Recent Colonization of a Major Salmon-Producing Lake in British Columbia by Pacific Lamprey (*Lampetra tridentata*)

Susan P. Farlinger and Richard J. Beamish

Department of Fisheries and Oceans, Resource Services Branch, Pacific Biological Station, Nanaimo, B.C. V9R 5K6

Farlinger, S. P., and R. J. Beamish. 1984. Recent colonization of a major salmon-producing lake in British Columbia by the Pacific lamprey (*Lampetra tridentata*). Can. J. Fish. Aquat. Sci. 41: 278–285.

Pacific lamprey (*Lampetra tridentata*) were first observed in Babine Lake, the largest natural lake wholly contained in British Columbia, in 1963 and are currently found along approximately 15% of the length of the lake near the outlet. The number of spawning adults in 1982 was estimated to be 7281. Since Babine Lake is a major nursery area for sockeye salmon (*Oncorhynchus nerka*), the colonization of this lake by a parasitic lamprey is of concern, particularly if the species can become nonanadromous. The colonization may be beneficial if a commercial fishery can be sustained and if the species does not begin to feed in freshwater. The reason for the recent colonization is unknown but it coincides with increased human manipulation of fishes and habitat, including the removal of a major rock slide, 65 km downstream of the lake.

La lamproie du Pacifique (*Lampetra tridentata*) a été observée pour la première fois dans le lac Babine, le plus grand lac compris entièrement dans les limites de la Colombie-Britannique, en 1963 et on la trouve actuellement sur environ 15 % de la longueur du lac, près de l'émissaire. En 1982, on estimait à 7281 le nombre d'adultes reproducteurs. Comme le lac Babine est une importante région d'alevinage du saumon nerka (*Oncorhynchus nerka*), la colonisation de ce lac par une lamproie parasite n'est pas sans causer d'inquiétudes, surtout si elle devenait non anadrome. Par ailleurs, si la lamproie pouvait être exploitée commercialement de façon soutenue et qu'elle ne commence pas à se nourrir en eau douce, la colonisation par cette espèce pourrait être avantageuse. On ignore la raison de cette récente colonisation, mais elle coïncide avec une manipulation accrue des poissons et de l'habitat par l'homme, dont l'enlèvement d'un important éboulis de roches à 65 km en aval du lac.

Received May 24, 1983
Accepted October 18, 1983

Reçu le 24 mai 1983
Accepté le 18 octobre 1983

The Skeena River in British Columbia is the second largest salmon-producing system on the west coast of Canada. The Babine River (Fig. 1) is the main tributary of the Skeena River and it flows out of Babine Lake, 402 km from the Pacific coast. Babine Lake is the largest natural lake that is wholly contained in the province of British Columbia. The lake is 150 km long, has a mean depth of 55 m, and a surface area of 491 km^2 (Johnson 1965). There is a recreational fishery in the lake; however, the lake is most important as the principal nursery area for sockeye salmon (*Oncorhynchus nerka*) of the Skeena River system.

In 1946, counts of live and dead salmon were first made in Babine Lake by Federal fisheries biologists for the entire sockeye salmon run. To make these counts, they established a fish counting fence across all of the river just downstream of the lake, and it is still in use. The first Pacific lamprey (*Lampetra tridentata*) was reported at the counting fence in 1963 (Jordan and Smith 1972); in 1971 a notation in the daily log produced at the counting fence stated that the number of lamprey had been "steadily increasing over the last few years."

The sockeye salmon spawning migration in Babine Lake from July to November traditionally provided salmon as food for local natives. Local native Indians whose families have fished sockeye salmon in the area for genertions were surprised when lamprey first appeared in the local streams. Our discussions with these Indians indicted that lamprey have had no place in their culture or remembered history. Other residents living beside small streams flowing into the lake reported that spawning lamprey were first observed in the late 1960s and early 1970s.

Pacific lamprey are known to be present in other tributaries of the Skeena River (Fig. 1). Fisheries personnel working in the Lakelse Lake and River as early as 1949 reported large numbers of lamprey (T. Bilton, Pacific Biological Station, Nanaimo, B.C., pers. comm.). Historically, lamprey have been present at Moricetown Canyon on the Bulkley River (Carl and Clemens 1948). A native of Moricetown relates tales of his father pickling lamprey 50 yr ago; another, an older woman, tells of other preparation methods. This incorporation of lamprey into local culture is not evident at Babine Lake.

Since there is no history of lamprey in this large and important lake, our study examined the extent of their colonization. With the development of methods for the identification of larval lamprey (ammocoetes) in British Columbia (Richards et al. 1982), we could determine if the species present in the streams were Pacific lamprey. In addition, we estimated the abundance of adults.

Materials and Methods

We conducted a general survey of lamprey distribution of streams and adjacent lakeshore using hand-held electrofishing equipment. All streams flowing into Babine Lake and Nilkitkwa Lake (Fig. 2) were surveyed from June to September 1981; in

