Papers and Proceedings of the Royal Society of Tasmania, Volume 118, 1984

(ms. received 1.II.1983)

THE UPSTREAM MOVEMENTS OF FISH IN THE PLENTY RIVER, TASMANIA

by R.D. Sloane
Department of Zoology, University of Tasmania and
Inland Fisheries Commission, Hobart, Tasmania

(with one table and six text-figures)

ABSTRACT

SLOANE, R.D., 1984 (31 viii): The upstream movements of fish in the Plenty River, Tasmania. *Pap. Proc. R. Soc. Tasm.*, 118:163 - 171. ISSN 0080-4703. Inland Fisheries Commission, Hobart, Tasmania, Australia.

A trap was installed in the Plenty River, southern Tasmania, in order to investigate upstream fish movements. The trap was monitored from May 1978 to September 1979. The catch included the lampreys *Mordacia mordax* and *Geotria australis*, the galaxiids *Galaxias maculatus*, *G. truttaceus* and *G. brevipinnis*, the sandy *Pseudaphritis urvillii*, the short-finned eel *Anguilla australis*, and a small number of blackfish *Gadopsis marmoratus*. The significance and timing of the movements of each species are discussed and related to existing knowledge.

INTRODUCTION

During the autumn of 1978 a fish trap was installed at a weir on the Plenty River, 2 km upstream from its confluence with the Derwent River in southern Tasmania (fig. 1). The upper limit of tidal influence in the Derwent River occurs 7 km below its confluence with the Plenty River.

The trapping programme was initiated in order to monitor the upstream migration of juvenile freshwater eels, *Anguilla australis* Richardson, as part of a separate study. However, during the period of trapping, a number of other species were captured. These were lampreys *Mordacia mordax* (Richardson) and *Geotria australis* Gray, the galaxiids *Galaxias maculatus* (Jenyns), *Galaxias truttaceus* (Valenciennes) and *Galaxias brevipinnis* Günther, the sandy *Pseudaphritis urvillii* (Cuvier and Valenciennes) and the blackfish *Gadopsis marmoratus* Richardson.

Little attention has been devoted to the upstream movements of these species in Australia. The spawning migrations of lampreys are well known phenomena in Australia (Potter *et al.*, 1968) but no detailed studies of these migrations have been published. Of the three galaxiids recorded in this study, the migrations of the 'whitebait' stage of *Galaxias maculatus* are the best documented. McDowall (1968) and Benzie (1968) studied this species in New Zealand, while Scott (1938) made observations on *G. maculatus* entering a Tasmanian stream. Scott (1936, 1941) also recorded migrations of juvenile *Galaxias truttaceus*. The upstream migrations of *Anguilla australis* elvers is at present being monitored in Tasmania (Sloane 1978, 1981) and in New Zealand this species has been studied in detail, most recently by Jellyman (1977). Beumer & Harrington (1982) recorded movement of both *A. australis* and *Gadopsis marmoratus* through a fish-ladder on the Lerderderg River, Victoria. There is no published information relating to upstream movement of *Pseudaphritis urvillii*.

METHODS

The upstream fish trap (figs 2 and 3) was installed at a weir which was formerly the site of a salmonid trap operated by the Tasmanian Inland Fisheries Commission. The trap was designed to capture fish migrating upstream through a diversion channel bypassing the weir. The weir forms a barrier to upstream fish migrations. Water passing through the

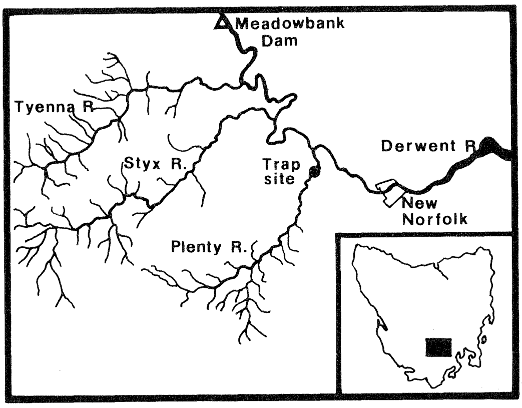

FIG. 1 - Location map showing the lower Derwent catchment and the Plenty River trap site.

diversion channel re-enters the river at the foot of the weir and provides a route for fish to pass upstream around the side of the weir.

