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Long-Distance Migrations by Inconnu (*Stenodus leucichthys*) in the Mackenzie River System

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ABSTRACT. Inconnu (*Stenodus leucichthys*) stocks of the Mackenzie River drainage exhibit complex life histories. In a single stock, some fish may make occasional or regular movements between freshwater and marine environments while others lead a completely freshwater existence. Many inconnu migrate between the Mackenzie River system and the Beaufort Sea, but during spawning migrations, most are believed to move only as far south as the Rampart Rapids near the community of Fort Good Hope. However, an inconnu tagged in the Liard River in northern British Columbia in 2001 was recaptured near Inuvik (Northwest Territories) in 2002, and a second inconnu tagged in the Liard River in 2002 was recaptured near Tuktoyaktuk (Northwest Territories) in 2003. These two fish exhibited some of the longest freshwater migrations by a species from Canadian waters other than Pacific salmon. Otolith strontium distributions of these two fish confirmed migrations of close to 1800 km between fresh and marine waters and indicated different life histories. Additional inconnu tagged in the Liard River in 2002 were recaptured in or near Great Slave Lake in 2002 and 2003. The movements of all these fish suggest that the management of inconnu stocks will be far more complicated than previously thought: they point out the need for management plans and protection that incorporate large geographic areas.

Key words: inconnu, migration, strontium, British Columbia, Northwest Territories, Liard River, Mackenzie River

RÉSUMÉ. Les stocks d'inconnu (*Stenodus leucichthys*) du bassin du Mackenzie affichent des cycles biologiques complexes. On trouve, au sein d'un seul stock, des poissons qui feront des allers retours sur une base épisodique ou régulière, entre un milieu d'eau douce et un milieu marin, tandis que d'autres passeront toute leur vie en eau douce. Un grand nombre d'inconnus migrent entre le réseau hydrographique du Mackenzie et la mer de Beaufort, mais on pense que, durant les migrations de frai, la plupart ne se déplacent en direction du sud que jusqu'aux rapides Rampart, près de la communauté de Fort Good Hope. Un inconnu marqué dans la rivière Liard dans le nord de la Colombie-Britannique en 2001 a cependant été recapturé près d'Inuvik (Territoires du Nord-Ouest) en 2002, et un deuxième inconnu marqué dans la Liard en 2002 a été recapturé près de Tuktoyaktuk (Territoires du Nord-Ouest) en 2003. Les migrations de ces deux spécimens comptent parmi les plus longues en eau douce effectuées par une espèce provenant des eaux canadiennes, autre que le saumon du Pacifique. La distribution du strontium otolithique de ces deux poissons a confirmé des migrations de près de 1800 km entre l'eau douce et l'eau de mer et a révélé des cycles biologiques différents. D'autres inconnus marqués dans la Liard en 2002 ont été recapturés en 2002 et 2003 dans le Grand lac des Esclaves ou à proximité. Les déplacements de tous ces poissons suggèrent que la gestion des stocks d'inconnu sera beaucoup plus compliquée que prévu: ils font ressortir le besoin d'élaborer des plans de gestion et une protection qui tiennent compte de vastes aires géographiques.

Mots clés: inconnu, *Stenodus leucichthys,* migration, strontium, Colombie-Britannique, Territoires du Nord-Ouest, rivière Liard, fleuve Mackenzie

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INTRODUCTION

Inconnu (*Stenodus leucichthys*) are the largest members of the whitefish subfamily Coregoninae, often attaining lengths of more than 1 m and weights over 20 kg (Scott and Crossman, 1973). Unlike other whitefishes, which feed on plankton and benthic invertebrates, inconnu are mainly piscivorous. Inconnu are iteroparous, and individual fish are thought to spawn every two to four years (Scott and Crossman, 1973). Inconnu distribution is limited to northern Eurasia, northern Alaska, and northwestern Canada. Within the Mackenzie River system, inconnu are believed to exhibit three life-history types: anadromous (in the lower Mackenzie River), non-anadromous (in the Great

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Slave Lake area), and riverine (in the upper Mackenzie River) (Reist and Bond, 1988; Howland et al., 2000) (Fig. 1). All life-history types are migratory to some degree, but to what degree is unknown. Because of the great variation in migratory behaviour between individuals within the same stock, inconnu exhibit complex life histories that are not yet fully understood.

