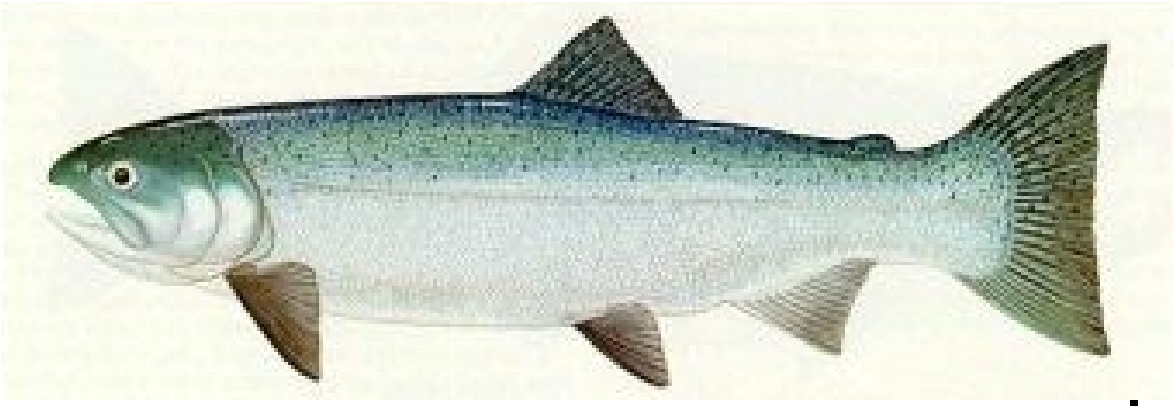
Radio-telemetry Study of Coho Salmon

(Oncorhynchus kisutch)



In the Millstone River, *1999-2000*

Submitted To:
Gary Rosberg,
Fish Management Instructor
British Columbia Institute of Technology

Submitted By:
Kris Castle
Amber Legault
British Columbia Institute of Technology
Fish, Wildlife & Recreation Program

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Acknowledgments

We would like to thank The Community Futures Development Corporation of Central Island (CFDC) for providing the funding for this project. Extended acknowledgments for his help, patience and support goes out to Mike MacIntyre, who provided all technical support as well as any training needed.

Special thanks goes to Aleria Ladwig from the Department of Fisheries and Oceans Canada for guiding us through this project and her continuous support.

1.0 Introduction

1.1 Background Information

1.1.1 Purpose

The purpose of this project was to monitor coho salmon migration patterns in the Millstone River using radio-telemetry. This project was done to confirm the previous years results; that the barriers found in the Millstone River impede the migration of coho salmon (*Oncorhynchus kisutch)*. The two years of data collected will be used to validate the construction of a complex chain of fishways. These fishways will allow coho salmon upstream into spawning grounds and hopefully establish a naturally regenerating stock of coho salmon in the Millstone River.

1.1.2 History of the Millstone Watershed

The Millstone River has not supported any native populations of coho salmon (*Oncorhynchus spp*.). This is due to the barriers obstructing spawning grounds upstream.

However, the many studies done on the Millstone River have found that the River has the potential to support a coho population if there was access beyond the two remaining barriers, into spawning grounds. In 1969 and 1979, the Fish and Wildlife Branch conducted surveys and determined that the River could support coho salmon populations. Further studies conducted by Malaspina College students on the tributaries within the watershed; found that additional streams could help the potential of the Millstone River to support coho populations.

Once it was concluded that the Millstone had the potential for coho salmon population, the Nanaimo Fish and Game Club and the DFO started releasing coho fry into the system in 1981 (Salmon in the City, 1998 in Ladwig, 1999).

1.1.3 Project Partners

The Department of Fisheries and Oceans (DFO) oversaw the Millstone River project. Aleria Ladwig from the Department of Fisheries and Oceans, habitat restoration branch, supervised the project and hired Mike MacIntyre for technical support.

The Community Futures Development Corporation of Central Island (CFDC) provided the funding for the study. The CFDC will also use the information gathered from this project to help with their Salmon in the City initiative.

Additional project partners include:

- Malaspina University College (MUC),
- Nanaimo River Hatchery, and
- The British Columbia Institute of Technology (BCIT).

1.1.4 Seeding in the Millstone Watershed

As part of the initiative to enhance salmon populations in the Millstone River, approximately 600 adult coho salmon, with a sex ratio of 60% females to 40% males from the Nanaimo River Hatchery, were added to the system. Once a week throughout November and December, 8-10 fish were taken from the hatchery and released into the system. Various sites were chosen above the barriers in attempts to ensure that the fish will spawn naturally in the system. The seeding project was done in attempts to establish a naturally occurring population of coho salmon in the River.

2.0 Description of the Study Area

The Millstone River lies in the city of Nanaimo, BC on Vancouver Island. The watershed is approximately 100 square kilometers (km^2). The River flows from Brannen Lake into Nanaimo Inner Harbor near the Nanaimo River estuary. Much of the stream flows through urban areas in the Coastal Western Hemlock, dry maritime biogeoclimatic zone. The substrate in the lower reaches of the stream is composed largely of boulders and cobbles with extensive bedrock in some areas. Therefore a combination of high water input and impermeable substrate creates strong intermittent flooding.

Figure 1: Map showing study area (Mapquest.com Inc.1999)

The study area for the Millstone River Radio-Tagging Project extended from the Millstone River estuary to 100-200 meters (m) upstream of the barriers. Access to the barriers is in Bowen Park in Nanaimo, BC. Figure 2 (shown on page 4) shows an orthophotograph with the Millstone River and its tributaries.

3.0 Material and Methods

3.1 Benchmark Survey

A foot survey was conducted in the lower reach of the Millstone River. Please refer to Figure 3 for a map of the area benchmarked and flagged and the location of the barriers on the River.