The catching box was usually emptied each morning throughout the sampling period but on some occasions several days elapsed between the trap being cleared. On each visit, the catch was identified and counted then liberated above the weir. Sub-samples of juvenile galaxiids were preserved in 10% formalin for subsequent confirmation of identification.

Water temperatures were recorded daily at 0800 h at the Salmon Ponds trout hatchery 1 km upstream from the trap. River flow data were obtained from a gauging weir operated by the Tasmanian Rivers and Water Supply Commission on a nearby stream, the Tyenna River, at Newbury. These data were found to correspond closely to qualitative water-level observations recorded on visits to the Plenty River trap.

RESULTS

The trapping programme commenced on 1 May 1978 and continued until the trap was damaged by a sudden flood in early September 1979. The loss of the trap and the deteriorating condition of the weir made further trapping impracticable. The vast majority of fish were

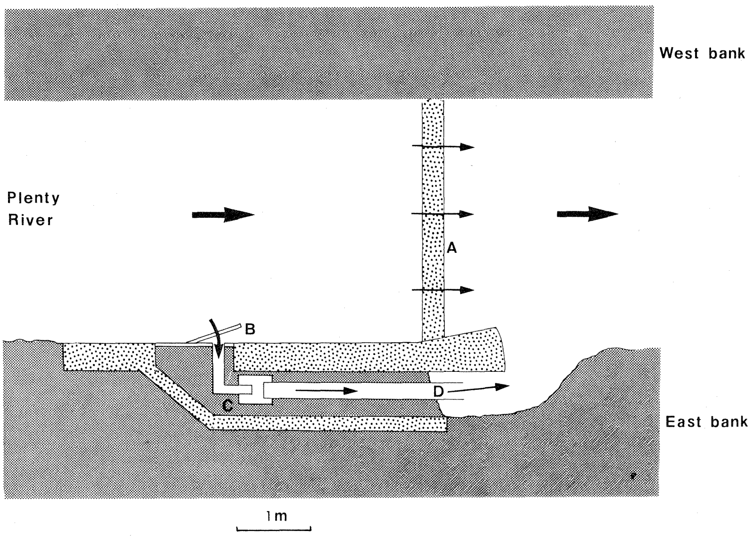

FIG. 2 - Details of the Plenty River weir and fish trap. Plan view of weir showing position of fish trap. A - weir face; B - trash screen; C - bypass channel; D - rampway entrance.

taken between mid-September 1978 and the end of January 1979. The daily catch records for this period are illustrated in fig. 4. Isolated catch records during the remainder of the 17 month sampling period are given in table 1. On occasions when the trap was visited after more than one day had elapsed, it was assumed that an equal proportion of the total catch entered the trap on each day.

Period of Migrations

The migration of 'Velasia' stage *Geotria australis* began at the Plenty River in mid-September. The onset of migration was heralded by the appearance of large flocks of cormorants seen gorging themselves on these animals in the lower reaches of the Derwent River. The migration reached its peak in October and continued until the end of November. *Mordacia mordax* first appeared in significant numbers at the Plenty River weir early in November. The numbers migrating reached the highest level at the end of November; small numbers were then caught through until early January (fig. 4). Lampreys of both species were only seen entering the trap at night. By torch light, they could also be seen climbing the rock face on the opposite side of the weir. During the day lampreys were found beneath the loose stones below the trap.

The run of *Anguilla australis* elvers began in late November and continued through December reaching a peak in January. The majority of elvers entered the Plenty River trap by night, but during the peak periods elvers were migrating all day.