Howland et al. (2000) summarized tagging studies conducted between the early 1970s and the mid-1990s, which indicated spawning areas for each of the three life-history types: 1) anadromous inconnu of the lower Mackenzie River returned to spawning areas in the Peel and Arctic Red rivers and to the Ramparts Rapids at Fort Good Hope on the Mackenzie River; 2) non-anadromous Great Slave Lake inconnu returned to spawning areas in tributaries of the lake, and 3) riverine (non-anadromous) inconnu from the upper Mackenzie River (including its tributary, the Liard River) spawned in nearby areas (see Fig. 1). Only two inconnu tagged in the lower Mackenzie River had ever been recovered upstream of Fort Good Hope (Howland et al., 2000), and there were no reports of inconnu tagged in areas upstream of Fort Good Hope being recaptured in the delta.

This paper presents biological information collected from inconnu tagged in the Liard River and recaptured in the Mackenzie Delta area and in Great Slave Lake. It also seeks to determine whether the information gathered from the recapture of these fish supports the concept, suggested by previous studies, of three distinct life-history types in the Mackenzie River.

METHODS

As part of a British Columbia Ministry of Water, Land and Air Protection project to identify inconnu spawning and overwintering areas, 44 inconnu were captured and radio-tagged during a two-year study: 18 in October 2001 and 26 during September–October 2002. All fish were captured by gillnets or angling in the Liard River, British Columbia, within a 15 km radius of the Fort Nelson River confluence (Fig. 1). Fish were anaesthetized; a radio transmitter was implanted in the body cavity; and an additional marker, a T-bar anchor tag, was inserted into the muscles on the left side, just below the dorsal fin. Tagged fish were held until they recovered and then released at their capture site. Additional details on methodology employed and results of the radio-tagging study will be presented elsewhere (J. Burrows, unpubl. data).

Otolith microchemistry can provide details on the types of environments occupied during a fish's life and help to determine its life-history type (e.g., Secor at al., 1995). Seawater, on average, contains 8.0 mg per litre strontium, whereas freshwater contains only 0.1 mg per litre (Rosenthal et al., 1970), and these differences in strontium level are reflected in fish otolith composition (e.g., Halden et al., 1995).

To determine life history, we measured and determined the pattern of strontium distribution (as strontium/calcium ratios, Sr/Ca) in otoliths of two recaptured inconnu, using the wave-length dispersive electron microprobe (Cameca SX-100) housed at the Department of Geological Sciences, University of Manitoba in Winnipeg. One of each pair of otoliths was prepared for microchemical analysis as described by Babaluk et al. (1997). The electron beam was operated at an accelerating voltage of 15 keV, a current of 20 nA, a diameter of 5 μm, and a center-to-center distance between sequential points of 7 μm. The beam traversed the otolith along the sulcus from the core area to the outer edge, incorporating all annual growth increments (annuli). Strontium Lα X-rays were counted at each point for 20 s. Strontium distribution graphs were then plotted as Sr/Ca ratios against otolith distance (number of sample points).

RESULTS

On 12 June 2002, one of the inconnu tagged in the Liard River was captured in a gill net set by a commercial fisherman in a lake near Inuvik, Northwest Territories (68°21′ N, 133°43′ W) (Fig. 1). The lake is locally known as Barge Lake, and its outflow is into the East Channel of the Mackenzie River. This fish had initially been captured, tagged, and released 15 km downstream of the confluence of the Liard and Fort Nelson rivers (59°38′48″ N, 123°57′48″ W) on 6 October 2001. Thus, it was at large for 149 days. The downstream migration by this inconnu was at least 1650 km, which is similar to the freshwater migration phase of some Pacific salmon and may represent a Canadian record for long-distance migration.

This inconnu measured 758 mm (fork length) and weighed 3780 g when it was tagged and released. When recaptured, it weighed 4000 g and appeared to be in good health. No increase in length was noted. The inconnu was a post-spawning male, which suggested that it had been in the upstream reaches of the Liard River to spawn in fall 2001. Its age was estimated, using the otolith section method, as 17+ years. Examination of its stomach contents revealed active feeding, as it had recently consumed 137 ninespine stickleback (*Pungitius pungitius*) and two ciscos (*Coregonus* sp.).