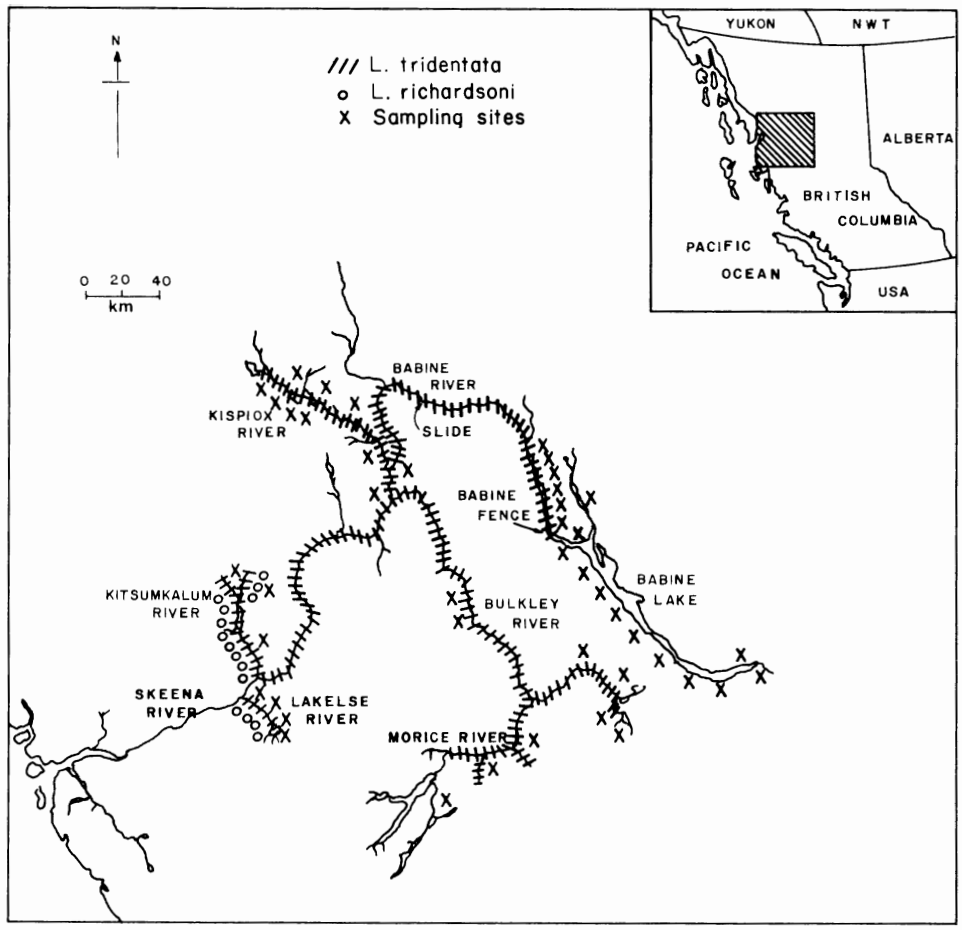

FIG. 1. Location of Skeena River and Babine Lake including the distribution of lamprey (*L. tridentata* and *L. richardsoni*) as determined in this study.

1982, streams at the edge of the distribution were reexamined. The presence of nests, spawning adults, or dead adults was also used to indicate the presence of lamprey. Lake shoreline adjacent to streams containing lamprey was surveyed from the surface and checked using scuba gear. In most locations, scuba observations did not reveal nests or adults that were not visible from the surface.

Minimum abundance of adults was estimated by counting nests during the spawning period. It was assumed that all nests contained eggs. Nests were 15–25 cm in diameter and 2–5 cm deep. They were easily identified by their silt-free appearance; however, not all nests were located in areas that could be surveyed. A factor was estimated to correct for the possibility that more than two lamprey used each nest and for nests that were not counted. The correction factor was determined by selecting one stream as an index. The number of lamprey in this stream each day of the spawning period was determined by summing the results of visual counts and numbers from traps set at the mouth of the stream. These counts were summed over the spawning period to produce the number of spawner days (Neilson and Geen 1981). Sex ratio was examined from samples of adults collected in the fall during their migration to the spawning areas and in the spring during spawning. Residence times were estimated for each sex by tagging (Floy anchor tag). The number of adults per nest was then estimated by dividing the spawner days for each sex by the resident times (Neilson and Geen 1981). Correction factors were then applied to the total counts of nests upstream of the Babine River counting fence.

Surveys of other streams and rivers in the Skeena system were undertaken to identify the distribution of Pacific lamprey. The area between sites that contained Pacific lamprey was considered to contain lamprey.

Adult lamprey were trapped at the mouth of Eel Creek using various sizes of conical or rectangular traps covered with 2.5-cm^2 mesh. Tunnels were inserted at both ends or at one end.

Samples of ammocoetes were obtained from streams, identified (Richards et al. 1982), and measured for total length.

Maturing adults migrating into Babine Lake from July to October were collected in traps at the counting fence and with dip nets from the river. Salmon fry traps set upstream of the counting fence in the spring captured ammocoetes.

Results

Distribution

Only ammocoetes of the Pacific lamprey were found in the Babine River and Lake system. Larval Pacific lamprey were found in all streams at the outlet end of Babine Lake, in Nilkitwa Lake, and in the connecting Babine River upstream of the counting fence (Fig. 2–5; Table 1). No lamprey were found between 9 Mile Creek and the inlet (Fig. 2; Table 1).

Ammocoetes were found in typical habitat of silt and detritus covered mud, in backwaters or near banks. In streams closer to the outlet (e.g. unnamed creeks 5 and 6, Fig. 4) ammocoetes were found as far as 1 km from the lake. In the streams farthest