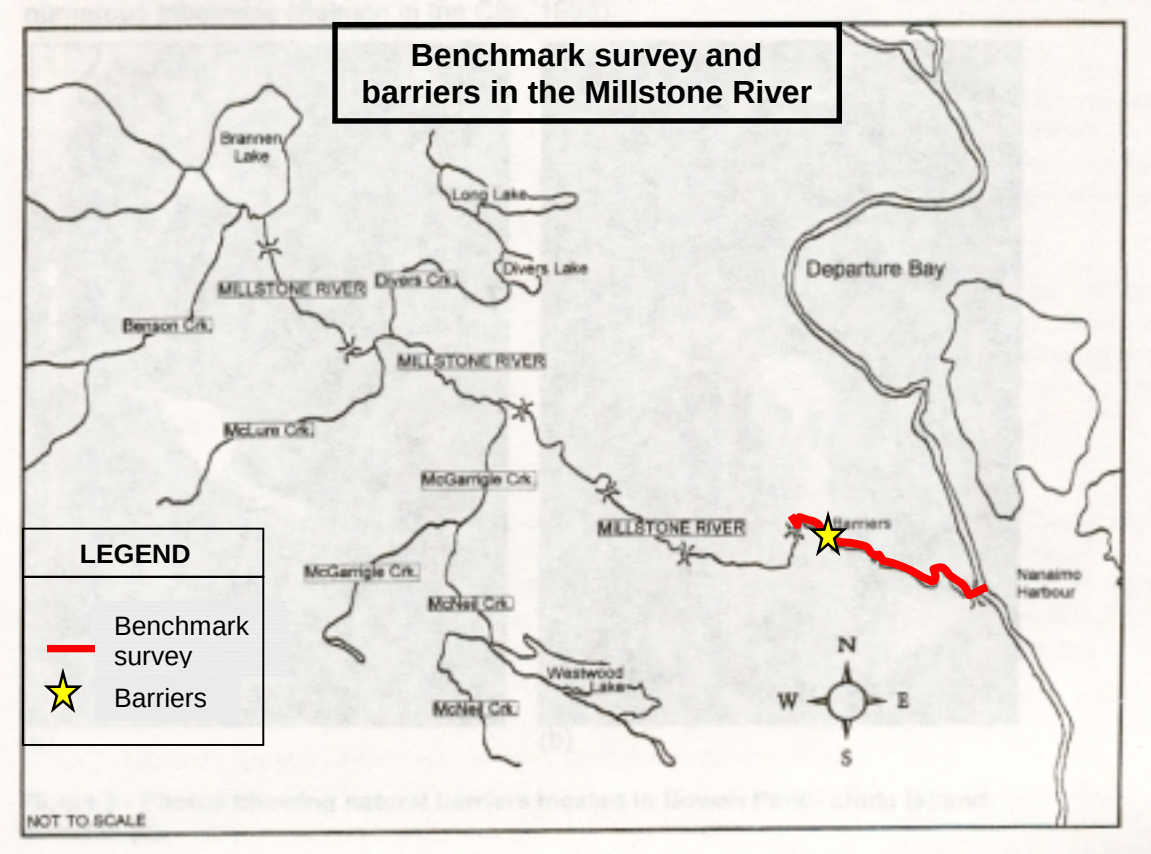

Figure 3: Location of benchmark survey from the Millstone River Estuary to 100-200 meters upstream from the barriers.

The study area was flagged at 100m intervals in order to provide established benchmarks for radio-telemetry. These flagged stations were cross-referenced with a professional drawing completed by Rik Norgan, an engineer with Fisheries and Oceans Canada (Ladwig, 1999). Mike MacIntyre, of Department of Fisheries and Oceans (DFO) provided a digitized map of the study site. Copies of this map were distributed to people monitoring the project to record daily fish-movement data.

3.2 Methodology for Adult Capture

The Nanaimo River Hatchery provided the study with 20 coho as successful fish capture was not possible in the Millstone River. The fish trap located at the waterfalls in the Millstone River was unsuccessful in capturing salmon and it was unsafe to use other methods such as dip netting and gillnetting due to high stream-flows and turbulent waters.

3.3 Radio-Tagging

Originally, 30 coho were to be captured and tagged. However, only nine tags from last year's study were usable, the other tags were inoperable due to improper storage. The CFDC purchased another nine tags later in the study and two tags could be reused, for a total of twenty tagged coho salmon used in the Millstone River radio-tagging project.

Telemetry involves attaching a frequency-specific radio transmitter to the fish and then estimating its location using a receiver. The migration patterns are then monitored and the information is downloaded into a portable computer. The telemetry receiver used in this study was a Lotek SRX_400. The average gain used in monitoring was 49 (MHz). To locate fish from a larger range the gain was increased. When the fish was located the gain may have been reduced to determine the most accurate position.

Figure 4: Photo showing radio-telemetry equipment.

3.3.1 Insertion Procedure

Before the radio tags were inserted into the fish they were anaesthetized in a solution of 80 liters of water, 0.8 milliliters of clove oil, and 10 milliliters of ethanol. After an average of 2 minutes the fish were ready for tag insertion.

The fish were then positioned so the radio-tag could be applied internally. A tube containing the tag was inserted in the mouth and pushed to the end of the stomach wall until resistance was felt indicating it was in the proper position. An orange Floy tag was then inserted below the dorsal fin insertion. The tagged fish were held overnight to ensure the fish did not regurgitate the tag.

Figure 5: Photo showing insertion of radio-tag into coho salmon.

The following information on each fish was recorded:

- Floy tag number,
- radio-tag channel,
- radio-tag code,
- sex and
- anaesthetized time.