On 8 October 2003, a second radio-tagged inconnu was captured by a subsistence fisherman in a gill net set in the harbour near Tuktoyaktuk, Northwest Territories (69°27′ N, 133°02′ W) (Fig. 1). This inconnu had been tagged on 27 September 2002 in the Liard River, approximately 1 km upstream of the Fort Nelson River confluence (59°32′36″ N, 124°01′43″ W). The recapture of this inconnu, which had been at large for 376 days, extends the known migration distance of Mackenzie River system inconnu to almost 1800 km.

The second recaptured inconnu measured 980 mm and weighed 9675 g when it was tagged and released. At the time of recapture, no increase in length was noted, and the fish

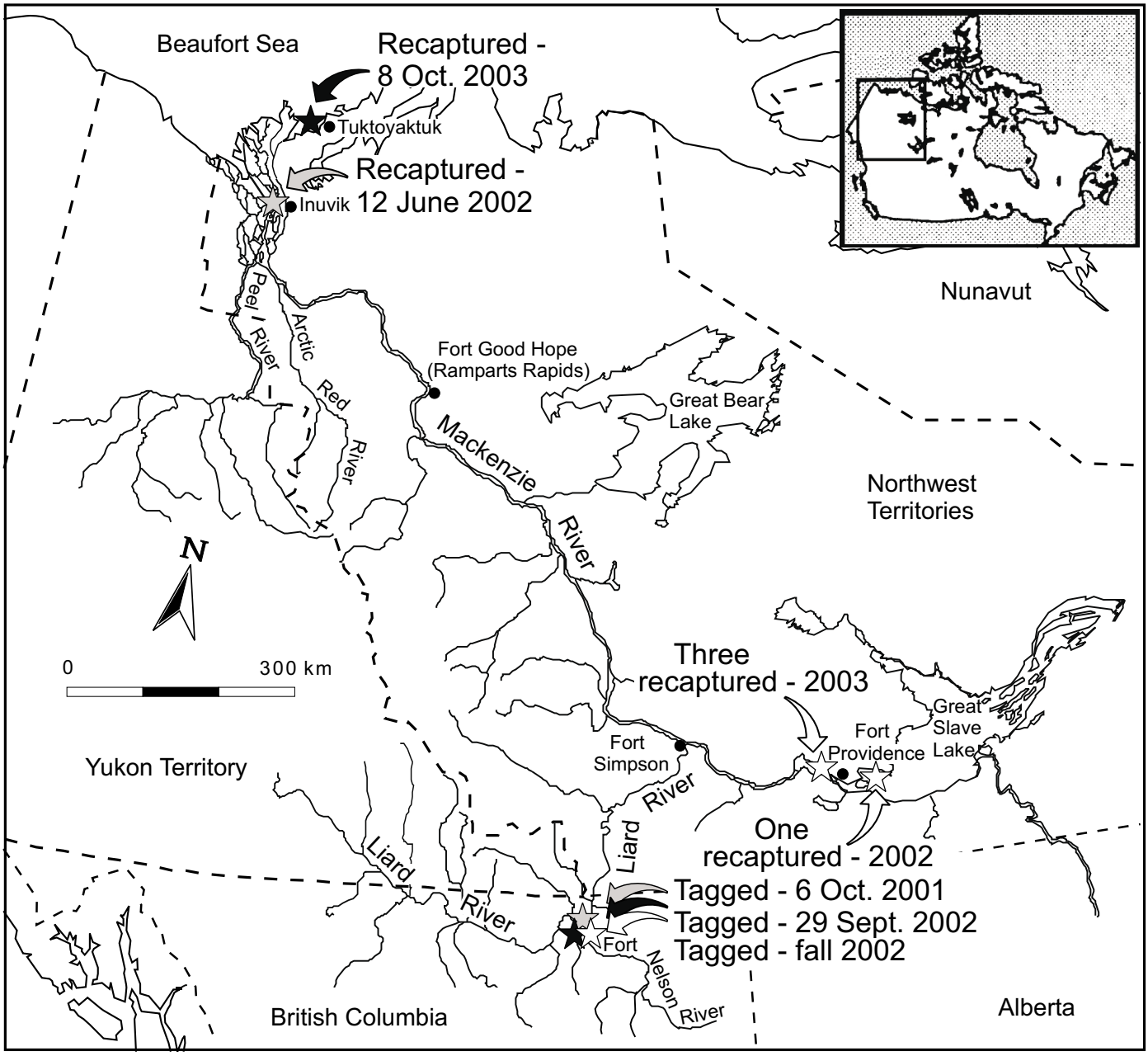

FIG. 1. Map of northwestern Canada showing tagging sites in British Columbia and recapture sites in Northwest Territories for tagged inconnu.

weighed only 5550 g. It appeared to be in poor health, exhibiting an emaciated abdomen, and its stomach was empty. This inconnu exhibited little evidence of egg development, suggesting it had been in the upstream reaches of the Liard River to spawn in fall 2002. Its otolith age was estimated as 29+ years. The overall poor condition of this fish, limited egg development, and age indicate senescence.