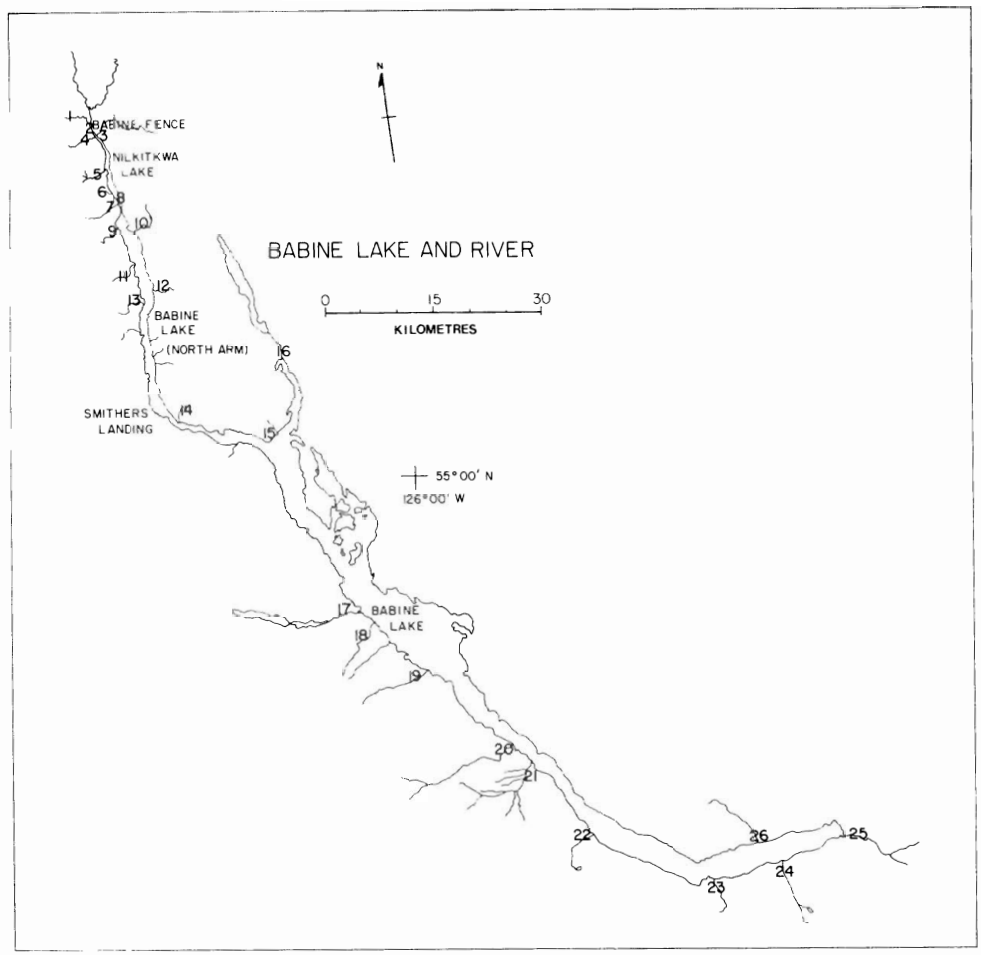

FIG. 2. Babine Lake and tributaries (see Table 1 for creek names).

from the outlet (e.g. Eel and 5 Mile Creek, Fig. 5) ammocoetes were found close to the mouth of the creek. In general, the larger ammocoetes were found closer to the mouth.

An intensive survey of Fulton River was made but no nests or ammocoetes were found. We have an unconfirmed report that from 1966 to 1968 small numbers of larval lamprey were captured in the fry traps in Fulton River (A. Coburn, Pacific Biological Station, Nanaimo, B.C., pers. comm.). The river was dammed in 1967 so it is possible that alterations to the river either prevented lamprey movement from the lake upstream of the dam or in some way changed the suitability of the river for lamprey spawning.

Ammocoetes ranged form 8 to 176 mm (Fig. 6). There are insufficient samples of *L. tridentata* ammocoetes from other rivers to permit quantitative comparisons of size; however, the data that are available (Kan 1975; Richards 1980; Pletcher 1963; R. J. Beamish, unpubl. data) suggest that ammocoetes from Babine Lake are larger than those found in many other river systems. (It is difficult to use larval length frequency data published prior to Richards 1980 because of the uncertainty of identification.) Metamorphosing lamprey collected in August and September of 1981 and 1982 ranged in size from 115 to 155 mm (Fig. 6), and these sizes also appear to be large for the species (Kan 1975; Beamish 1980; R. J. Beamish, unpubl. data; Richards 1980; Pletcher 1963).

Pacific lamprey ammocoetes were present in the Bulkley and Kispiox river systems (Fig. 1) and were found in the extreme headwater creeks of these systems. The Morice River is a well-known source of lamprey as evidenced by the name Lamprey Creek that flows into the Morice River. We did not find ammocoetes in the river flowing into Morice Lake, but the survey of this river was not extensive.

Adult Pacific lamprey are common in the upper Bulkley River and Bulkley Lake, Morice River, and the Kispiox River. Collections of ammocoetes and observations of adults indicate that Pacific lamprey ammocoetes were present in the Skeena River downstream of the Bulkley River. Our surveys of the Kitsumkalum and Lakelse rivers produced ammocoetes of *Lampetra richardsoni* as well as Pacific lamprey. The reports of adult lamprey in the Kispiox, Bulkley, and Morice rivers, the presence of ammocoetes in the extreme headwater creeks, and the incorporation of lamprey into local culture indicate that lamprey have had an historic presence in these rivers.