3.4 Monitoring of Tagged coho

The first release of radio-tagged fish occurred on November 25th, 1999. The first 9 fish were released at two different sites along the Millstone River, four below the waterfall at 1850m and five fish just below the barriers at 2020m.

The second release of radio-tagged fish occurred on January 7th, 2000. The final eleven fish were released at three different locations into the system, at 520m, 1850m, and 2030m. There was then a total of 20 tagged fish in the River.

The monitoring of tagged coho began on November 26th, 1999, the day after the fish were released. Students from BCIT and MUC did monitoring approximately three times a week under the supervision of Mike MacIntyre. Monitoring started at the barriers (2020m) and continued to the estuary. All monitoring was done on foot; however, when access was poor a vehicle was used.

The Lotek SRX_400 telemetry receiver used, displayed the radio-tag's individual code and channel. This allowed for the identification of each individual fish. The strongest signal that was found was recorded. Ideally this signal was above 200Mhz. Upon finding the strongest signal the following was recorded:

- tag channel and code,
- maximum signal received and
- meterage.

4.0 Results

4.1 Tag information for each fish

On November 24th, 1999 nine coho (5 females, 4 males) and on January 6th, 2000 eleven coho (5 females, 6 males) were fitted with radio tags. The first nine tagged fish released into the system are found below in Table's l and ll. Channel, code, Floy tag number, sex and placement of fish either above the existing fish ladder, or below the barriers were all recorded.

TABLE l: Fish released above the fish ladder at 1850m.

Channel	Code	Floy Tag #	Sex
02	12	00516	F
02	13	00518	M
04	15	00525	F
04	16	00515	M

TABLE ll: Fish released below the barriers at 2020m.

Channel	Code	Floy Tag #	Sex
02	11	00522	M
02	14	00524	F
04	17	00519	M
04	18	00520	M
04	19	00523	F

The final eleven fish that were later released into the system are found below in Table III. Channel, code, Floy tag number, sex and release site for the eleven fish were all recorded.

Two of the tags (02/13 & 04/18) used in the first release of fish were found along the stream bank due to the mortalities of those fish. Therefore these tags could be reapplied, and used for the final eleven fish that were released into the system.

TABLE III: Information for fish released later in study.

Channel	Code	Floy Tag #	Sex	Meterage
02	13 (2nd use)	00512	M	520
04	18 (2nd use)	00514	M	520
20	20	00511	F	520
20	22	00510	F	520
20	23	00509	F	2030
20	21	00508	F	520
21	14	00507	M	520
21	26	00506	F	1850
21	25	00505	M	1850
21	27	00504	M	2030
22	29	00503	M	1850

4.2 Comparison of movement patterns to the previous year

In November 1999, nine fish were released below the barriers. However, only seven were located after the first monitoring day. Last year's study five fish were also released below the barriers with varying results. The movement patterns from the previous study is as follows:

- one fish dropped out of the system once released,
- two fish left the system for unknown reasons a few days after release,
- one fish dropped back never reaching the location of release again and
- one fish swam up the fish ladder and held below the barrier for 5 days.

This year's results have shown similar movement patterns. Most fish dropped back immediately after release and did not migrate past the barriers.

4.3 Barrier Impassibility

All twenty fish that were tagged and monitored did not ascend above the barriers. Please refer to figure 6, showing the maximum distance each fish reached in the Millstone River. However, upon release most of the tagged fish were nearing the ripe stage of the spawning period, therefore they were under natural spawning stress. Further stress was added by being captured, anaesthetized and tagged. Therefore, the fish used in this study may have exhibited non-natural behavior.

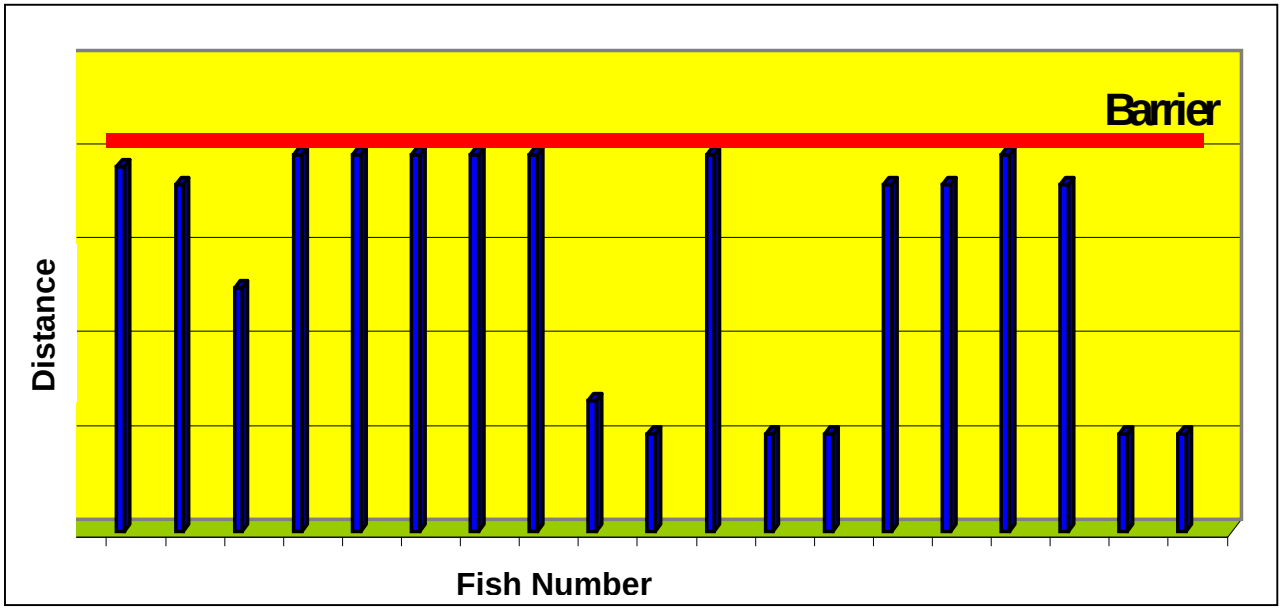

Figure 6: Maximum distance each fish reached in the Millstone River.

