1970-1971. Circled numbers indicate miles from Iceberg Bay.



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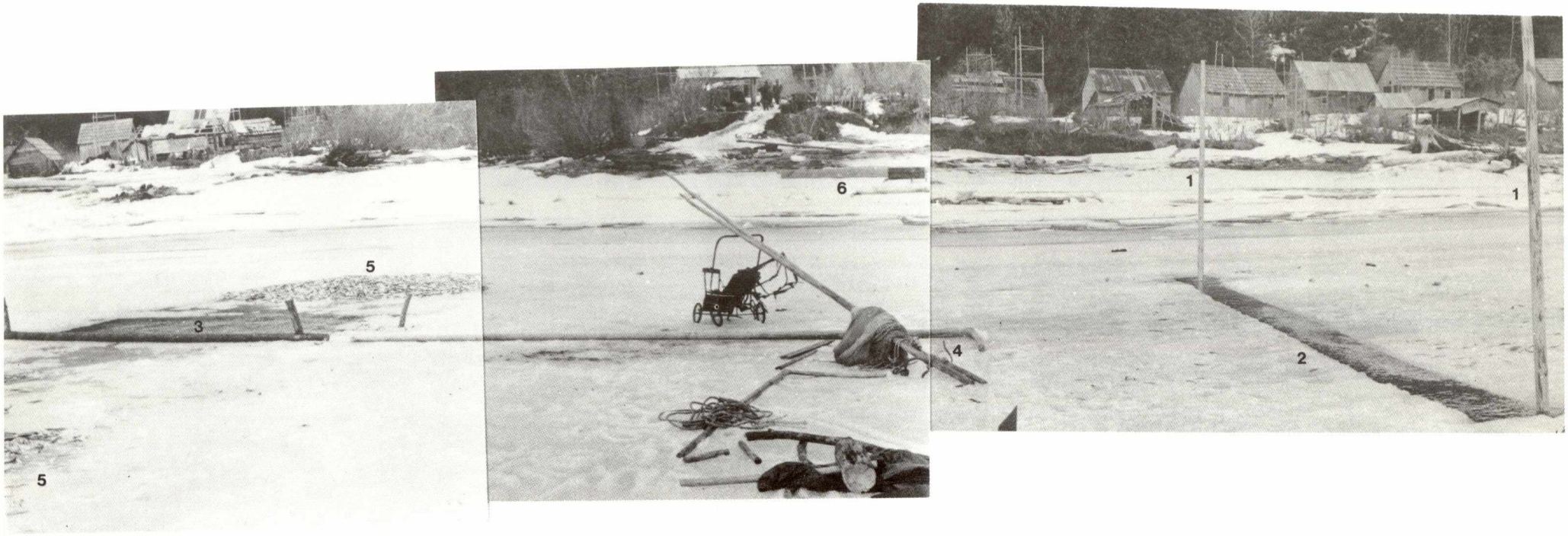

Figure 3: Composite photograph of stationary trawl set through the ice at Fishery Bay (Mile 18) in 1969. The trawl's mouth is held open by two poles (1) which are forced into the sandy bottom through the slit (2) which is at a right angle to shore. A second hole (3) is cut downstream, above the cod end of the trawl. The cod end is lifted with special poles (4), and the catch emptied onto the ice (5). From there, the catch is transported to a stockpile (6). Smokehouses and drying racks can be seen in the village.

Figure 4: Native fishermen releasing catch from cod end of Fishery Bay trawl.

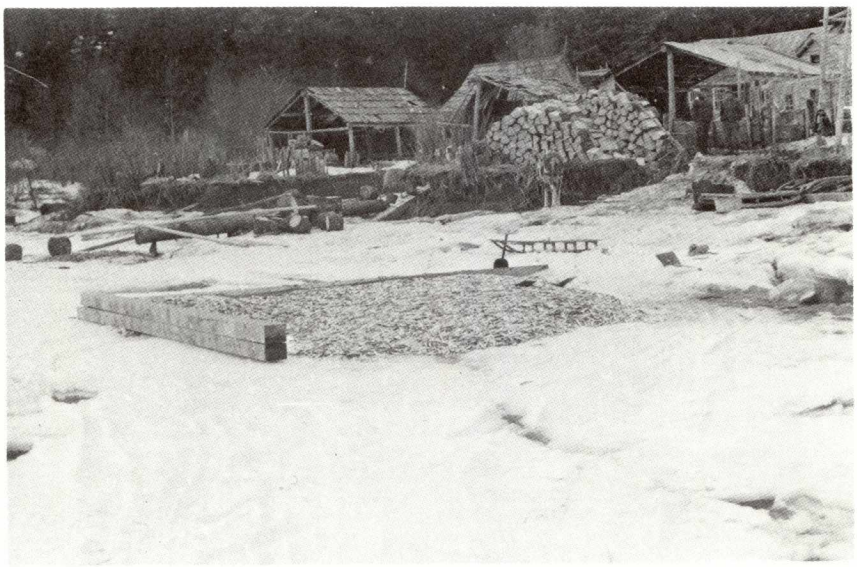

Figure 5: Catch stockpiled on edge of ice near village. Note smokehouses and firewood stacked in background.

Figure 6: Fishery Bay stationary trawl tended by boat in 1970. Trawl set poles and herring skiff used to hold catch are on the left.

Figure 7: Major log accumulations at Mile 32. Note river tugboat nearing at lower end of accumulation. One-third of the accumulation had been removed at this time (Photo from Boyd and McIndoe, 1968).

TABLE 1: Fishing effort and daily catch of the 1971 native fishery.

Date	Number of Fishermen	Number and Type of Gear	Approximate Daily Catch
Mar. 18	5	1 trawl	nil
22	5	1 trawl	100 lbs.
23	11	3 trawls	100-1,000 lbs.
25	12	3 trawls	100-1,000 lbs.
27	25	7 trawls 5 dipnets	10,000-20,000 lbs.
28	30	7 trawls 10 dipnets 1 gillnet	approx. 60,000 lbs.
29	10	1 trawl 3 dipnets	1,000-2,000 lbs.
31	10	2 trawls 3 dipnets	1,000-2,000 lbs.
Apr. 2	12	4 trawls	6,000-12,000 lbs.
3	10	3 trawls	10,000-20,000 lbs.
4	10	3 trawls 4 dipnets	approx. 20,000 lbs.
5	30	5 trawls	20,000-60,000 lbs.
6	18	3 trawls	approx. 40,000 lbs.

TABLE 2: Cunits of logs driven annually on the Nass River (Columbia Cellulose and Canadian Cellulose companies, pers. comm.).

1967 - 152,000	1972 - 268,000
1968 - 303,000	1973 - 336,000
1969 - 363,000	1974 - 280,000
1970 - 201,000	1975 - 280,000
1971 - 274,000	

Present Nass River log drive operations proceed in the following manner: logs from winter cutting are stacked above high water ('cold decked') in designated stacking areas along the mainstream, or are transported and held above high water at permanent dumping sites (Figure 2). Loose logs are dumped from cold decks or directly from summer cutting ('hot dumping') at these dumpsites between April 1 and October 31. Numerous fin booms are used to guide the logs to Iceberg Bay (Mile 0) for sorting and bundling. Logs are dumped in bundles and released in booms only at Ginluluk and only during the spring and fall freshets. Stranded logs are removed from the river and generally stacked below high water during low water periods (October 1 to March 31). Blasting of obstructions in the river is restricted to low water periods. Blasting in water depths greater than 46mm is by approval of fishery officer, and only after November 1. No blasting is allowed below Mile 32 during March, with the exact dates to be set by fishery officer according to the presence of eulachon adults, eggs, or larvae.

The incidence of log stranding in the Nass River was examined in 1968 by Fisheries Service staff. They estimated (Table 3) that 60 percent of the jams were below Canyon City (Mile 45) (Figure 2). The 1968 log recovery rate from dumpsite to Iceberg Bay was estimated by Columbia Cellulose to be only 10 percent, and that 300,000 to 600,000 logs were stranded at the time of the Fisheries inspection. An example of a major accumulation is presented in Figure 7. Marked improvements in incidence of stranding and in removal of accumulations have since been made by the company, particularly after the British Columbia Forest Service implemented pre-water scaling.

Table 3: Distribution and relative size of log accumulations in the Nass River (after Boyd and McIndoe, 1968).