Spawning and Adult Biomass in Babine Lake

The occurrence of dead lamprey at the counting fence steadily increased after the first report of two dead lamprey washed against the counting fence on July 11, 1963 (F. P. Jordan, Pacific Biological Station, Nanaimo, B.C., pers. comm.). In our study, lamprey were observed migrating through the counting fence into Babine Lake from mid-July until mid-October. These migrants spawned from mid-June to late July in the following year (Beamish 1980) (Fig. 7, 8). Dead, spawned

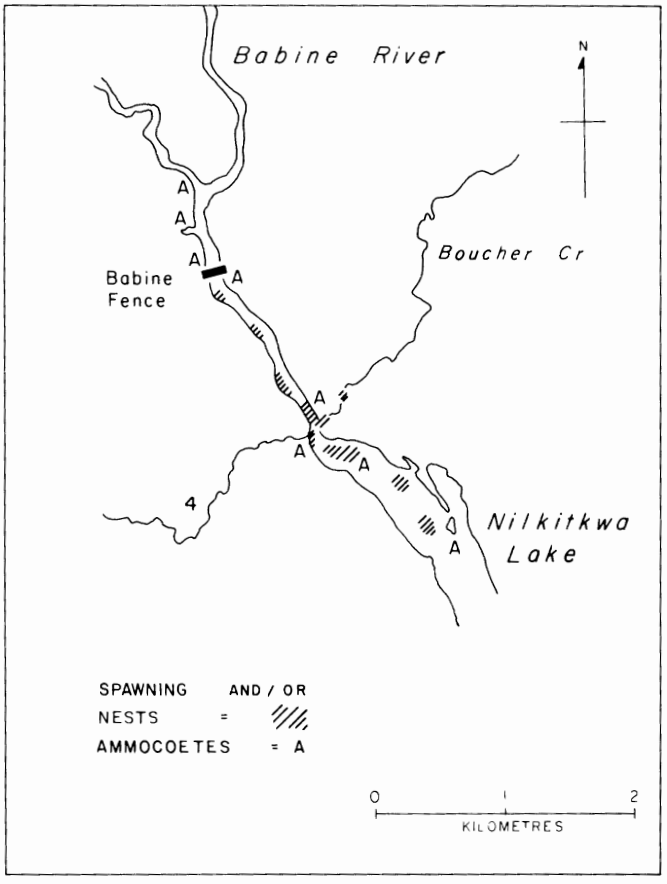

FIG. 3. Location of Pacific lamprey ammocoetes and adults immediately south of the counting fence.

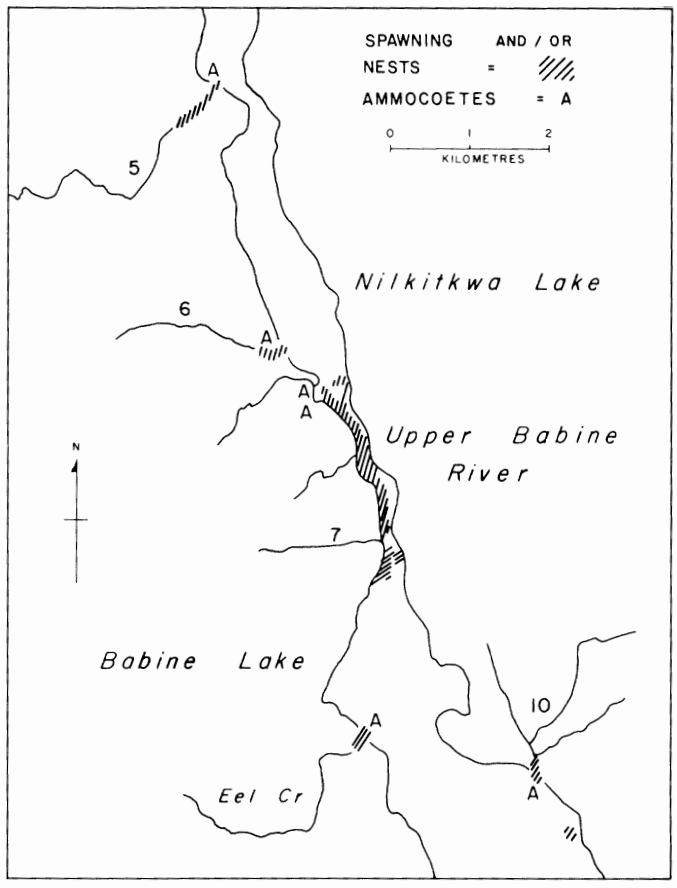

FIG. 4. Location of Pacific lamprey ammocoetes and adults in the Nilkitkwa Lake and upper Babine River area.

lamprey were washed downstream and some were retained at the counting fence.

Lamprey spawned from the counting fence to 9 Mile Creek (Fig. 2). Lamprey were observed to spawn in creeks as far as 1 km from the lake, although most nests were closer to the lake. In the upper Babine River, Nilkitkwa Lake, and lower Babine River, nests and spawners were observed in gravel shoals where there is a definite and consistent unidirectional flow at depths ranging from 30 cm in riffle areas to 4 m in cut bank areas. The deep (4 m) spawners were observed only in small numbers above Boucher Creek and at the Upper Babine River where it flows from the lake. The largest proportion of lamprey spawned in depths of 1 m or less.

Scuba dives were made in areas that were thought to be possible deep spawning areas. These included Babine Lake at unnamed creek No. 10, Babine Lake at Eel Creek, upper Babine River, and lower Nilkitkwa Lake. At the former two sites, there was a barely detectable movement of water over mud or hard sand bottom and no sign of lamprey spawning activity. In lower Nilkitkwa Lake at a consistent depth of 5 m, no sign of spawning was detected on the mud and weed bottom.

In Eel Creek, in both 1981 and 1982, the first spawners were observed on June 19. In 1982, over the next 10 d, the numbers in the creek rose rapidly to 143 spawners on July 1 (Fig. 8). After a freshet, numbers remained about 110 and then began to decline after July 9. (When high water levels prevented daily counts it was necessary to estimate daily abundance with the use of a predictive regression on the preceeding and following counts.) Spawning was complete by the end of July. Spawning occurred from the mouth of the creek to approximately 400 m up the creek.