4.4 Movement patterns from this year's study

Channel 02 Code 12

Fish #02/12 was released at 1850m (below the fish ladder) and proceeded to move upstream to the bottom of the barriers. It then fell back to 1200m and was located three more times in this area.

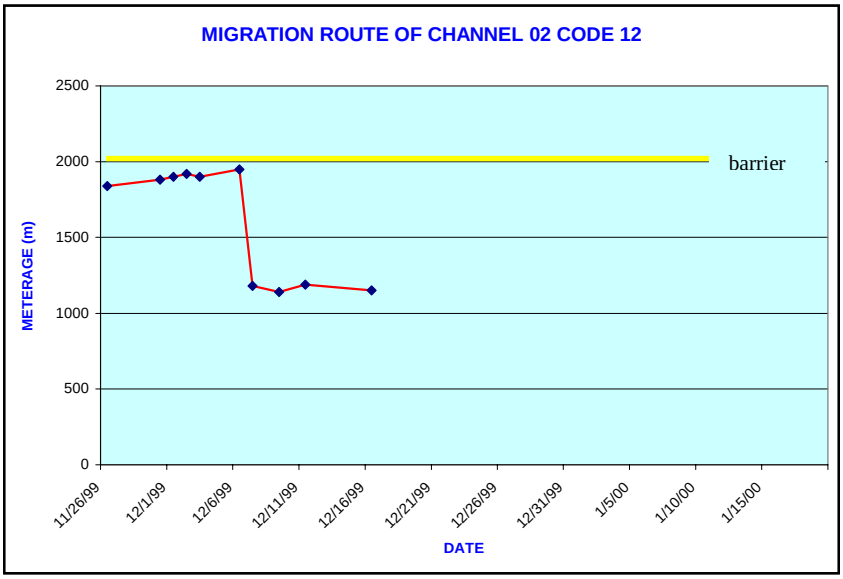

Figure 7: Data for Channel 02 Code 12

Channel 02 Code 13

Fish #02/13 was released at 1850m (below the fish ladder) and proceeded upstream until it reached the barriers. It then fell drastically downstream for a few days and then worked its way back up to the bottom of the barriers.

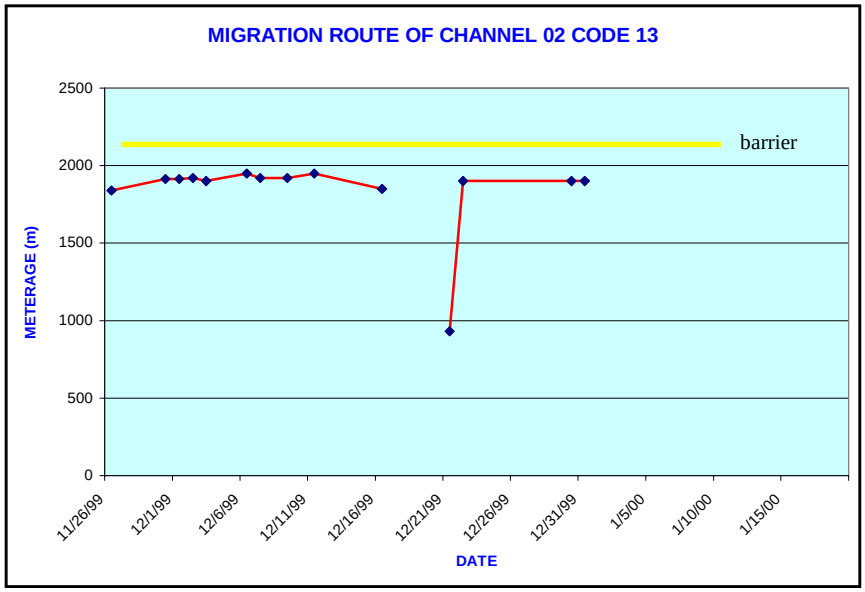

Figure 8: Data for Channel 02 Code 13

Channel 04 Code 15

Fish #04/15 was release at 1850m (below the fish ladder) and immediately fell back to 500m meters where it stayed until the end of monitoring, indicating possible death and falling to the bottom of river.