Relatively small numbers of *Pseudaphritis urvillii* were recorded in the trap from October to February with January being the most important month for upstream movement (fig. 4). These fish varied in size and could not be designated as juveniles.

Only a relatively small number of juvenile *Galaxias brevipinnis* were recorded in this study (n = 97). From the limited data presented in figure 4, the migration appears to correspond closely to that of *Galaxias truttaceus*. The run of juvenile *G. truttaceus* began late in October and finished early in January with the main peak occurring early in November. Although the run of *G. truttaceus* started a little earlier and was of shorter

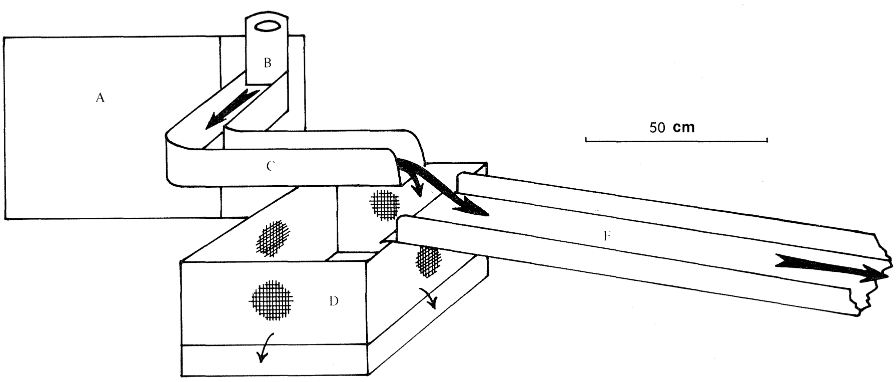

FIG. 3 - Diagram of the Plenty River fish trap showing details of construction. A - blocked off entrance to former fish trap bypass channel; B - sliding control gate to adjust water flow. Flow maintained at approximately 15 l/sec; C - duct carrying water to the trap; D - catching box with 2 mm woven mesh sides; E - rampway leading to the foor of the weir (inclined at 15° and lined with a mat of loosely woven rope and willow branches). The arrows indicate the direction of water flow.