Locations	Mileage	Distance in Miles	Number of Log Accum. observed		Remarks
			Minor (0-1000)	Major (1000+ logs)	
Monkley Pier to Canyon City	14 - 45	31	34	19	New and old logs
Canyon City to Aiyansh	45 - 53	8	10	7	Predom'ly new logs
Aiyansh to Kinskuch	53 - 75	22	1	0	Canyon
Kinskuch to Kinley	75 - 96	21	11	5	Predom'ly new logs
Kinley to Meziadin	96 - 120	24	0	0	Natural accuml'ts few-small
TOTALS		106	56	31	

II. METHODS

A. 1969:

From March 20 to March 25, a preliminary survey was made to:

1) inspect the native fishery;
2) define limits of spawning, and
3) establish sampling methods for succeeding programs.

Liaison with native fishermen helped to define spawning limits and to develop methods of eulachon capture. Also, 125 fish were obtained from fishermen operating in Fishery Bay, and preserved for later analysis of fork lengths, otolith ages, and sex ratio.

Several side channels below Mile 32 were checked for presence of eulachon spawners, dissolved oxygen and pH levels, and gravel quality. Five creeks below Mile 31 were also checked for the presence of spawners. The river was mainly covered by ice during the survey.

B. 1970:

From March 18 to March 27, a nylon gillnet (9.1m x 2.4m, 3cm stretch mesh) was used for test fishing between Miles 9 and 35. Set times were no more than 24 h and averaged 4.5 h. The net was set from a boat and as close to perpendicular with the current as possible. A total of 597 fish were preserved in 10 percent formaldehyde and sampled for sex, spawning condition (i.e., unspawned, partially spawned, or spawned out), and measured for standard length (distance from the most anterior part of the head to the posterior margin of the last whole vertebral centrum). In addition, 298 fish were aged by scale and/or otolith method. Of these, 170 fish were aged by both methods to compare aging methods.

From March 21 to March 24, a fine-mesh dipnet (4.3m aluminum handle, 46mm square mouth, 1mm diameter mesh openings[1]) was used to sample egg deposition at 18 transects between Miles 15 and 35. One-meter sweeps were made, usually from a boat near each bank and in midstream at each transect. Numbers of live and dead eggs and the substrate type were recorded for each sweep.

During the field study, there was intermittent sampling of surface water temperatures with pocket thermometers, suspended solids with a U.S.D.H. 48, and river velocities with a Gurley Flowmeter. The river was ice-free during the 1970 study.

C. 1971

The same gillnets used in 1970 were used to sample the eulachon migration from March 19 to April 6 between Miles 0 and 35. In the period March 20-30, heavy ice flows below Mile 18 made gillnetting difficult, so a trawl net (60cm diameter opening) was used in the sampling. In the upstream reaches, solid ice cover prevented the setting of gillnets until late in the study period. The trawl was towed 12m behind a boat at 4-6km/hr., at a depth of about 1.5m.

A Ross Model 200A echo sounder was used from March 19 to April 6, at transects established at Miles 3, 18, 20, and 25. Transect crossings were made at various times and tides. Where possible, a dipnet was used to sample targets.

From April 6 to April 8, egg samples were collected at 86 transects between Miles 14 and 35. The dipnet used in 1971 was smaller (20cm triangular mouth) and longer (5.5m handle) than in 1970, and was much easier to handle. Samples were taken as in 1970, with approximately $0.2m^2$ of substrate being swept for each sample.

A Ryan thermograph was installed at Mile 32 from March 14 to April 3.

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[1]No. 1400 'Marquisette' netting.

III. RESULTS AND DISCUSSION

A. Timing

1. Adult Migration. In 1881, J.G. Swan, from discussion with local traders, set the timing of the Nass River eulachon run to be generally the second to third week in March, lasting in exceptional years into the first week of April. There apparently also was a second, poorer-quality run towards the end of June. Further, Swan noted accumulations of predators when the runs began (p.260):

> ....Porpoises, seals, dog-fish, ground-sharks, and halibut harass them in the strait, and if they rise to the surface, they are attacked by clouds of gulls [see Figure 81, ducks, and other sea fowl.

Similar concentrations of predators were noted during the 1971 study. Seals were noted upstream of Mile 28, in excess of 300 bald eagles were seen between Miles 12 and 30, and thousands of gulls were present between Miles 12 and 28.

Using various indices for the timing of the Nass eulachon run in 1971 (Tables 1 and 4), Swan's observations are confirmed. The run began in the third week of March and peaked in the fourth week of March. Native fishermen believe that there are at least two spawning waves. Heavy catches of unspawned fish in the first week of April (Table 1) indicate a second wave of migration. There may also be a late June run, although it is not exploited by the native fishery. Fisheries Service test-fishing for salmon during June and July at Monkley occasionally produces small catches of eulachon (R. Dickson, pers. comm.). L.J. Gray (pers. comm.) estimated that the Nass eulachon run arrived in late March of 1973, and near March 9 (but did not peak until near the end of March) in 1974.

The time that the run begins in the Nass River appears to be dependent upon the severity of the winter. Migration appeared to have

Figure 8: Flock of seagulls feeding on eulachons at the mouth of the Ishkheenickh River in March of 1970 Mile 17.5).

TABLE 4: Indices of timing of Nass eulachon migration, 1971.

Date	Average Fish/Gillnet-hr. (Location, No. of Sets)	Average Fish/5-min. Trawl Location, No. of Tows)	Max. Tide Ht. in m.	Observations of Predators
Mar. 19	0 (mi 14-2 sets)	-	5.5	Gulls appeared at Mi 12; feeding dives.
20	-	-	4.3	No. of gulls increased 1000x.
22	-	-	5.2	Seals appeared in river.
23	0 (Mi 14-1 set)	-	5.8	7 seals between Mi 12-14.
	23 (Mi 18-1 set)			
24	16 (Mi 18-1 set)	-	6.4	
25	3 (Mi 18-2 sets)	27 (Mi 18-1 tow)	6.7	
28	-	32 (Mi 18-7 tows)	7.3	
29	-	0 (Mi 6-4 tows)	7.0	Many groups of 6-10 sea lions at Mi 6.
		0 (Mi 12-2 tows)		
		4 (Mi 14-4 tows)		
		16 (Mi 18-2 tows)		
30	-	97 (Mi 18-3 tows)	6.7	
		12 (Mi 20-3 tows)		
31	-	6 (Mi 18-4 tows)	6.4	Gull activity lower at Mi 17, higher at Mi 14.
		37 (Mi 12-1 tows)		
		10 (Mi 14-4 tows)		
Mar. 31-Apr. 1	1 (Mi 31-3 sets)			
Apr. 2	0 (Mi 20-1 set)	0 (Mi 25-4 tows)	5.5	
3	<1 (Mi 31-1 set)	0 (Mi 20-4 tows)	5.2	Gull activity down from Apr. 2.
		14 (Mi 25-4 tows)		
5	-	-	5.2	Heavy gull activity at Mi 12-18.
7	57 (Mi 28-1 set)	-		
Apparent Peak:	Mar. 23	Mar. 30	Mar. 28	Mar. 29

been stalled for a week after the abnormally bad winter of 1970-71 (see weather records in Table 5). Eulachons were not caught until March 23 in 1971. In 1970, eulachons already were concentrated in the lower reaches of the Nass when sampling began on March 18.

Timing of migration has been suggested to depend on water temperature. Ricker et al (1954) found a statistically significant relation between the timing of Fraser River eulachon catches and Fraser River water temperatures; for each mean 0.6 degree over 5°C that the Fraser was during the March 20 - April 10 period, the migration was advanced by about a day. Smith and Saalfield (1955) found that upstream movement of Columbia River eulachon did not occur until water temperatures exceeded 4°C. In contrast, 1971 temperature records from the Nass indicated that peak migration was occurring at temperatures as low as 0 - 1°C (Table 6). It was also noted that, despite warmer temperatures in the Fraser River, the Fraser run arrives almost a month after the Nass and Skeena runs. This would tend to discredit the theory that timing of migration is largely dependent on river water temperatures of 4 - 5°C. It is possible that it is the difference between the sea and river temperatures that is critical. Adult eulachon acclimated to 5 and 10°C began to suffer mortality at 11 and 18°C respectively (Biahm and McConnell, 1971). No studies have been done on the eulachon's resistance to temperatures colder than acclimation, but juvenile salmon acclimated to 5°C die when exposed to 0°C water (Brett, 1952).

The Nass run also generally arrives at a time when river discharge is near its annual minimum, but this is not the case for the Fraser (Figure 9).