A total of 141 mature lamprey were tagged at the mouth of the creek and 36 were recovered after spawning. The estimated residence time in the creek was 6.5 d for males and 4.6 d for females. The low recovery rate indicates that the estimated residence times may only approximate actual residence times. The sex ratio of 4 males to 3 females (Fig. 9) was determined from a sample of 252 fish, trapped at the entrance of Eel Creek as they moved into the creek during the spawning period. Samples of 357 adults collected during the upstream migration from mid-July to mid-September of 1979–82 had a sex ratio of 1:1. Because of the relatively small samples and because the fall migrants were not sampled continuously throughout their migration, it is not known if the change in sex ratio was real. Thus, the sex ratio of 4 males to 3 females was used in the population estimate. If the sex ratio of 4:3 results from increased mortality among females, possibly during the maturation process, then the estimate of number of lamprey at the time of fall migration will be larger.

The total number of spawner days was 3349, or 1914 male and 1435 female spawner days. Using the estimated residence times, the number of males was 294 (1914 ÷ 6.5) and females was 312 (1435 ÷ 4.6), or 606 lamprey. Since 120 nests were counted, the ratio of lamprey to nest counts was 0.462:1. This ratio was used to prorate the total nest count to estimate the total number of adults. The sex ratio determined from residence

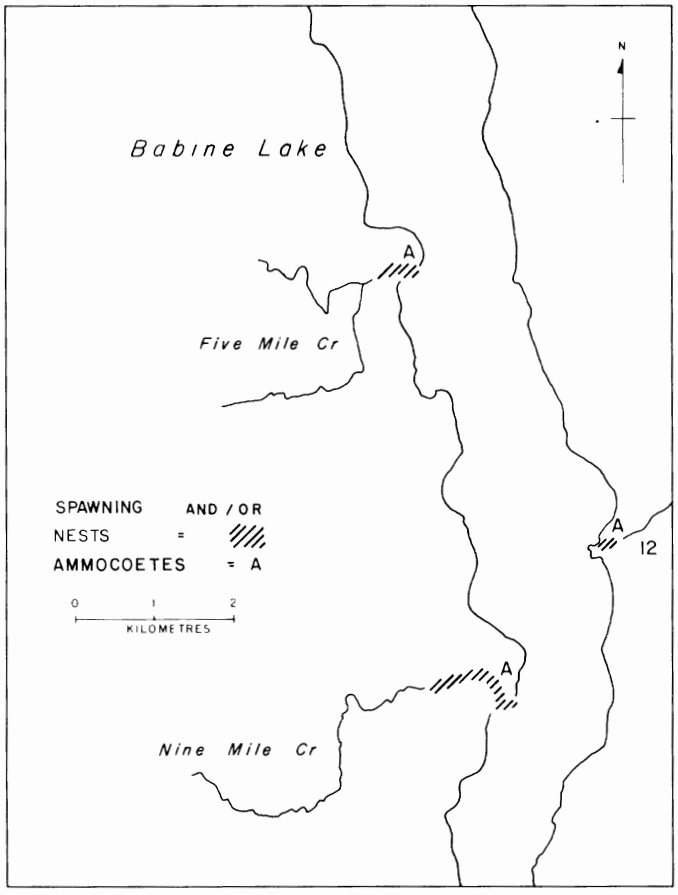

FIG. 5. Most southerly location of Pacific lamprey ammocoetes and adults in Babine Lake.

times is inconsistent with actual counts, suggesting that the factor used to prorate nest counts must be regarded as approximate.

Nest counts were made at the end of the spawning period (Table 2). The total number of nests counted upstream of the counting fence was 1442. Using a sex ratio of 4:3, the total number of adults was estimated as 7281. Because visibility was poor in some areas and in some creeks such as 5 Mile and 9 Mile Creeks, it is possible that the estimate is low even after correcting for unseen or destroyed nests or multiple use of nests. The amount of mortality that occurs from fall to spring is unknown. To estimate the number of lamprey moving into the lake the estimate of 7281 adults would have to be corrected for this mortality.

Discussion

There is no history of lamprey in Babine Lake. The first lamprey was observed at a fish counting fence in 1963, 17 yr after construction of this barrier across the Babine River immediately downstream of the lake. Local native Indians had no knowledge of lamprey in Babine Lake prior to this observation, yet lamprey were well known from nearby river systems. Because spawning lamprey are large and easily observed and carcasses of dead spawned lamprey have only recently been observed in Babine Lake there can be little doubt that if lamprey were present in Babine Lake in the past, they would have been observed. Thus, the lamprey that are now in the lake must result from a recent colonization.

Larval lamprey are now present in all of the streams closest to the outlet except Trail Creek. Colonized streams that are farthest from the outlet are populated in the vicinity of the creek mouth, suggesting that colonization is still occurring. While homing and straying studies were not undertaken, it appears that both homing and straying are occurring, resulting in a progressive colonization of streams flowing into the lake. Thus, it is probable that all streams suitable for spawning will eventually be colonized. Since ammocoetes do exist in suitable habitats in the lake, and ammocoetes will disperse from the spawning streams as indicated by the capture of 1344 ammocoetes in salmon fry traps at the counting fence from May to August 1982, it is also probable that lamprey will disperse throughout the lake. The ultimate size of the adult population in Babine Lake is difficult to determine; but the current population may be in an exponential growth phase, indicating that the final numbers should be considerably higher than the current estimate of 7281 adults.