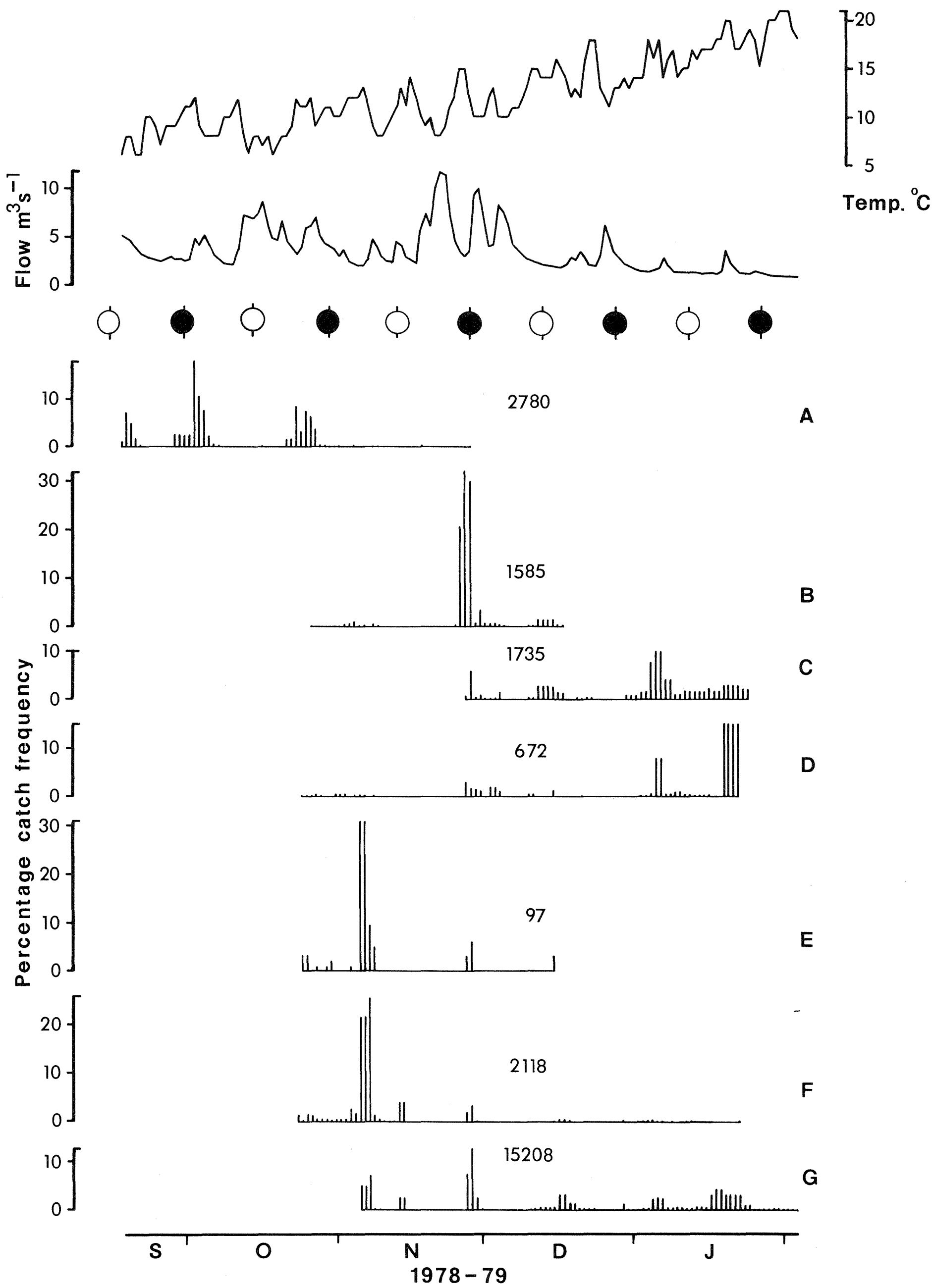

FIG. 4 - Daily catch frequency records for the major migrating species together with daily river flow and morning water temperature records. Days of full moon (open circles) and new moon (solid circles), and the numbers of each species captured, are indicated. Species A *Geotria australis*, B *Mordacia mordax*, C *Anguilla australis*, D *Pseudaphitis urvillii*, E *Galaxias brevipinnis*, F *G. truttaceus*, G *G. maculatus*.

TABLE 1

INCIDENTAL RECORDS FROM THE PLENTY RIVER FISH TRAP.
All the galaxiids recorded in this table were fully pigmented adults and thus were not included in figure 5.

Trapping Period	Numbers	Species
27-28.x.78	1	*Galaxias truttaceus*
29-30.x.78	1	" "
5-7.xi.78	1	*Anguilla australis*
5-7.xi.78	2	*Galaxias maculatus*
10-13.xi.78	1	*Galaxias truttaceus*
27-28.xi.78	5	" "
10-12.xii.78	1	*Gadopsis marmoratus*
12-16.xii.78	2	" "
5-7.i.79	1	*Galaxias truttaceus*
5-7.i.79	18	*Gadopsis marmoratus*
7-9.i.79	3	" "
11-13.i.79	1	" "
19-23.i.79	4	" "
19-23.i.79	2	*Galaxias truttaceus*
19-26.iii.79	3	*Galaxias maculatus*
4-9.iv.79	1	" "
8-14.v.79	1	" "

duration, the peak movements of this species correspond with those of *Galaxias maculatus* over the same period. Large numbers of juvenile *G. maculatus* moved into the trap over an extended period from early November to early February. They were frequently seen moving into the trap during the daylight hours. Only a few adult *G. maculatus* were captured during the trapping period (table 1), lending no support to a returning upstream migration of spent adults as indicated by Scott (1938) and Phillips (1919).