Once in the river, eulachon movement upriver appeared to be dependent on tides. This could have been deduced solely from the native catch method of a stationary trawl fished on ebb tides, but echo sounding and test fishing done in 1971 also indicated that

TABLE 5: Selected weather data from nearest weather stations to Nass Drainage for 1969 through 1971.

(Meteorological Branch, 1970, 1971, 1972)

Characteristic	Month	1969 (Terrace)	1970 (Terrace)	1971 (Terrace)	1971 (Aiyansh)
Monthly	Jan.	-15	-5	-6	-6
Mean	Feb.	-2	+3	-2	-4
Temperature (^{o}C)	Mar.	+2	+4	0	-1
Total winter snowfall (cm.) at Aiyansh		149	171		274

TABLE 6: Temperatures and suspended solids noted during eulachon runs, 1970 and 1971.

Date	1970 (Hand) °C	1970 (Hand) ppm S.S.	1971 (Ryan) °C min.	1971 (Ryan) °C mean	1971 (Ryan) °C max.
Mar. 14			0.5	1.0	1.5
15			0.5	0.8	1.0
16			0.5	0.8	1.0
17			0.5	0.8	1.0
18	2	9	0.0	0.3	0.5
19	2.5	50	0.0	0.5	1.0
20	4-5	43	0.0	0.5	1.0
21		19	0.5	0.8	1.0
22			0.0	0.3	0.5
23	2	9	0.0	0.3	0.5
24	3		1.0	1.0	1.0
25	3	24	1.0	1.0	1.0
26			1.5	1.8	2.0
27			1.5	1.5	1.5
28		16	1.5	1.5	1.5
29			2.0	2.0	2.0
30			1.0	1.5	2.0
31			1.0	1.3	1.5
Apr. 1			1.0	1.0	1.0
2			1.5	2.3	3.0
3			1.5	1.8	2.0

[a] Boxed-in period is at estimated peak migration of eulachons in 1971.

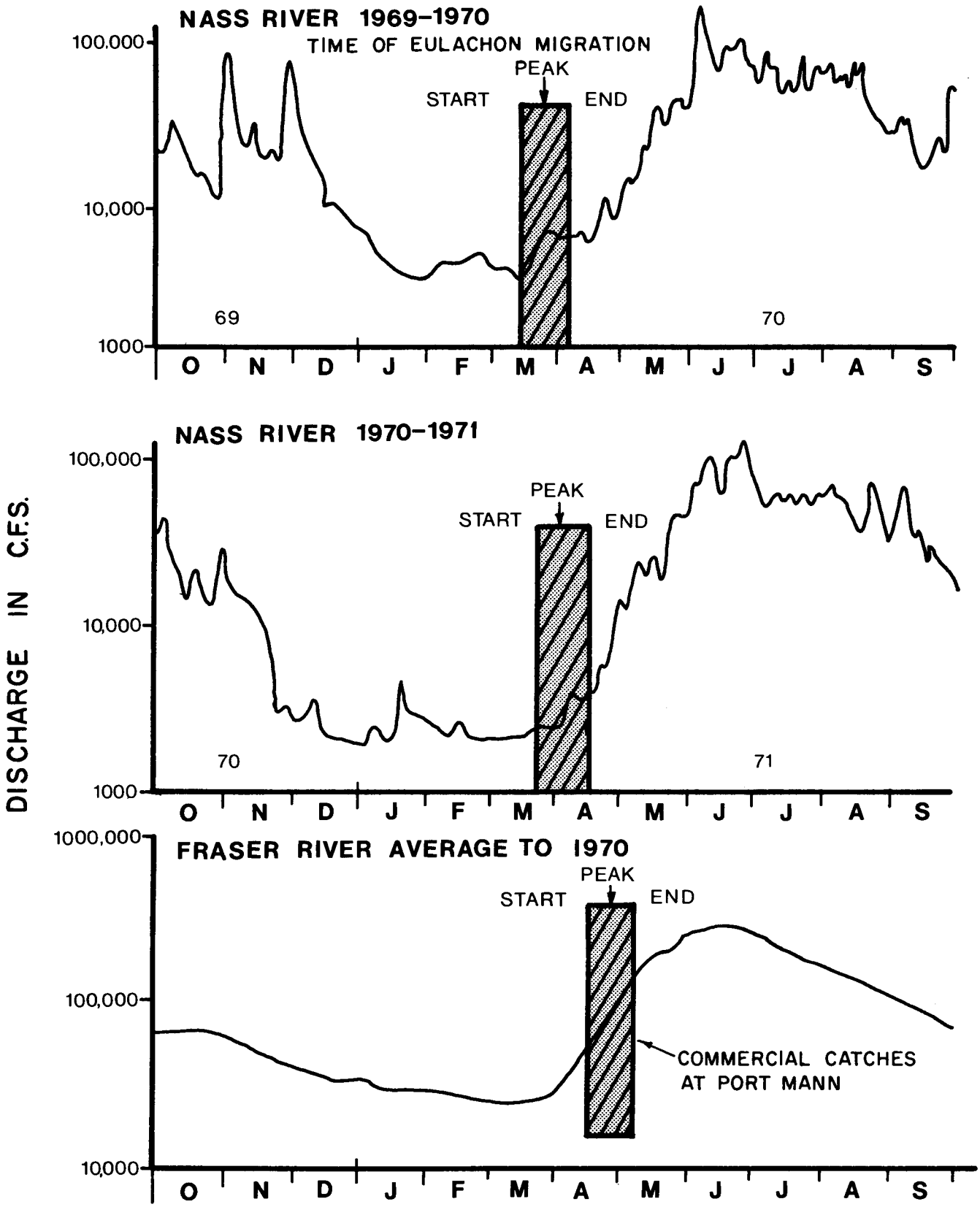

Figure 9: Nass and Fraser River hydrographs (data from Water Survey of Canada), compared to eulachon migration times.

approximate weekly and daily peaks of abundance could be forecast from the height and timing of the high tides (Table 4).

Eulachons are probably relatively poor swimmers. Atlantic herring (Clupea Harengus) is the species most similar ecologically to eulachon that has been studied as to performance (Boyar, 1961). Boyar's calculations show that herring have maximum speed to length ratios of 6 to 9, which is less than the 10 which has been used as a general ratio for other species. It is likely that eulachon performance would be even poorer than that of herring, as the herring's body is deeper and presumably more muscular. This may be why the Nass River eulachon migration is timed so as to coincide with minimum river discharge and maximum flood tides.

2. Spawning

Marked fluctuations in the numbers of spawned-out fish caught in test fishing in 1970 and 1971 reinforce the belief that the run occurs in two and possibly three waves (Table 7). It would appear that, in 1970, there was a wave ending March 22, with a second wave thereafter. In 1971, sampling did not begin until March 25, but it would appear that there was an influx of fresh spawners at the start of April (Table 4).

3. Incubation

Smith and Saalfield (1955) determined that Columbia River eulachon eggs require 380 degree (fahrenheit)-days to hatch. Intermittent measurements of Nass River temperatures made by the Inland Waters Directorate indicate that 45-50^{o}F is common from the third week of April and throughout May. If Nass River eulachon have thermal requirements for incubation that are similar to those of the Columbia River stock, Nass River incubation would take 30-40 days, or to the middle of May. This is longer than the 14-21 days that has been generally assumed by Scott and Crossman (1973).

TABLE 7: Spawning condition of eulachons at various times and locales on the Nass River, 1970 and 1971.

Year	Date	Mile	(As Percent of No.) Unspawned	Partial	Spawned	No.
1970	Mar. 17	13	12	5	83	42
	Mar. 17	28	22	5	73	23
	Mar. 19	31	0	0	100	3
	Mar. 22	35	6	0	94	17
	Mar. 25	14	16	62	22	32
	Mar. 25	31	16	75	9	92
1971	Mar. 25	18	43	0	57	49
	Mar. 28	17	67	0	33	18
	Mar. 28	18	37	0	63	52
	Mar. 29	12	5	0	95	19
	Mar. 29	14	6	0	94	18
	Mar. 29	18	9	0	91	54
	Mar. 30	20	14	3	83	36
	Mar. 31	6-12	5	0	95	87
	Mar. 31	14	24	0	76	45
	Apr. 1	35	0	0	100	34
	Apr. 3	26-28	36	0	64	25

4. Fry Migration

Both McHugh (1940) and Smith and Saalfield (1955) noted that newly-hatched eulachon larvae were very feeble swimmers and probably were swept out of their nursery river within days of hatching. This is assumed to hold for the Nass River as well.