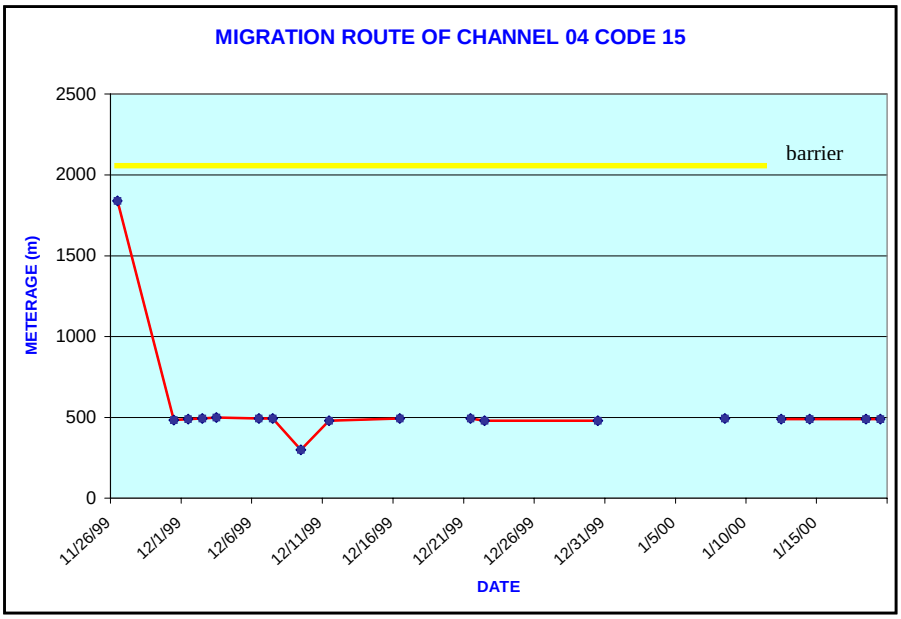

Figure 9: Data for Channel 04 Code 15

Channel 04 Code 16

Fish #04/16 was released at 1250m and stayed in this area until falling back to 500m in mid December where it stayed until the end of monitoring, indicating possible death and falling to the bottom of river.

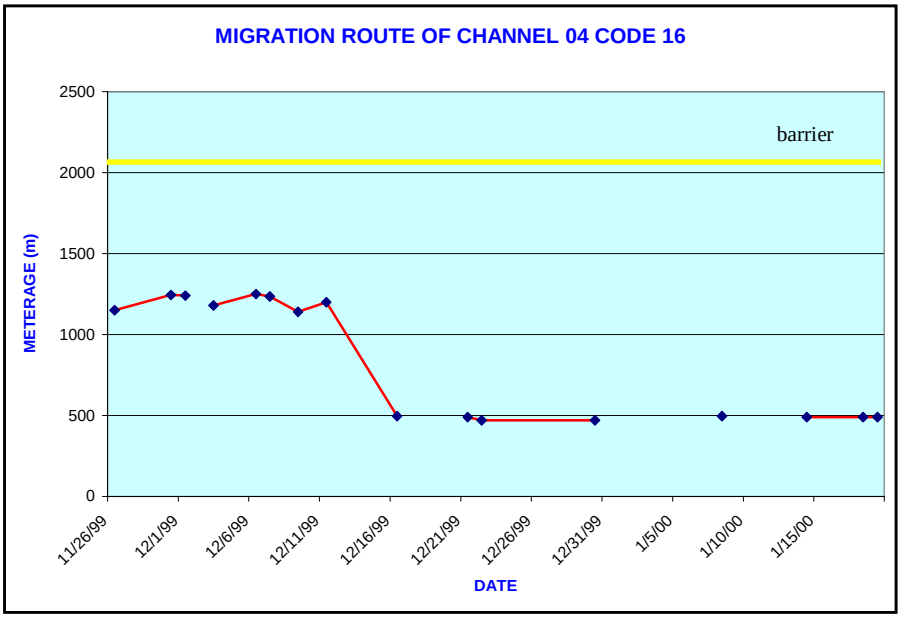

Figure 10: Data for Channel 04 Code 16

Channel 02 Code 11

Fish #0211 was released at 2020m (below the barriers) where it stayed for approximately a week. Through December and January it was found down stream a few times.

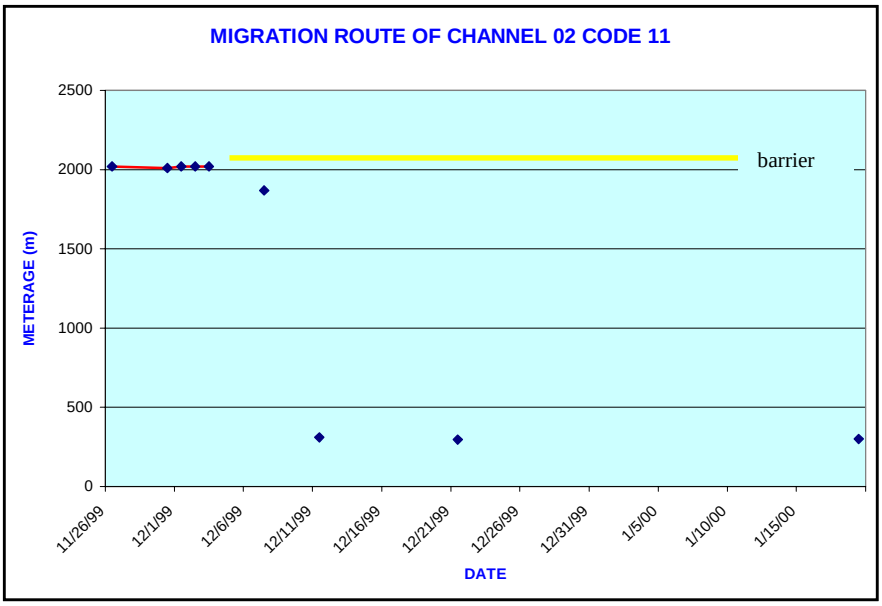

Figure 11: Data for Channel 02 Code 11

Channel 02 Code 14

Fish #02/14 was released at 2020m (below the barriers) and was not located again.