A small number of blackfish, *Gadopsis marmoratus*, were captured during the trapping operation (table 1). The most significant capture was that of 18 blackfish which entered the trap on 6 and 7 January 1979.

Environmental Influences

Water Temperature

Morning (0800 h) water temperature records showed an overall increase from 5°C to 20°C during the main migration season, mid-September to the end of January (fig. 4). All species captured were recorded over a wide temperature range and exhibited no precise temperature preference (fig. 5). The earliest migrant, *Geotria australis*, entered the trap predominantly at stream temperatures between 6°C and 14°C. *Mordacia mordax* was mainly captured at water temperatures between 12°C and 16°C and during the period of its migration, showed a significant ($0.01 < p < 0.05$) positive correlation between water temperature and catch ($r = 0.3159$, 53 days). Similarly, both *Anguilla australis* and *Pseudaphritis urvillii* entered the trap in greater numbers at higher water temperatures; there was a very highly significant ($p < 0.001$) positive correlation between water temperature and catch (calculated for all days during the recorded migration period of each species), for *A. australis* ($r = 0.4450$, 59 days) and for *P. urvillii* ($r = 0.4818$, 91 days). Correlations between water temperature and number of fish captured were not significant ($p > 0.1$) for all other species recorded. *Galaxias brevipinnis* and *Galaxias truttaceus* were generally recorded at water temperatures between 8°C and 16°C whereas the much more extensive migration of *Galaxias maculatus* spanned a wider temperature range, from 8°C to 22°C (fig. 5).

River Flow

The river flow graph is basically a mirror image of the temperature graph (fig. 4) as freshes in the stream correspond with periods of reduced water temperature, consequently these two influences are difficult to separate. As accurate flow recordings were not

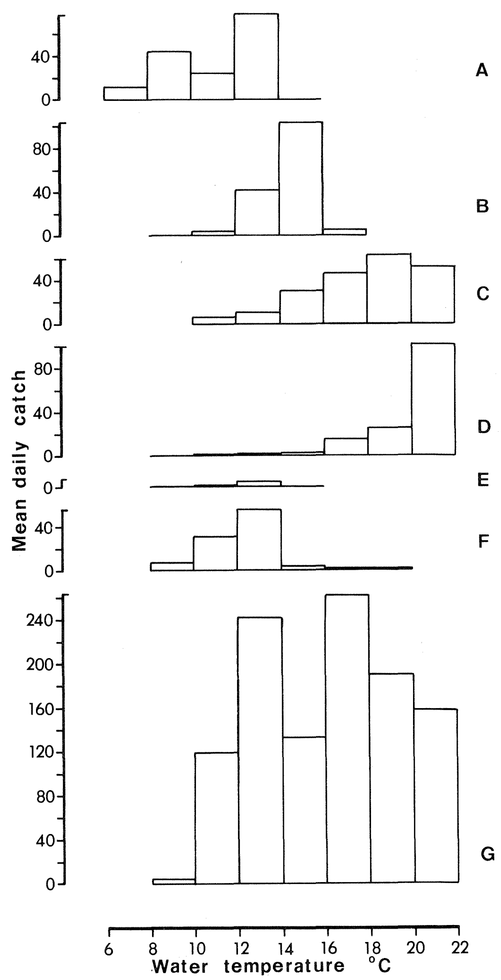

FIG. 5 - Catch data from figure 4 expressed as the number of each species trapped per day at various morning water temperatures (recorded at 0800 h); species as in figure 4.

obtained from the Plenty River, correlations with river flow were not considered to be statistically reliable.

Lunar Period

The percentage catch of each species, arranged by lunar days (fig. 6) shows that peak periods in the upstream movement of several species corresponded with specific lunar periods. The main peak in the catch of *Geotria australis* occurred during the first quarter, soon after the new moon (days 0 to 4) and no lampreys of this species entered the trap during the second lunar quarter. The main movement of *Mordacia mordax* occurred during the last three days of the lunar month. *Anguilla australis* catches were spread throughout the lunar month with a small peak during the second quarter (day 6 to 9). The greatest capture of *Pseudaphritis urvillii* occurred at the beginning of the third quarter (day 21 to 24). *Galaxias* spp. showed a peak in catch during the first lunar quarter (day 5 to 7) with *G. maculatus* exhibiting a second peak at the end of the last quarter.