B. Distribution and Relative Abundances

1. Upriver

Observations and discussion with native fishermen in 1969 indicated that eulachons were not present above Mile 32, which is the maximum upstream limit of visible tidal influence. Test fishing and egg deposition surveys in 1970 and 1971 confirmed that spawning stopped at Mile 32 (Tables 4, 8; Figure 10). Fraser River eulachons similarly have been noted to extend only to the limit of tidal influence (McHugh, 1940).

Egg sampling was more successful in 1971 than in 1970 due to improvements in dipnet design; conclusions regarding variations in egg density within Miles 14 to 32 are therefore drawn from 1971 data only (Figure 10). The area of heaviest spawn occurred in a riffle area above Ginlulak (Mile 25) and in a large pool at and downstream of the Ginlulak dumpsite (eggs were found here in layers up to 3cm thick). Egg sampling was discontinued at Mile 14, but minor spawning may occur downstream to continuous salt water influence (Mile 11), as partially-spawned fish were often caught in dipnets below Mile 14. None of the tributaries or sidechannels examined in 1969 had eulachons present. It was found that the sidechannels averaged 5-7ppm dissolved oxygen at 38-40^{o}F, or only 40-55 percent saturation. These low values probably reflect a high level of terrestrial organic input. Eulachons were noted to congregate off the mouths of the Ishkeenickh River (Mile 18) in 1970 and 1971 and Monkley Creek (Mile 15) in 1971, but the tributaries themselves were not utilized.

TABLE 8: Gillnet catches of eulachons at varying times and locales in 1970.

Date (March)	Location (Mile)	Size of Catch	No. of Sets
18	13	Many	1
	14	Few	2
	17	Few	1
	26	Few	1
	28	None	1
	30	None	1
	31	None	1
19	13	Many	1
	17	Few	4
	26	Few-None	3
	30	None	1
	31	Few	1
20	9	Many	3
	13	Many	1
	15	Many	4
	17	None	1
	18	Many	2
	21	Few	1
	26	Many	1
	31	Many	1
21	30	Many	1
22	30	Few	1
23	31	Many	1
	33	None	1
	34	None	1
	35	None	1
24	14	Many	3
25	13	Many	2
26	31	Many	1
27	13	Many	2
	31	Few	1
	32	Many	1

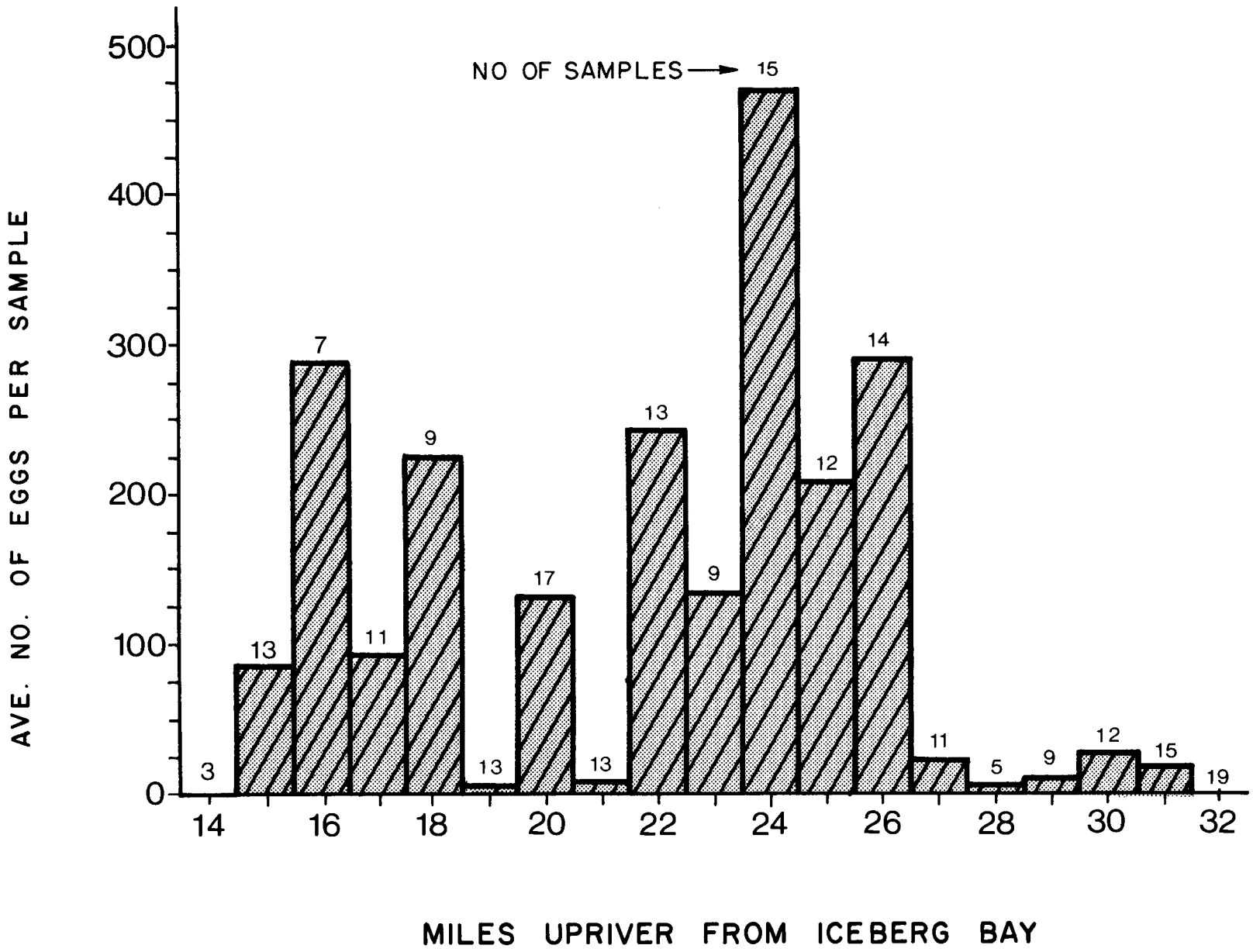

Figure 10: Variations in egg density with distance upriver in 1971.

2. Within Cross-section

The horizontal distributions of echo targets at flood and ebb tides in 1971 (Figures 11 and 12) indicate that migrants avoid the major channels, preferring instead the less rapid flows over submerged bars and near the riverbanks. Vertical target distributions showed near-surface concentrations during flood tides and scattering at ebb tides (Table 9) during the day; this may be the result of avoidance of an intruding salt wedge at flood tide. The one transect made at night showed target concentrations near the bottom, despite it being a flood tide. It is possible that this behavior is indicative of active spawning (see following discussion of substrate preferences).

Egg deposition varied horizontally to a considerable degree. Grouping of collection sites into either 'stream' or 'bank' categories reveals statistically significant accumulations in midstream areas (Figure 13). Egg deposition also varied significantly with depth; eggs generally were more abundant in greater than four meters of water depth than in shallower areas (Figure 14), but eggs were found in water depths of as shallow as 5cm at low tide at Mile 26.5. It should be noted that the values given in this study for water depth are quite inaccurate, in that depth varied considerably with tide in the lower reaches of the Nass River.

3. With Substrate

Eggs were highly concentrated on sand (Table 10). This is in accord with the previous observations of Swan (1880) and McHugh (1940) on the Nass and Fraser Rivers, but does not agree with Smith and Saalfield (1955)--Columbia River eulachon eggs were found primarily on pea-sized gravel and only secondarily on coarse sand.