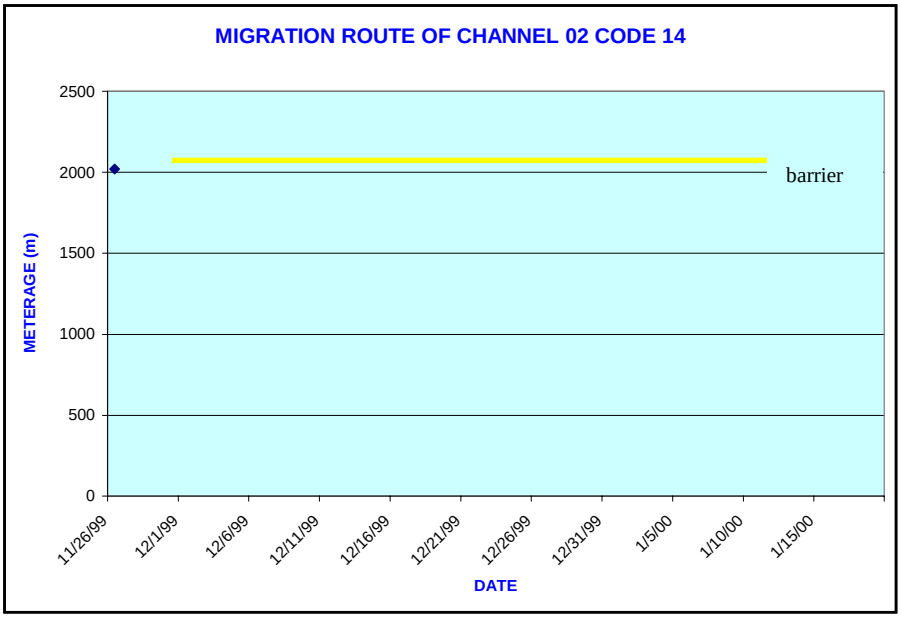

Figure 12: Data for Channel 02 Code 14

Channel 04 Code 17

Fish #04/17 was released at 2020m (below the barriers) and was not located again.

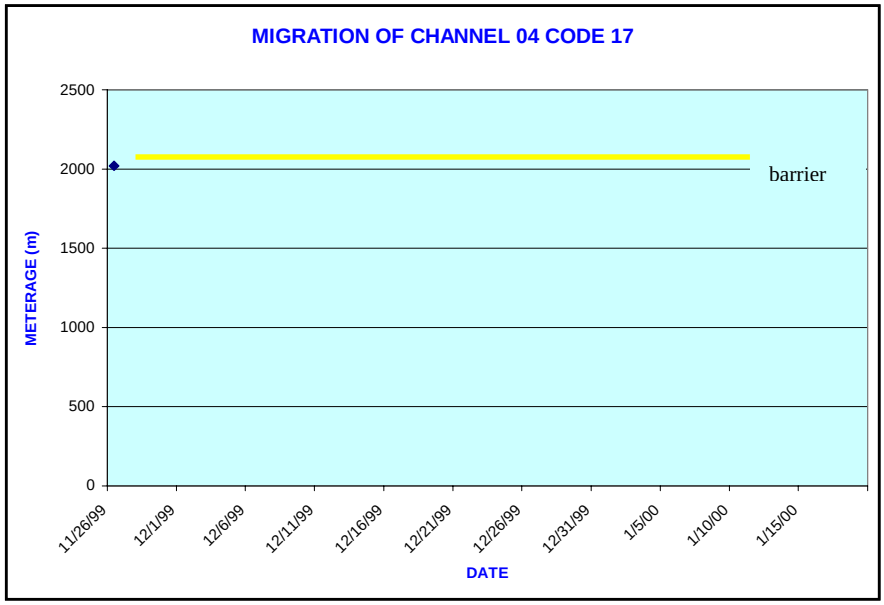

Figure 13: Data for Channel 04 Code 17

Channel 04 Code 18

Fish #04/18 was released at 2020m (below the barriers) and instantly fell back to 1000m over the next week. It then stayed in this area until mid December.

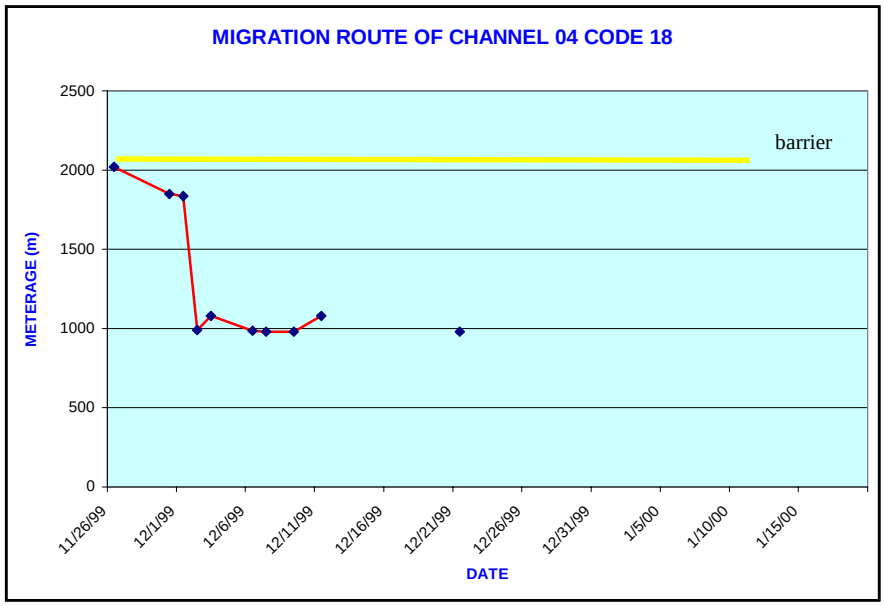

Figure 14: Data for Channel 04 Code 18

Channel 04 Code 19

Fish #04/19 was released at 2020m (below the barriers) where is remained for two weeks. It fell back to 1150m over the next few days and last located on the second week in December.