The strontium distribution for the first inconnu (Fig. 2a) showed a relatively low region, corresponding to at least the first two annuli (years), followed by marked increases and decreases for the remainder of its life. Brown (2000), using a similar electron microprobe (Cameca SX-50), demonstrated similar patterns of strontium distribution for Yukon River anadromous inconnu. The strontium distribution indicates that the inconnu remained in freshwater for the first two years of its life. Its third year started in freshwater, but in that year it made its first migration to and from seawater (i.e., the Beaufort Sea). This initial journey was followed by 10 more annual migrations (to age 13). The fish remained in freshwater for the next year (to age 14) before making another two migrations to and from the Beaufort Sea. It then returned to freshwater, where it remained until it was recaptured. The strontium distribution analysis therefore suggests that, if we include the initial distance moved from the Beaufort Sea to the Inuvik area before continuing up to the Fort Nelson/Liard confluence, the upstream distance travelled by this fish exceeded 1700 km and may have been closer to 1750 km.

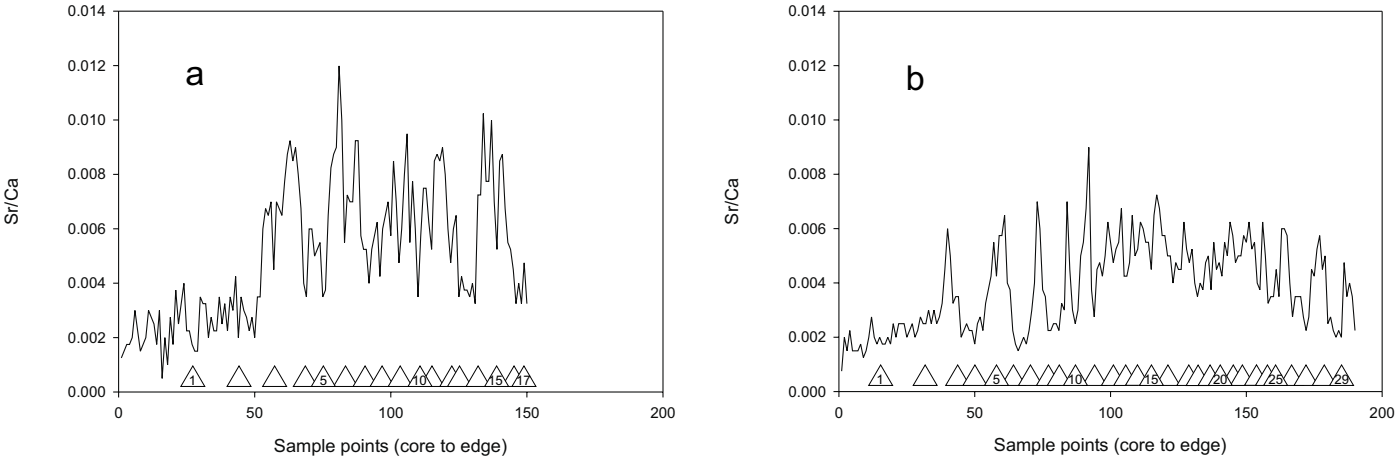

FIG. 2. Strontium distributions (as Sr/Ca) from electron microprobe line-scans of otoliths collected from two inconnu: a) captured near Inuvik, 12 June 2002; b) captured in Tuktoyaktuk Harbour, 8 October 2003. Numbers within triangles correspond to fish age in years.