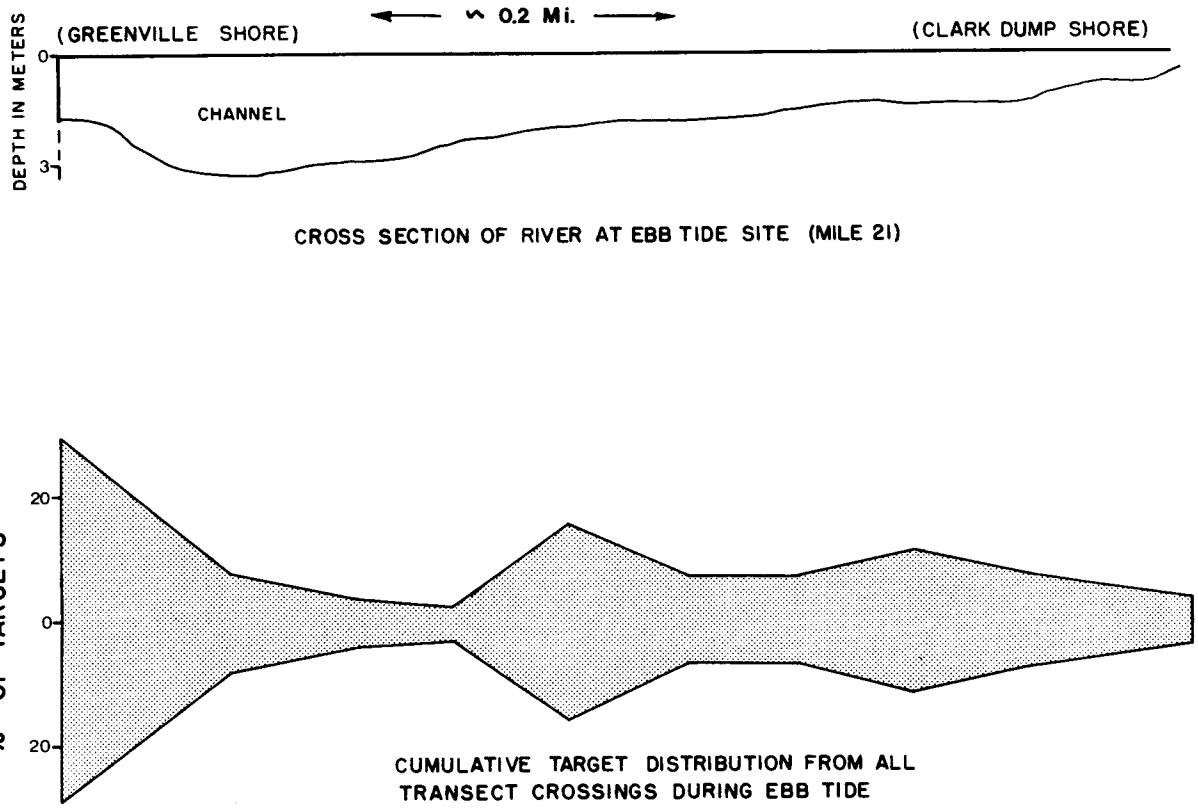

Figure 11: Horizontal distribution of echo targets at ebb tides in 1971 at Mile 20 (above).

Figure 12: Horizontal distribution of echo targets at flood tides in 1971 at Mile 18 (below).

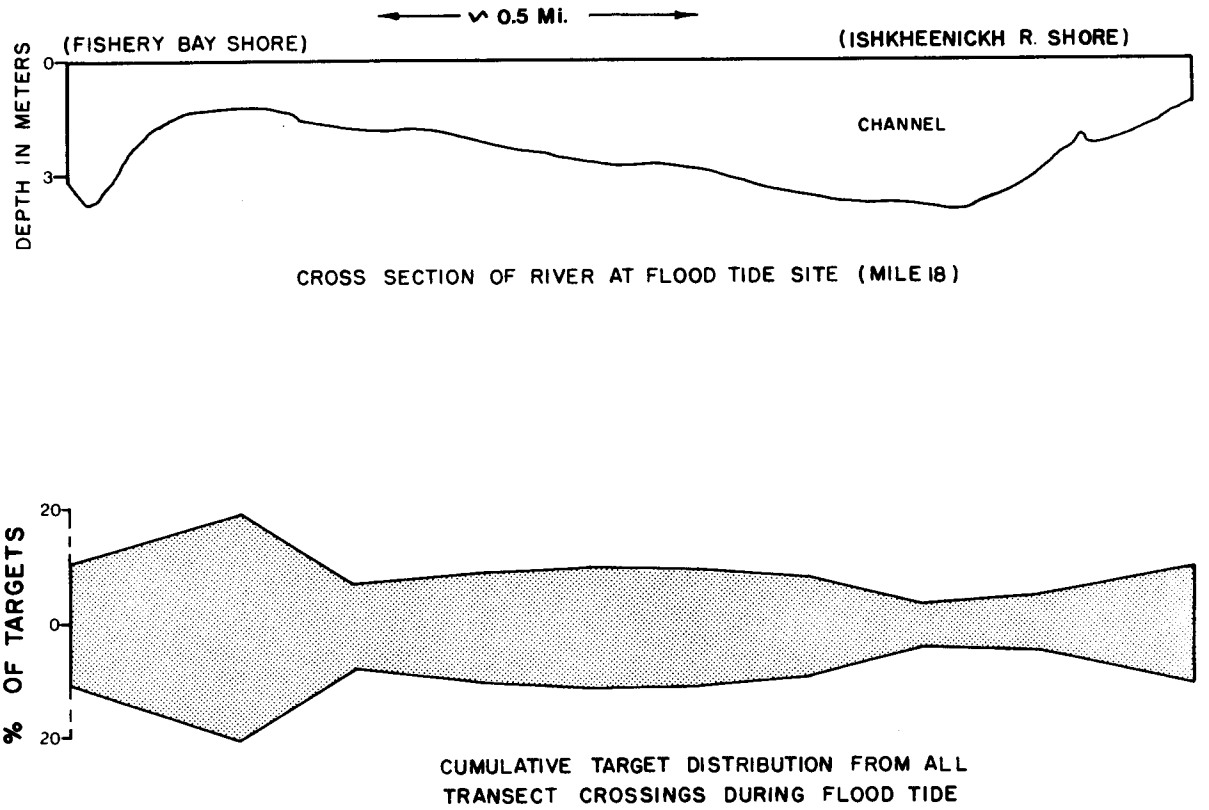

TABLE 9: Example of change in vertical distribution of targets with tide. Taken from 9 transects near Mile 18, from 1454 to 1547 hrs. (flood) and 1733 to 1757 hrs. (ebb), March 29, 1971.

Transect #	Tide	Estimated % of Targets in Water Column	
		Bottom Half	Top Half
1	Flood	20	80
2	Flood	20	80
3	Flood	10	90
Flood Average:		15	85
4	Ebb	30	70
5	Ebb	60	40
6	Ebb	20	80
7	Ebb	50	50
8	Ebb	80	20
9	Ebb	50	50
Ebb Average:		50	50

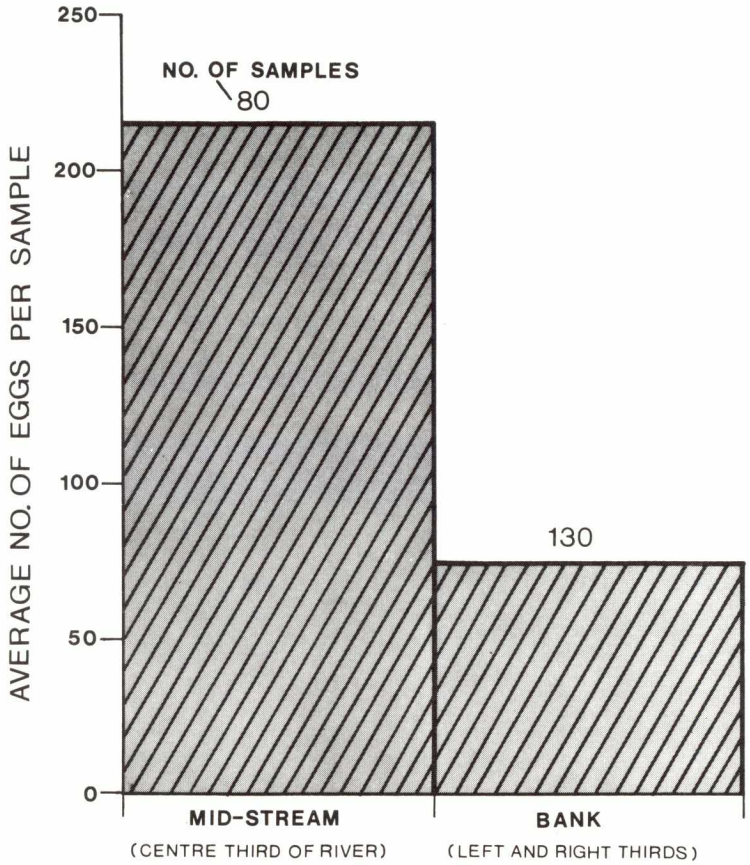

Figure 13: Variation in 1971 egg deposition with location in cross-section.