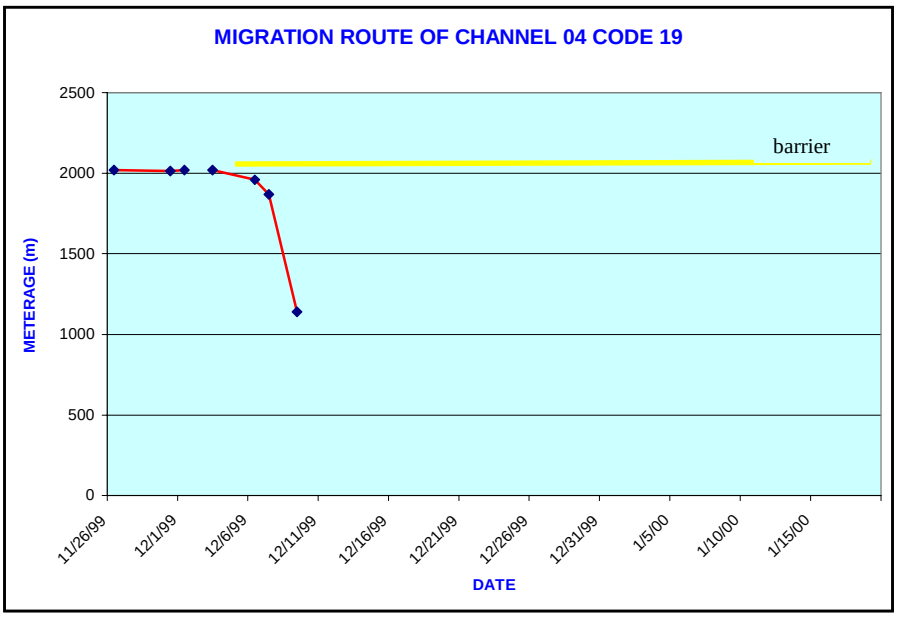

Figure 15: Data for Channel 04 Code 19

Channel 20 Code 20

Fish #20/20 was released at 520m and was then located once more the following day at 720m.

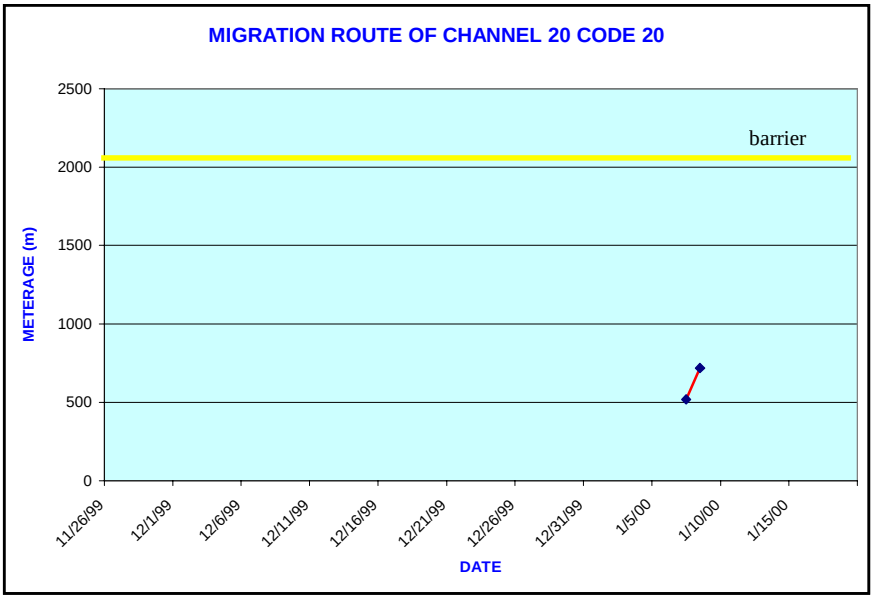

Figure 16: Data for Channel 20 Code 20

Channel 20 Code 22

Fish #20/22 was released at 520m and remained in this area for one week.

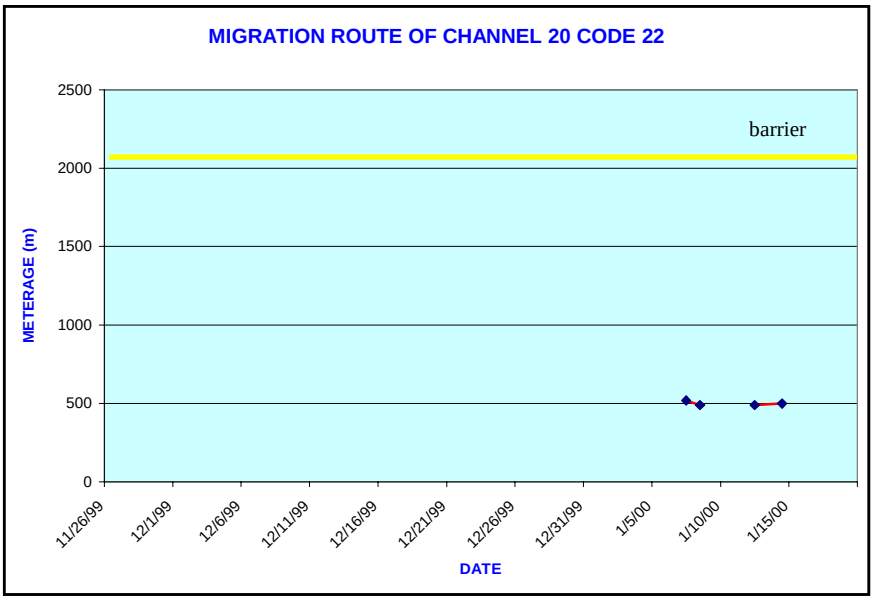

Figure 17: Data for Channel 20 Code 20

Channel 20 Code 23

Fish # 20/23 was released at 2020m (below the barriers) and fell back to 1250m over a two and a half week time period.