Pacific lamprey are present and appear to be abundant in other tributaries of the Skeena River. At present there is no indication that they are a more important predator or competitor on commercial fishes in freshwater or salt water than the host of other predators and competitors. There is some evidence that recently metamorphosed Pacific lamprey will actively attack young salmon in salt water (Beamish 1980), and there is evidence that Pacific lamprey will attack adult sockeye salmon that are aggregating prior to return to freshwater (Williams and Gilhousen 1968; Beamish 1980). However, in salt water, Pacific lamprey feed on a variety of hosts (Beamish 1980) and

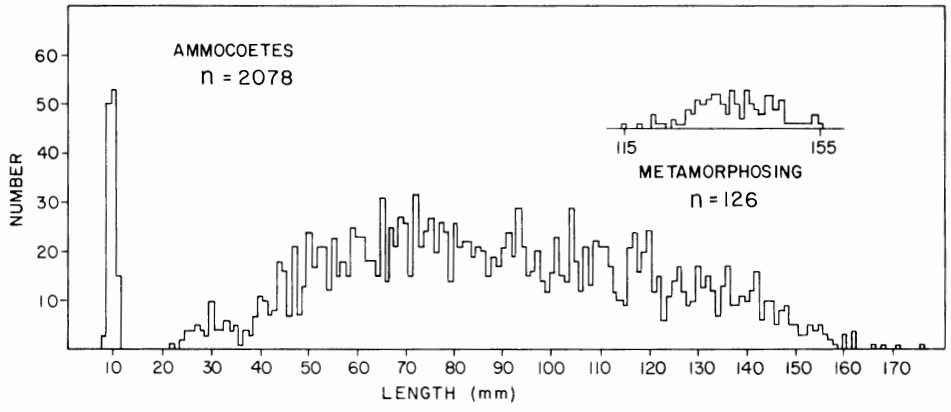

FIG. 6. Length frequency of Pacific lamprey ammocoetes collected in 1981 and recently metamorphosed juvenile adults collected in 1981 and 1982.

TABLE 1. Ammocoete distribution in tributaries of Nilkitkwa Lake, Babine Lake, and Babine River (see Fig. 2–5).

Location	Date surveyed	No.	Comments[a]
1, Nichyeskwa Creek	Aug. 17, 1981	78	On downstream side of confluence in mud bank. Nothing Nichyeskwa proper (100 m). No spawners
2A, Babine Lake below fence, west	Aug. 17, 1981	31	In silty side channel
2B, Babine River at fence, west	Aug. 17, 1981	148	In shallow backwater
2C, Babine River above fence			
East	Aug. 18, 1981	275	Along bank on shallow side. Other
	Aug. 22, 1981	320	side, not much
West	Aug. 25, 1981	49	
	Aug. 25, 1981	3	
3, Boucher Creek	Aug. 24, 1981	39	In marshy mouth area. Ammocoetes.
4, Unnamed creek	July 8, 1981		Only at mouth
	Aug. 1981		
5, Mouth of unnamed	Aug. 16, 1981	72	In large silt beds at mouth
creek 1 km upstream	Aug. 30, 1981	47	In silt by road
6, Unnamed creek	Aug. 30, 1981	72	0.5 km upstream
7, Trail Creek	Aug. 15, 1981	78	Silt banks at marsh outlet
	Aug. 21, 1981	78	
	Aug. 22, 1982	157	
8, Upper Babine River	Aug. 26, 1981	103	Upstream of Smokehouse Island
9, Eel creek	July 16, 1981	24	Most ammocoetes at mouth or farther
	July 17, 1981	20	out. Creek reduced to a trickle.
	July 28, 1981	121	Young-of-the-year found in mud
	Aug. 16, 1981	63	flats 30 m from mouth. A few larger, mostly young-of-the-year
10, Unnamed creek	July 17, 1981	45	Very large ammocoetes at mouth.
	Aug. 16, 1981	71	Nests found 100 m upstream
11, 5 Mile Creek	Aug. 9, 1981	9	Ammocoetes found only at mouth, shocked up 200 m. Nests seen up to 0.5 km.
12, Unnamed creek	Aug. 16, 1981	147	Only at mouth. Beyond 20 m, very little flow
13, 9 Mile Creek	July 16, 1981	8	Adult at mouth, nests to 1 km. Dead spawner 5 km
14, Unnamed creek	July 3, 1982		
	Oct. 11, 1982		
15, Unnamed creek	Oct. 11, 1982		
16, Morrison River	Aug. 9, 1981		
	July 3, 1982		
	Oct. 11, 1982		
17, Fulton River	July 13, 1981		
	Aug. 14, 1981		
	Oct. 14, 1982		
18, Tachek Creek	Aug. 13, 1981		
19, Sockeye Creek	Aug. 13, 1981		
20, Pierre Creek	Aug. 13, 1981		
21, Twain Creek			
22, Cross Creek			
23, Pinkut Creek			
24, 4 Mile Creek	Aug. 10–12, 1981		
25, Sutherland River			
26, 6 Mile Creek			

[a]No lamprey and no nests found at locations 14–26.

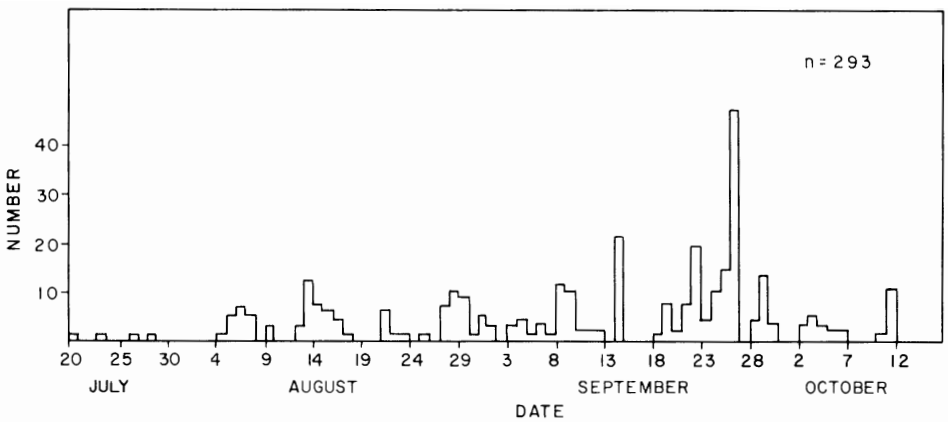

FIG. 7. Number of adult lamprey observed migrating through the counting fence during July–October 1982 (fence removed on October 12).