DISCUSSION

It has been assumed that all the fish recorded during the trapping programme were moving upstream, although the design of the fish trap did not completely exclude the possibility of some fish passing downstream into the catching box. However, the position and size of the upstream entrance relative to the weir, the trash screen position across the entrance and the small fraction of water splashing back into the catching box from the rampway, combined to minimise the possibility. The absence of adult eels, lamprey macrophthalmia and trout fry from the catch support this assumption.

Lampreys entered the Plenty River trap during the hours of darkness and were trapped mainly on dark nights, during the first and last quarters of the moon; such behaviour is generally true of all lamprey migrations (Hardisty & Potter 1971). Potter *et al.* (1968) reported that the migratory movements of *Mordacia mordax* began at dusk, with adults burying themselves deep into the river bed by day. Lynch (1978) reported a run of *Geotria australis* during mid-October at the lower Forth River in northern Tasmania, the same time of year as indicated for southern Tasmania by the present study. In New Zealand, *G. australis* have been observed ascending streams somewhat earlier, with May, June and July being important months for migration (Maskell 1929). Potter *et al.* (1968) determined that spawning run *M. mordax* first enter rivers on the Australian mainland during July and August, with the peak of migration from the beginning of September to the end of November. They suggested the spawning run in Tasmania occurred at approximately the same time. The present study indicates a later, November-December migration for the

Plenty River. The main movement of *M. mordax* into the Plenty River trap occurred during a period of increased water temperature (13°C-15°C) and an associated reduced river flow. This contrasts with the general finding that high water levels are associated with lamprey migrations (Hardisty & Potter 1971).

The upstream migration of *Anguilla australis* took place in the Plenty River during a similar period to the migration recorded by Sloane (1978) at Trevallyn Power Station in northern Tasmania where the run commenced in November and continued until the beginning of February. Beumer & Harrington (1982) considered that the upstream migration season of *A. australis* in the Lerderderg River, Victoria, was just commencing when trapping was discontinued on 2 December. Cairns (1941) and Jellyman (1977) found January and February to be the main months for the migration of *A. australis* elvers in New Zealand. Jellyman (1977) suggested that low water temperatures (less than 10°C) could retard elver migrations. In the Plenty River increased elver catch was related to increased water temperature and reduced river flow.

Conditions of reduced flow and increased water temperature were also associated with the upstream migration of *Pseudaphritis urvillii* in the Plenty River. Although little is known of the life history of this species, two unpublished Tasmanian studies (Sloane 1976, Hortle 1978) indicate an upstream migration phase, with young *P. urvillii* entering fresh water from the estuary or sea. Hortle (1978) suggested progressive upstream movement over a number of years. Lake (1971) made brief mention of migrations of *P. urvillii* in the Murray River, observed during autumn and winter. A compensatory upstream movement of young fish during the summer is suggested by the data presented here.