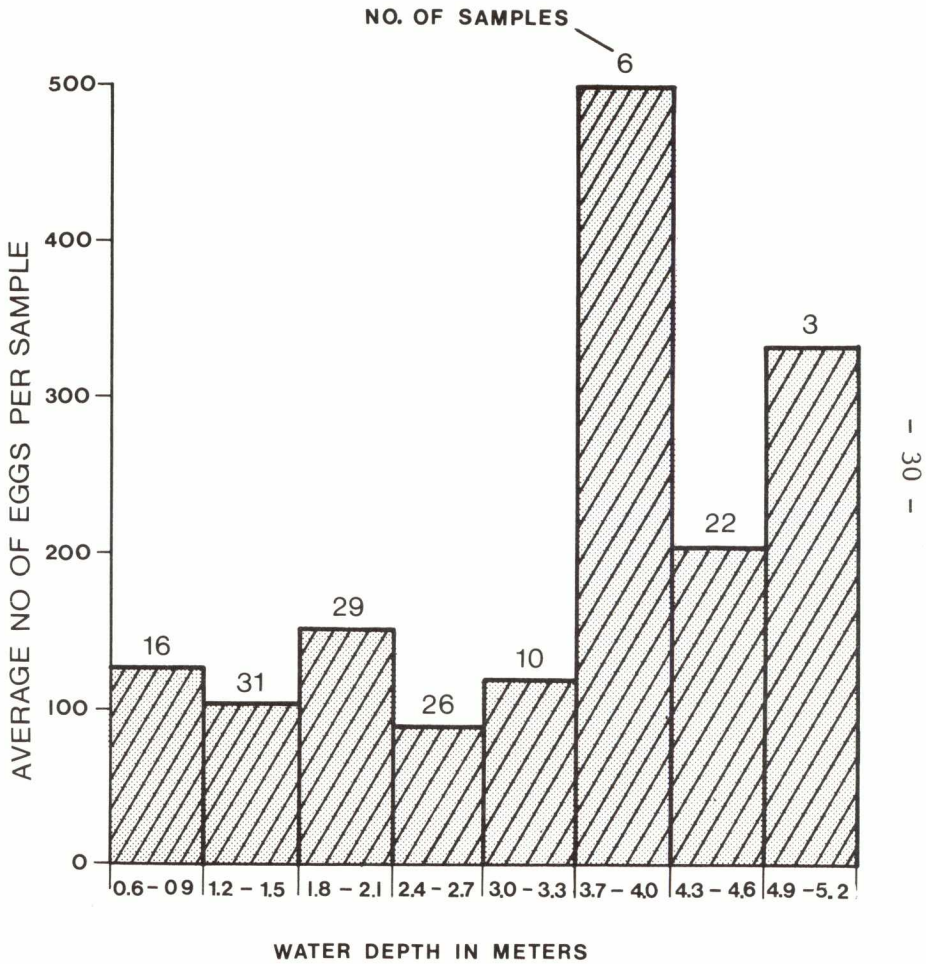

Figure 14: Variation in 1971 egg deposition with depth. (Water depths greater than 5.2m could not be sampled, but few areas were that deep.)

TABLE 10: Variation in 1970 and 1971 egg depositions with substrate.

		Substrate			
		Silt	Sand	Gravel	Organic
1970	Live Eggs	0	34	15	8
	Dead Eggs	0	14	11	4
	Total Eggs	0	48	36	12
	% Dead	0	29	31	33
1971	Live Eggs	46	28,188	338	108
	Dead Eggs	49	17	26	26
	Total Eggs	95	28,205	364	134
	% Dead	52	<1	7	26
	No. of Samples	19	92	61	29
	Eggs/Sample	5	307	6	5

It should be emphasized that the spawning act has never been documented[1], and that the substrate preferences of spawning adults may be very different from those assumed from egg sampling. It is possible that eulachons broadcast spawn without regard to substrate, allowing eggs to be carried by the current until contacting the bottom. Smith and Saalfield (1955) felt that spawning occurred at night; if so, it is unlikely that substrate preferences exist during the actual spawning act. Such a theory would account for the large accumulation of eggs that was observed in 1971 in the Ginlulak pool (Mile 24). It was indeed noticed that there were large numbers of eulachons in a riffle 0.4 to 0.8km upstream of the Ginlulak pool. Eggs were found attached to the gravel in this riffle, but not in quantities proportionate to the number of fish present.

It had been attempted in 1971 to determine egg deposition densities with artificial substrate units similar to those used successfully by Rothschild (1961) for American smelt (Osmerus mordax). The units consisted of burlap wrapped around rocks. Nass River eulachon eggs adhered very poorly to the unit. It therefore would appear that the attachment properties of the eggs of these two closely-related species are quite different.

Although substrate may be of little concern to the spawning adult, it is of consequence to the incubating embryo. Egg mortality was far higher in silt than in any other substrate (Table 10). Areas of organic accumulations (i.e., bark, needles) showed elevated

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[1] In recent discussions with Don Croker, a local free-lance photographer and journalist, Mr. Croker outlined his observations of eulachons spawning in a shallow side-channel of the Klinaklini system in March of 1972. Apparently, spawning occurred in a fast, smooth-flowing section below a log jam. The bottom was pan-shaped and covered with a mixture of sand and pea gravel. Fish held in the area until 1400-1500 hrs, when the males moved upstream, and the females grouped below. Milt was released simultaneously by the males, and drifted back to the females, who immediately laid their eggs. The entire act was over very quickly, and the spent fish began to drop downsteam. This behavior is very similar to that of herring (Clupea pallasii) as observed by L.A. Webb (pers. comm.).

mortalities when compared to gravel or sand. Because the eggs were recovered within a few days of spawning, the overall incubation mortality on silted and organic substrates would be expected to be far higher than the present results indicated.

C. Characteristics of Spawners

1. Determination of Sex

Scott and Crossman (1973) list several external dimorphic characteristics for eulachons, including the following. Spawning males have a distinct midlateral ridge, and their head, fins, and scales are tuberculate. Male pelvic and pectoral fins are 17.6 and 15.8 percent, respectively, of standard length, versus 14.3 percent for both fin types in females. Hart and McHugh (1944) noted that Fraser River males were easily distinguished by their greater rigidity, resulting from greater development of body-wall musculature.

These sexual differences were checked for Nass River eulachons, and all characteristics, except the proportions of paired fins, were found to apply. Use of the males' greater rigidity was found to be the most practical method of rapid field separation of sexes. The paired fin proportions as stated by Scott and Crossman (1973) apparently were taken from the Fraser River study of McHugh (1939). A random sample of 88 Nass eulachons from the preserved sample of 1971 did reveal a significant difference in fin proportions with sex (Figure 15); however, Nass fish appear to possess relatively smaller fins than do Fraser fish (Table 11). It is therefore suggested that use of fixed values for paired fin proportions be avoided until annual and geographic variations are more fully examined.

2. Sex Ratio

Sex ratios varied with location, within the duration of the run, and between years in the Nass River (Table 12). With respect to location, the number of males relative to females increases with the distance up the river. This may be purely a result of the more

Figure 15: Sexual dimorphism in Nass River eulachons. Note the relatively longer pectoral and pelvic fins and the papillae along the lateral line of the male (lower photo).

TABLE 11: Pectoral and pelvic fin lengths in relation to standard length of Nass River eulachons.

Characteristic	Sex	No.	% Mean	As Arcsin %	Std. Dev.
Pectoral / Standard Ratio	Male	38	12.7	20.6	0.6
	Female	50	11.8	20.1	0.9
	(T = 3.2; sig. to 0.05 level)				
Pelvic / Standard Ratio	Male	38	13.4	21.5	0.7
	Female	50	11.1	19.5	0.9
	(T = 11.5; sig. to 0.05 level)				

TABLE 12: Sex ratio (males per female), by time and location, 1969-1971. Sample sizes are in parentheses.

Year	Date	Location (Miles) 0-14	15-21	22-28	28-32	Overall
1969	Mar. 20-25	-	0.1	-	-	-
		(0)	(125)	(0)	(0)	-
1970	Mar. 17-25	1.2	-	2.9	114+	3.2
		(120)	(0)	(63)	(114)	(297)
1971	Mar. 23-28	-	0.2	-	-	0.2
		(0)	(256)	(0)	(0)	(256)
	Mar. 29-Apr. 1	0.02	0.2	0.3	4.9	0.8
		(106)	(117)	(36)	(235)	(494)
	Apr. 1-7	-	5.3	24.0	2.7	4.2
		(0)	(57)	(25)	(70)	(152)
	Overall	0.02	0.3	1.2	4.2	0.7
		(106)	(430)	(61)	(305)	(902)

developed musculature in the male allowing better performance. It may also be due to the existence of two separate spawning waves, with a male-dominated wave spawning in the upper reaches of the river. The other wave, composed mainly of females, may spawn in the lower reaches of the river. With respect to timing, the number of males increases as the run progresses. This suggests that, if separate spawning waves exist, the male-dominated wave comes in later than does the female-dominated wave. Regarding annual variations, the male-to-female ratio was higher in 1969 and 1970 than at the same time in 1971. Other observations discussed previously indicate that the 1971 migration had been delayed due to the severity of the winter. If sex-dominated spawning waves exist in the Nass, such a delay would result in the increase in the male-to-female ratio also being delayed in 1971.