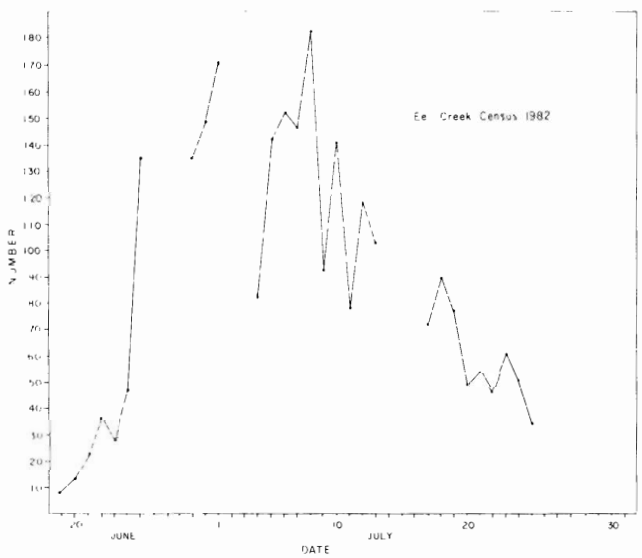

FIG. 8. Number of spawning lamprey observed in Eel Creek, 1982.

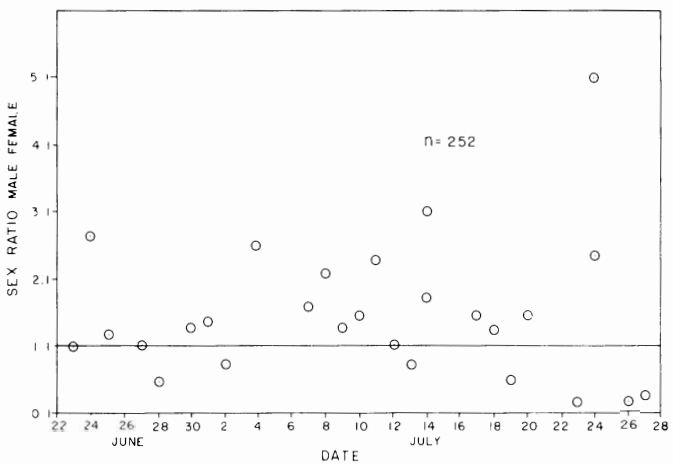

FIG. 9. Sex ratios of Pacific lamprey captured at the mouth of Eel Creek, 1982, during the spawning period.

TABLE 2. Nest counts in Babine Lake area in 1982 (see Fig. 2 for location of unnamed creeks).

Location	Date	Count
2C, Upstream of counting fence including mouth of Boucher Creek	July 28	557
4, Unnamed creek	July 23	25
5, Unnamed creek	July 20	46
6, Unnamed creek	July 20	4
8, Upper Babine River	July 26, 27	610
9, Eel Creek	July 24	120
10, Unnamed creek	July 5	25
11, 5 Mile Creek	July 26	50
13, 9 Mile Creek	July 26	5

there is no evidence of preference for important commercial species of salmonids.

There is evidence that Pacific lamprey prefer to feed on midwater species such as Pacific hake (*Merluccius productus*) and walleye pollock (*Theragra chalcogramma*) (Beamish 1980). Until more is known about Pacific lamprey in the ocean and the causes of mortality of salmon in the coean, there is no evidence to indicate that an increased lamprey production in the Skeena system will affect salmonids in salt water in the same manner as salmonids were affected in freshwater in the Great Lakes (Smith 1971).

A major impact on commercial species may occur if the Pacific lamprey can become landlocked (or nonanadromous) and if the abundance continues to increase in the lake. While it is postulated that the sea lamprey (*Petromyzon marinus*) can become nonanadromous, it is not known if the ability to adapt to a nonanadromous habit is a component of the genotype of the Pacific lamprey. There are no documented reports of Pacific lamprey feeding on freshwater fishes in any of the tributaries of the Skeena River, and the only documented example of important predation by lamprey on freshwater fishes in British Columbia is by *Lampetra macrostoma*, a species distinct from the Pacific lamprey (Beamish 1982). Thus, this question of whether or not the anadromous form can become nonanadromous is vital to the understanding of the consequences of the increased abundance in Babine Lake.

If it is found that the nonanadromous habit is part of the genotype of this species then the effect on resident fishes may be similar to the effect *L. macrostoma* has on resident fishes in Lake Cowichan and Mesachie Lake on Vancouver Island (Beamish 1982). In these lakes more than 50% of all salmonids have been observed to have lamprey scars. Younger fish are

attacked by lamprey, and 1- and 2-yr-old coho salmon (*Oncorhynchus kisutch*) have been killed or severely emaciated by lamprey attacks (Beamish 1982). The wounding and scarring data and the observed mortalities indicate that *L. macrostoma* is a major component of the causes of natural mortality for salmonids in these lakes. Because *L. macrostoma* spawns in the lake, it would be difficult to eliminate it from the lake. If the Pacific lamprey in Babine Lake becomes nonanadromous and behaves as *L. macrostoma* has, it will be a very important predator of salmonids in the lake.