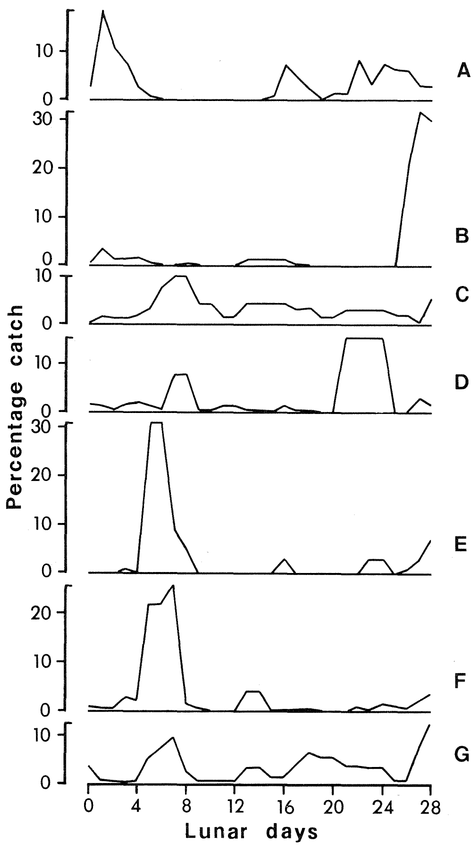

FIG. 6 - Catch data from figure 4, expressed by days in a lunar month (day 0 is the day of the new moon); species as in figure 4.

Scott (1938) studied the movements of *Galaxias maculatus* in Punchbowl Creek, northern Tasmania. He found an extensive juvenile influx in October followed by a less important influx in March. Tasmanian records from 'whitebait' statistics indicate that the initial movement of *G. maculatus* into fresh water occurs mainly in September, October and November (Lynch 1965-72, 1979). In New Zealand, McDowall (1968) found the peak migration period for this species is usually between mid-August and early November. It seems possible that there is a delay of between one and two months between the initial arrival of *G. maculatus* juveniles in the 'whitebait' run and the penetration upstream into fresh water as recorded 9 km above tidal influence at the Plenty River weir. Scott (1941) found migration of juvenile *G. truttaceus* in company with *G. maculatus*, with the main body arriving in late September-early October. September, October and November also appear to be the most important months for *G. truttaceus* in Tasmanian whitebait runs (Lynch 1965-71, 1979). Again, a delay between the arrival of *G. truttaceus* in fresh water and the further upstream penetration is indicated. In Tasmania, *G. brevipinnis* migrations have been observed in late October by Sloane (1978) at Trevallyn Power Station and by Lynch (1978) at the Forth River weir.

A study on the breeding and early development of the blackfish *Gadopsis marmoratus* (Jackson 1978), gives no indication of a migratory phase in the life history. Jackson (1975) also studied the movements of adult *G. marmoratus* by tagging and he concluded that they exhibit very little movement. It seems likely that the captures of blackfish in the present study represent incidental wanderings rather than any significant migration. Recapture data from tagged *G. marmoratus* led Beumer & Harrington (1982) to conclude that movements of this species through the Lerderberg fish ladder were random.

The absence of brown trout *Salmo trutta* Linnaeus, from the capture data indicates that the flow through the trap was not adequate to attract this species. The subsequent reopening of the salmonid trap at the Plenty River weir resulted in the capture of 70 sea-run brown trout weighing up to 4 kg, during May and June 1982 (Lynch 1982).

CONCLUSION

With the exception of *Geotria australis*, the main months for migration of the species in this study were the summer months of November, December and January. This has important consequences as low river flows at this time may result in even small dams, weirs and culverts becoming effective barriers to migration.

The Plenty River trap illustrates that a bypass channel and/or a simple fish ladder could be used to permit the free upstream passage of a number of migratory fish. With detailed knowledge of the extent and timing of such migrations and some knowledge of the climbing abilities of the species involved, temporary passes or trap and porterage programmes need only be operated for a short period each year to enable migration upstream to adult habitats or spawning grounds.

ACKNOWLEDGEMENTS

Maintenance of the trap, recording of fish numbers and collection of samples were carried out by Mr I. Cameron of the Tasmanian Inland Fisheries Commission Hatchery, 'Salmon Ponds'. The trap was installed as part of a post-graduate study of eel biology being conducted by the author through the Zoology Department, University of Tasmania. Mr B. Rumbold built and installed the trap. Mr W. Fulton assisted with monitoring of the trap and identified the juvenile stages of galaxiids. I would also like to thank Dr R.W.G. White for constructive criticism of the manuscript.

REFERENCES

Benzie, V.L., 1968: A consideration of the whitebait stage of *Galaxias maculatus attenuatus* (Jenyns). *N.Z. J. mar. Freshwat. Res.*, 2: 559-573.