Variations in eulachon sex ratios have been noted in other rivers, but variations do not appear to be consistent between systems. Hart and McHugh (1944) note that males are generally more numerous in the Fraser River, but that females predominate at the end of the run. Smith and Saalfield (1955) found males to dominate commercial catches on the Columbia River throughout the season.

3. Age

Of 53 fish taken at Mile 18 in 1969, 83 percent were four-year-olds, 15 percent were three-year-olds, and 2 percent were five-year-olds. The overall age composition in 1970 was similar to that of 1969, save for a greater proportion of three-year-olds (Figure 16A). In 1971, three-year-olds dominated the total sample, and a few two-year-olds were recorded as well (Figure 16B).

Hart and McHugh (1944), utilizing scale aging techniques, found most Fraser spawners to be two-year-olds. Ricker et al (1954) checked this result using both scales and otoliths from Fraser River specimens, and found that otolith ages tended to exceed scale ages by one to three years. However, Nass River scale and otolith ages were found to agree for 92 percent of 170 fish in 1971. Of the 13

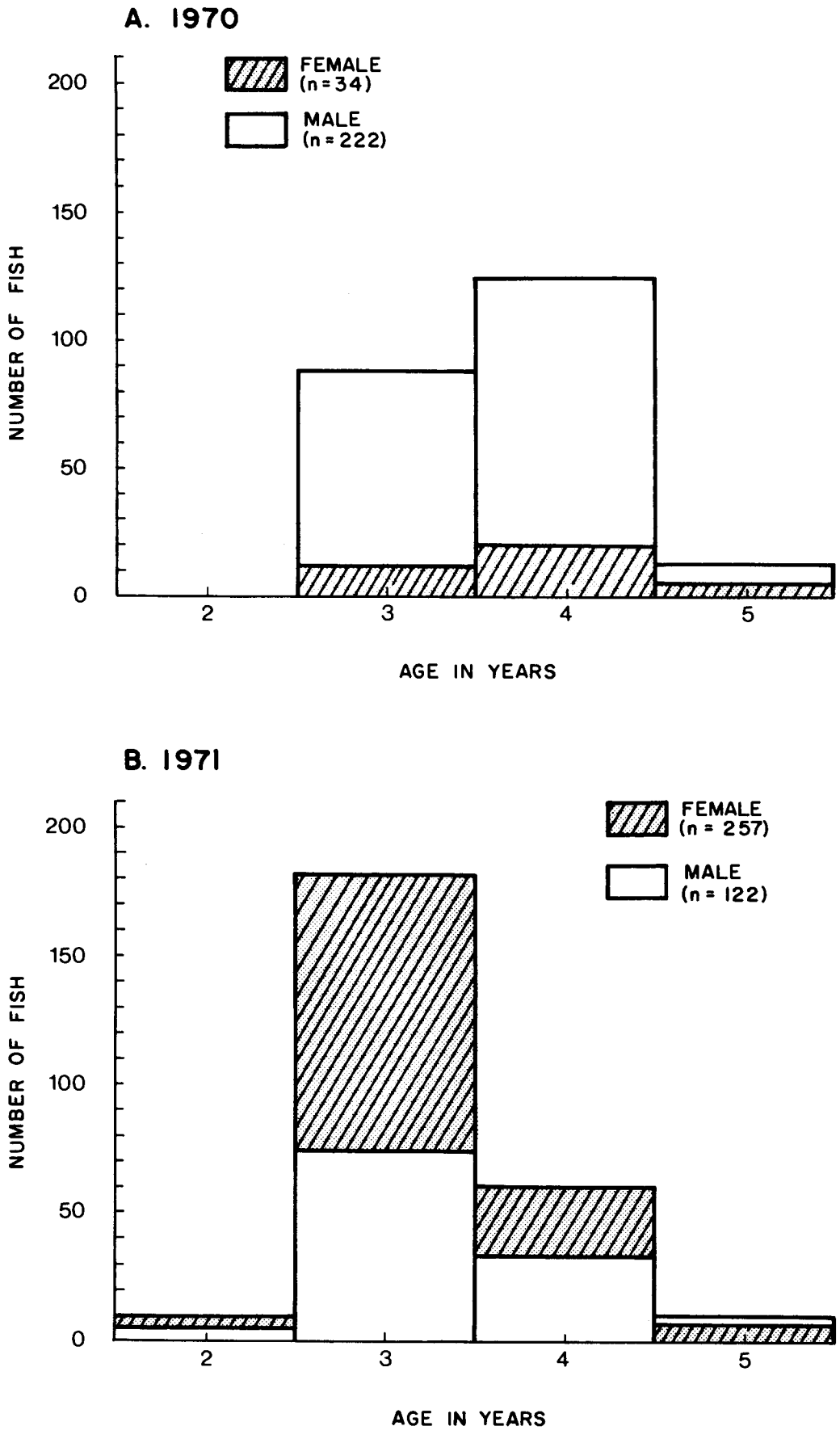

Figure 16: Age composition by sex, of Nass River eulachons in 1970 and 1971.

disagreements, 11 showed otolith ages exceeding scale ages by one year. Smith and Saalfield (1955) found otoliths of Columbia River eulachons generally to show ages of three to four years, with three-year-olds more abundant; two- and five-year-olds were taken, but only occasionally. Fish caught off the northern Washington coast in May were in their third year of life (Smith and Saalfield, 1955). Barraclough (1964) found that gonads of eulachon taken off the B.C. coast did not begin to mature until age 2+. It therefore appears that eulachon spawning runs are generally dominated by three- and four-year-olds (relative proportions of these two age groups seem to be variable), but that minor numbers of both older and younger age groups do participate in spawning runs.

Since no spawning checks were noted on any scales from the Nass River, repeat spawning is probably minor or non-existent on the Nass. This agrees with observation from other areas (Barraclough, 1964).

Separation of the 1970 and 1971 Nass River samples by sex did not reveal any marked variation in age compositions with sex (Figure 16A,B).

4. Length

The mean lengths of Nass River eulachons of age groups 3 to 5 did not vary significantly with sex (Table 13). Age 2 males were significantly larger[1] than age 2 females; the biological significance of this is unknown. The 1970-71 average standard length for age 2 was 148mm; for age 3, 164mm; for age 4, 176mm; and for age 5, 188mm. As older fish are invariably larger, no statistical test was made of these results.

The overall mean length for all age groups in 1970 was significantly larger than in 1971. This reduction occurred over all age

[1]Student's t-test at p = 0.05.

TABLE 13: Variation in standard lengths (mm) of Nass eulachons according to sex, age, and sample year.

		MALE			FEMALE			OVERALL	
Age	Year	Mean	Std.Dev.	No.	Mean	Std.Dev.	No.	Mean	No.
2	1970	-	-	-	-	-	-	-	0
	1971	155	10.9	5	144	6.9	9	148	14
3	1970	173	11.3	87	171	16.2	11	173	98
	1971	167	52.3	74	157	16.2	183	160	257
4	1970	179	11.2	123	181	11.8	19	179	142
	1971	174	10.2	33	171	10.3	60	172	93
5	1970	188	6.1	12	192	3.5	4	189	16
	1971	188	19.8	7	183	11.3	7	186	14
Overall	1969	-	-	-	-	-	-	161[a]	(125-192)[b]
	1970	-	-	-	-	-	-	177	(140-207)
	1971	-	-	-	-	-	-	165	(112-226)
	Total	175	-	341	163	-	292	168	747

[a] No. = 113 fish

[b] Range

groups, and is amplified by the appearance of two-year-olds in 1971. This annual variation of length could also be the result of variations in gear types, capture locations, and/or capture timing. Table 14 summarizes variations over just the 1971 study period; the results are conflicting and could indicate interaction between two or more factors.

Overall mean lengths for all age groups for each study year ranged from 161 to 177mm (three-year average 168mm). This is comparable to the average of 150-180mm noted for Fraser River runs (Hart and McHugh, 1944), and to the Columbia River average of 175mm (Smith and Saalfield, 1955).