There may also be benefits from an increased abundance of lamprey. Lamprey are an important commercial species in many countries (S. P. Farlinger and R. J. Beamish, unpubl. data). The lamprey in the Skeena River area are large and suitable for export. Because lamprey are esteemed as a food item, it is possible that a commercial fishery could develop if the sustained yield is sufficiently high.

It is useful to consider how the colonization into Babine Lake occurred. As shown, Pacific lamprey have been found in extreme headwaters of other tributaries of the Skeena River. According to local residents they have always been present and apparently abundant in the Kispiox River (Fig. 7), yet they have not migrated up the Babine River, beyond the Kispiox River into Babine Lake. It is possible that the population in the Skeena River is increasing and that movement into Babine Lake is a result of a normal expansion of the population. However, the Kispiox and Bulkley rivers (Fig. 7) both appear to be completely colonized, and as was observed in Babine Lake, it would be expected that colonization would continue in upstream areas before downstream rivers and streams are completely colonized. The lack of lamprey in the Babine River indicates that it was more than a naturally expanding population that provided the stimulus for lamprey to stray a little farther up the Babine River.

There have been several man-induced changes in the Babine Lake area. The counting fence was established in 1946 and the construction of several sockeye salmon enhancement facilities was initiated in the mid-1960s. These enhancement facilities were constructed after the initial observation of lamprey at the counting fence, indicating that colonization of the lake had already occurred. Thus, there does not appear to be a direct relationship between the colonization of Babine Lake and the establishment of enhancement facilities. It is unknown if the construction of the counting fence influenced the colonization.

In 1951 there was a major rockslide just upstream of the Kispiox River (Godfrey et al. 1954). The rockslide greatly restricted access of salmon to the lake in 1951 and 1952 and caused the loss of many thousands of fish and reduced spawning success. The rockslide occurred in an area of the river that was characterized by extremely swift water. The rockslide was removed in 1953 and the alterations to the river may have enabled lamprey to continue migrating up the river or in some way provided a stimulus to continue migration. Larval lamprey might have been introduced as bait into Babine Lake as a result of increased sports fishing activities in the late 1950s; however, there is little evidence to support deliberate or accidental introductions of lamprey.

Whereas the cause of colonization of Babine Lake is unknown there is little doubt that it has occurred recently. The effect of this colonization remains to be determined. The expected increase in abundance can be beneficial if a commercial fishery for lamprey develops but it may be extremely harmful if Pacific lamprey can and do become nonanadromous.

Acknowledgments

The field assistance of Mr G. A. Thomas and his helpful suggestions throughout the project were greatly appreciated. D. Southgate and staff at the counting fence provided equipment and accommodation. Fishery Officers Don Meyers, Terry Turnbull, Peter Waloshyn, and G. Cockell provided valuable assistance and information. Heidi Fargo, Ray Scarsbrook, and Mike Smith assisted in the collection of samples. Many other people provided assistance and information and we thank them for their advice and support.

References

BEAMISH, R. J. 1980. Adult biology of the river lamprey (*Lampetra ayresi*) and the Pacific lamprey (*Lampetra tridentata*) from the Pacific coast of Canada. Can. J. Fish. Aquat. Sci. 37: 1906–1923.

1982. *Lampetra macrostoma*, a new species of freshwater parasitic lamprey from the west coast of Canada. Can. J. Fish. Aquat. Sci. 39: 736–747.

CARL, G. C., AND W. A. CLEMENS. 1948. The freshwater fishes of British Columbia. B.C. Prov. Mus. Handb. No. 5. 1st ed.

GODFREY, H., W. R. HOURSTON, J. W. STOKES, AND F. C. WITHLER. 1954. Effects of a rock slide on Babine River salmon. Fish. Res. Board Can. Bull. 101: 100 p.

JOHNSON, W. E. 1965. The morphometry of Babine Lake and Nilkitkwa Lake. Fish. Res. Board Can. Manuscr. Rep. 819: 16 p.

JORDAN, F. P., AND H. D. SMITH. 1972. Summary of salmon counts and observations from the Babine River counting fence 1967–1979. Fish. Res. Board Can. Tech. Rep. 331: 63 p.

KAN, T. T. 1975. Systematics, variation, distribution and biology of lampreys of the genus *Lampetra* in Oregon. Ph.D. thesis, Oregon State University, Corvallis, OR. 194 p.

NEILSON, J. D., AND G. H. GEEN. 1981. Enumeration of spawning salmon from spawner residence time and aerial counts. Trans. Am. Fish. Soc. 110: 554–556.

PLETCHER, F. T. 1963. The life history and distribution of lampreys in the Salmon and certain other rivers in British Columbia, Canada. M.Sc. thesis, University of British Columbia, Vancouver, B.C. 195 p.

RICHARDS, J. E. 1980. Freshwater life history of the anadromous Pacific lamprey *Lampetra tridentata*. M.Sc. thesis, University of Guelph, Guelph, Ont. 99 p.

RICHARDS, J. E., R. J. BEAMISH, AND F. W. H. BEAMISH. 1982. Descriptions and keys for ammocoetes of lampreys from British Columbia, Canada. Can. J. Fish. Aquat. Sci. 39: 1484–1495.

SMITH, B. R. 1971. Sea lampreys in the Great Lakes of North America, p. 207–247. *In* M. W. Hardisty and I. C. Potter [ed.] The biology of lampreys. Vol. 1. Academic Press, London and New York.

WILLIAMS, I. V., AND P. GILHOUSEN. 1968. Lamprey parasitism on Fraser River sockeye and pink salmon during 1967. Int. Pac. Salmon Fish. Comm. Prog. Rep. 18: 22 p.