Beumer, J.P. & Harrington, D.J., 1982: A preliminary study of movement of fishes through a Victorian (Lerderderg River) fish-ladder. *Proc. R. Soc. Vict.*, 94: 121-132.

Cairns, D., 1941: Life history of the two species of New Zealand fresh water eel. I. Taxonomy, age and growth, migration and distribution. *N.Z. J. Sci. Tech.*, 23: 53-72.

Hardisty, M.W. & Potter, I.C., 1971: The general biology of adult lampreys. In Hardisty, M.W. & Potter, I.C. (Eds): THE BIOLOGY OF LAMPREYS. Academic Press, London. Vol. I: 127-206.

Hortle, M.E. (1978): THE ECOLOGY OF THE SANDY, *PSEUDAPHRITIS URVILLII*, IN SOUTH-EAST TASMANIA. Unpub. B.Sc. Honours thesis, University of Tasmania.

Jackson, P.D., 1975: BIONOMICS OF BROWN TROUT (*SALMO TRUTTA* LINNAEUS 1758) IN A VICTORIAN STREAM WITH NOTES ON INTERACTIONS WITH NATIVE FISHES. Unpub. Ph.D. thesis, Monash University.

_____________, 1978: Spawning and early development of the river blackfish, *Gadopsis marmoratus* Richardson (Gadopsiformes: Gadopsidae), in the Mckenzie River, Victoria. *Aust. J. mar. Freshwat. Res.*, 29: 293-298.

Jellyman, D.J., 1977: Summer upstream migration of juvenile freshwater eels in New Zealand. *N.Z. J. mar. Freshwat. Res.*, 11: 61-71.

Lake, J.S., 1971: FRESHWATER FISHES AND RIVERS OF AUSTRALIA. Nelson, Melbourne: 61 pp.

Lynch, D.D., 1965, 66, 67, 68, 69, 70, 71, 72, 78, 79, 82: TASMANIAN INLAND FISHERIES COMMISSION REPORT (year ended 30th June). Government Printer, Hobart.

McDowall, R.M., 1968: *Galaxias maculatus* (Jenyns), the New Zealand whitebait. *Fish. Res. Bull. N.Z.,* 2: 1-84.

Maskell, F.G., 1929: On the New Zealand lamprey, *Geotria australis* Gray. I. Biology and life history. *Trans. R. Soc. N.Z.,* 60: 167-201.

Phillipps, W.J., 1919: Life history of the fish *Galaxias attenuatus*. *Aust. Zool.,* 1: 211-213.

Potter, I.C., Lanzing, W.J.R. & Strahan, R., 1968: Morphometric and meristic studies on populations of Australian lampreys of the genus *Mordacia*. *J. Linn. Soc. (Zool.),* 47: 533-546.

Scott, E.O.G., 1936: Observations on fishes of the family Galaxiidae: Part I. *Pap. Proc. R. Soc. Tasm.,* 1935: 85-112.

____________, 1938: Observations on fishes of the family Galaxiidae: Part 2. *Pap. Proc. R. Soc. Tasm.,* 1937: 111-143.

____________, 1941: Observations on fishes of the family Galaxiidae: Part 3. *Pap. Proc. R. Soc. Tasm.,* 1940: 55-69.

Sloane, R.D., 1976: INTER-RELATIONSHIPS BETWEEN NATIVE AND INTRODUCED FRESHWATER FISH. Unpub. B.Sc. Honours thesis, University of Tasmania.

____________, 1978: Elver migration and porterage 1977-78. TASMANIAN INLAND FISHERIES COMMISSION REPORT (year ended 30 June 1978). Government Printer, Hobart. Appendix III: 36-37.

____________, 1981: Elver migration and porterage 1980-81. TASMANIAN INLAND FISHERIES COMMISSION REPORT (year ended 30 June 1981). Government Printer, Hobart. Appendix II: 25-26.