The otolith strontium distribution for the second inconnu showed a migration history different from that of the first recaptured fish (Fig. 2b). Like the first recaptured inconnu, this fish lived in freshwater for the first two years of its life and made its first migration to a marine environment in its third year. However, unlike the first fish, which then made annual migrations to and from the sea for several years, this inconnu spent at least one complete year in freshwater between migrations to sea until the age of 10 years. From age 11 to age 26, with perhaps one exception (its 23rd year), it made annual forays into seawater. For the last few years of its life, it appears to have spent one year completely in freshwater followed by a migration to the sea until it was recaptured in the marine environment of Tuktoyaktuk Harbour in its 30th year (age 29+).

Four additional inconnu tagged in British Columbia during late September or early October 2002 have been recaptured in or near Great Slave Lake (Fig. 1). One was captured by a commercial fisherman in December 2002 in Great Slave Lake, and the other three were recaptured between 11 June and 12 July 2003 in the Mackenzie River just downstream of Fort Providence, near the outlet of Great Slave Lake. However, other than tag number and recapture location and date, no data have been obtained from these fish.

DISCUSSION

Inconnu of the lower Yukon River have one of the longest recorded migrations in North America. Alt (1977) reported a Yukon River inconnu that had travelled nearly 1600 km upstream after being tagged, while Brown (2000) reported inconnu from the same river migrating 1700 km between the sea and freshwater spawning areas. Inconnu in Siberia are known to travel up to 2000 km prior to spawning (Vork, 1948a, b; Kirilov, 1962, cited in Alt, 1977). The recaptures of tagged inconnu near Inuvik and Tuktoyaktuk mark the longest verified migrations for anadromous inconnu in Canadian waters. These migrations are similar in length to or longer than those observed by Brown (2000) for Yukon River inconnu. While it is impossible to determine with the data presented here whether either of the inconnu recaptured in the lower Mackenzie River had traveled farther upstream to spawn either before or after tagging, it is possible that the actual distance of the spawning migrations is even greater than reported here.

Until biological samples are available from inconnu tagged in the Liard River and recaptured in the Great Slave Lake area, we can only speculate as to whether these fish represent overwintering anadromous inconnu of the Mackenzie Delta, Great Slave Lake fish, or riverine inconnu of the upper Mackenzie River. Similarly, while the recapture of two of 44 tagged inconnu shows that movements between the Liard River and the Beaufort Sea occur, only additional tagging, either near the delta or in the Liard River, can provide estimates of how common this movement is. Further study may show that these fish represent a fourth life-history type, similar to that of anadromous fish of the Mackenzie Delta (which make short migrations), except that these fish make extremely long migrations to upper areas of the Mackenzie system.

Inconnu are an important component of the lower Mackenzie River subsistence, commercial, and domestic fisheries. However, because inconnu of the lower Mackenzie River were not thought to travel such great distances, management plans for the species have been limited to areas north of the Rampart Rapids at Fort Good Hope (e.g., Stephenson and Moshenko, 2000). Howland et al. (2000), however, reported that a few inconnu tagged in the lower portions of the river were recaptured as far upstream as Fort Simpson (Fig. 1). Our results confirm this movement and extend the migration distance considerably farther. Future studies should concentrate on attempting to determine what component of the stock makes migrations of this nature.

With respect to management considerations, the migrations reported here include provincial and territorial

jurisdictions and extend through three settled aboriginal land-claim areas. Additional land claims are currently under negotiation in areas travelled by these fish. The migrations described here demonstrate the need for co-operative management plans that take into account possible harvesting of the same stock at multiple times and locations. Furthermore, with recently renewed oil and gas exploration in the Mackenzie and Liard river valleys, and with plans in place to construct a Mackenzie Valley pipeline, some non-anadromous and migratory fish stocks, including inconnu, may be subject to negative impacts from this activity. Extreme care and adequate mitigative measures must be exercised during such developments to ensure that interruptions to important fisheries do not occur and that spawning areas are not adversely affected.

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