The largest fish taken on the Nass was 226mm. This is smaller than the record maximum of 305mm (Hart and McHugh, 1944), but larger than the usual maximum of 205mm (Scott and Crossman, 1973).

D. Implications of Findings With Respect to Log Drive Activities

Three minor impacts were identified during this study, and immediate actions were taken to modify log drive procedures to minimize these problems. Catches appear to have remained constant since then, indicating that the measures taken were adequate to maintain the run:

(1) Blasting restrictions have become more stringent. Blasting in water depths greater than 18 inches now require fishery officer approval and are carefully examined as to eulachon presence and requirements from March 1 (migrating adults) to May 15 (incubating eggs) in most years--delays in timing, however, rule out the use of a fixed calendar period.

(2) Restriction of silt and organic inputs from timber-harvest activities, which may reduce eulachon egg survival, are closely monitored by the fishery officer throughout the year. Sample actions for the Nass have included requests to improve dumping ramps, to delimb logs prior to watering, and to remove logging debris from decking areas to above the high water mark. Considerable effort is applied here, due to additional impacts on salmon.

TABLE 14: Variation in standard lengths of Nass eulachons in 1971, according to gear type, location, and date of capture.

GEAR TYPE	LOCATION	DATE	MEAN(mm)	STD.DEV.	N
Gillnet	Mile 0-18	Mar. 23-25	157	11.9	152
Gillnet	" 19-32	Apr. 1-7	168	6.9	104
Trawl	" 0-18	Mar. 25-31	165	13.0	87
Trawl	" 19-32	Mar. 30-Apr. 3	172	14.2	61
Dipnet	" 0-18	Mar. 28	164	10.6	18

(3) Restriction of log accumulations is now a major program carried out each year by CanCel. It was found during the 1970 study that areas with log jams had significantly higher velocities than clear areas, and that the velocities in log jam areas equalled the maximum theoretical burst speed of the average-sized eulachon (Table 15). Although it is unlikely that eulachons would be totally blocked across the river's complete cross-section, log jams could be a hinderance to eulachon migration, especially in view of the cross-section preferences displayed in Figures 12 and 13.

E. Comparison of Nass River Eulachons to Other Runs

In summary, the biology of Nass eulachons is largely similar to that of the more southern stocks that have been studied previously. However, there are several differences worth noting:

1) Adult migration occurs at colder river temperatures than previously recorded, and it is suggested that the difference between river and sea water temperatures cannot be too great (i.e., over $4^{o}C$), or migration will be delayed.

2) Several independent observations suggest that the Nass River run is composed of at least two spawning waves that are markedly different as to timing, location, and sex ratio.

3) Ratios of pectoral and pelvic fins to standard length for Nass fish were smaller than for Fraser Fish.

TABLE 15: Theoretical eulachon swimming velocities as compared to actual water velocities of Nass River.

A. CALCULATION OF EULACHON BUST SPEEDS:

(1) Boyar (1961) gives maximum 30-second busts speed for Atlantic herrings as:

$$9 \times B.\ L.$$

(2) Assuming eulachons have similar capabilities, the 30-second burst speeds are:

Size of Eulachon	S.L. (mm)	Speed (fps)
Largest	226	6.7
Mean	168	5.0
Smallest	112	3.3

B. ACTUAL WATER VELOCITIES (March 25-26, 1970):

	Areas with Log Jams			Without Log Jams			
	Mean	Std.Dev.	No.	Mean	Std.Dev.	No.	Sig.
Surface	4.9fps	1.01	4	2.4fps	1.12	13	p=0.01
Subsurface	4.7	1.12	5	1.9	1.02	12	p=0.01
Range	(2.8-6.3 fps)			(0.4-4.8)			

IV. CONCLUSIONS

The Nass River eulachon run has supported a native fishery for centuries. Concerns were expressed in 1968 by the Nishga Tribe that eulachon stocks were being damaged by log driving. In response, the Fisheries and Marine Service studied the runs from 1969 to 1971.

The biological information collected in this study was of value in itself, in that very little information exists for northern stocks. The run into the Nass River begins mid-March and could extend into mid-April, but generally peaks in late March. Yearly variations in timing of arrival are attributed to the river-sea temperature differential. Variations in predator activity, gillnet catches, and spawning condition and sex ratio in catches indicated that the run is made up of two overlapping spawning waves. Movement upriver appeared to be dependent on the timing and height of flood tides. The upper limit of migration and spawning coincided with the limit of visible tidal influence at Mile 32; peak egg deposition occurred downstream near Mile 24. Within the cross-section, migrants avoided the higher-velocity channels, and normally moved higher in the water column at flood tides. Egg deposition was concentrated in the mainstream, midchannel, below 3.7m in depth, and on sand. Egg mortaility was found to be higher in silt and areas of organic accumulations.

Characteristics of spawners included:

1) Significant sexual variations in occurrence of tubercles, ratios of pectoral and pelvic fins to standard length, and body-wall musculature;

2) Variations in sex ratios with location, timing, and year;

3) Ages of spawners from 2 to 5 years, with three and four-year-olds dominant.

4) Overall standard lengths of 161 to 177mm (maximum 226mm), with significant variations according to age and year, and possibly location, timing, and gear type.

The Nass River run was found to differ from southern runs in earlier timing of migration, and the smaller pectoral- and pelvic-standard length ratios.

Three possible impacts of log driving (blasting of obstructions, silt and organic inputs, and log accumulations) were minimized by immediate actions of local fishery officers, and incorporated in the company's operating plan for the log drive.

An annotated list of the known eulachon references is included with this report.

V. ACKNOWLEDGEMENTS

T. Bird directed the 1969 and 1970 collection programs. M. Brownlee, R. McIndoe, and R. Taylor assisted in data collection. J. Sarrich of Twinriver Timber provided accommodation for the field crews. Fishery Officers W. A. Kent, L. J. Gray, and W. McKenzie gave assistance and information on the native fishery. Some of the photographs of the Fishery Bay stationary trawl (Figures 4 and 5) were obtained from G. Scott. E. Barraclough and D. Croker supplied several of the eulachon references cited in the bibliography. T. Bird, F. Dickson, and C. Graham reviewed the manuscript. A. Donson drafted the figures and the cover illustration.

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Barraclough, W.E. MS 1967a. Data record. Number, size, and food of larval and juvenile fish caught with a two boat surface trawl in the Strait of Georgia, April 25-29, 1966. Fish. Res. Bd. Canada. MS Rept. Ser. No. 922.
- total of 18 eulachons caught off Fraser River; stomach contents included copepods, copepod eggs, and sand grains.

Barraclough, W.E. MS 1967b. Data record. Number, size and food of larval and juvenile fish caught with an Issacs-Kidd trawl in the surface waters of the Strait of Georgia, April 25-29, 1966. Fish. Res. Bd. Canada. MS Rept. Ser. No. 926.
- total of 6 eulachons caught off Fraser River; one had eaten copepods, the rest were empty.

Barraclough, W.E. MS 1967c. Data record. Number, size composition and food of larval and juvenile fish caught with a two-boat surface trawl in the Strait of Georgia, June 6-8, 1966. Fish. Res. Bd. Canada. MS Rept. Ser. No. 928.
- several thousand eulachons (mainly larva) caught; stomach contents included phytoplankton, copepods and eggs, cladocerans, trematode parasites, and smaller eulachons. Pacific herring, surf smelt, Pacific sandlance, and chinook, sockeye, and chum salmon noted as predators of eulachons.

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Ricker, W.E., D.F. Manzer and E.A. Neave. 1954. The Fraser River eulachon fishery, 1941-1953. Fish. Res. Bd. Canada. MS Rept. No. 583.
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- total of 148 eulachons caught near Fraser River; feeding on copepods, cirripeds, and trematodes.

Robinson, D.G., W.E. Barraclough and J.D. Fulton. MS 1968. Data record. Number, size composition, weight and food of larval and juvenile fish caught with a two-boat surface trawl in the Strait of Georgia, June 5-9, 1967. Fish. Res. Bd. Canada. MS. Rept. Ser. No. 972.
- approximately 2 x 10^5 eulachons (most with yolk sac) caught; larger fish contained copepods, cirripeds, trematodes, nematodes, cladocerans, and amphipod. Predators of eulachon included pacific herring, steelhead trout, chum and sockeye salmon, surf smelt, kelp greenling, and pacific sandlance.

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