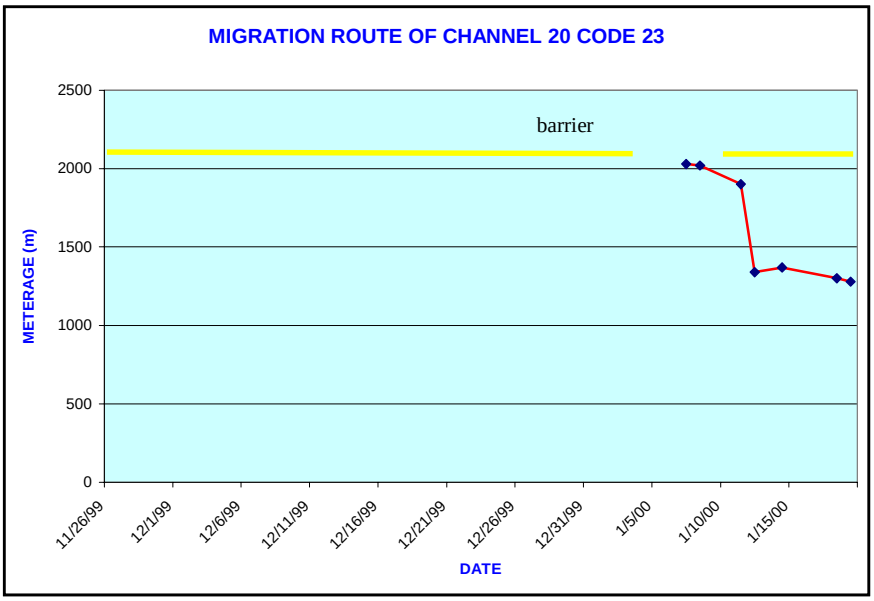

Figure 18: Data for Channel 20 Code 23

Channel 20 Code 21

Fish #20/21 was released at 520m and was located once more the following day in the same area.

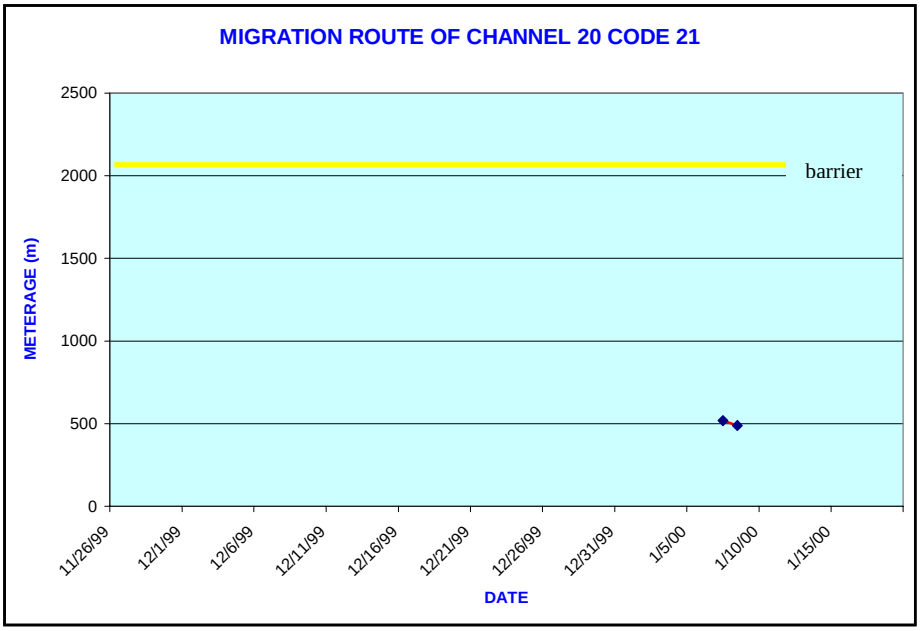

Figure 19: Data for Channel 20 Code 21

Channel 21 Code 24

Fish #21/24 was released at 520m and was located in this area for a week and a half.

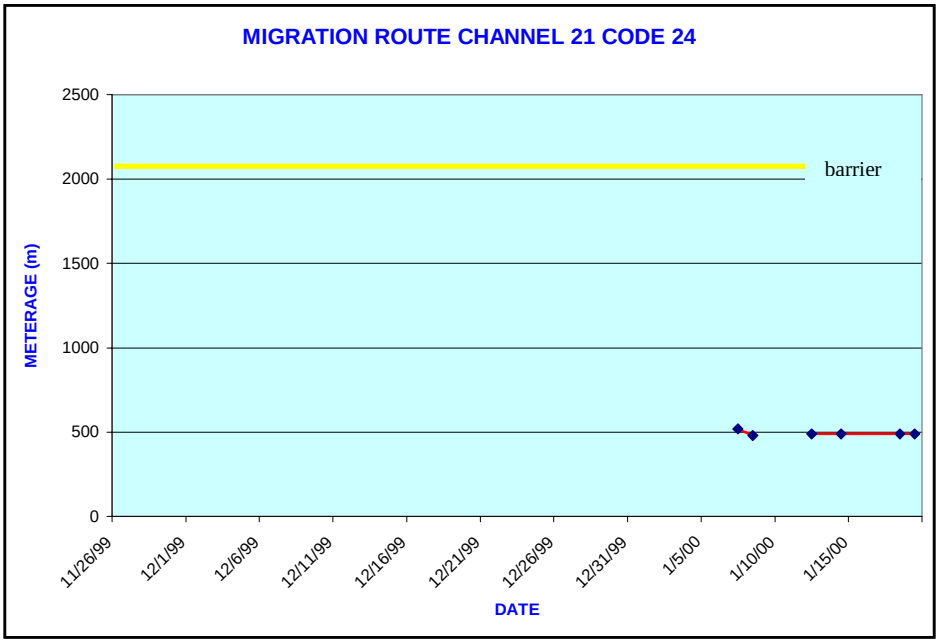

Figure 20: Data for Channel 21 Code 24

Channel 21 Code 26

Fish #21/26 was released at 1850 (below the fish ladder) and slowly fell back to 1600m over the next two and a half weeks.

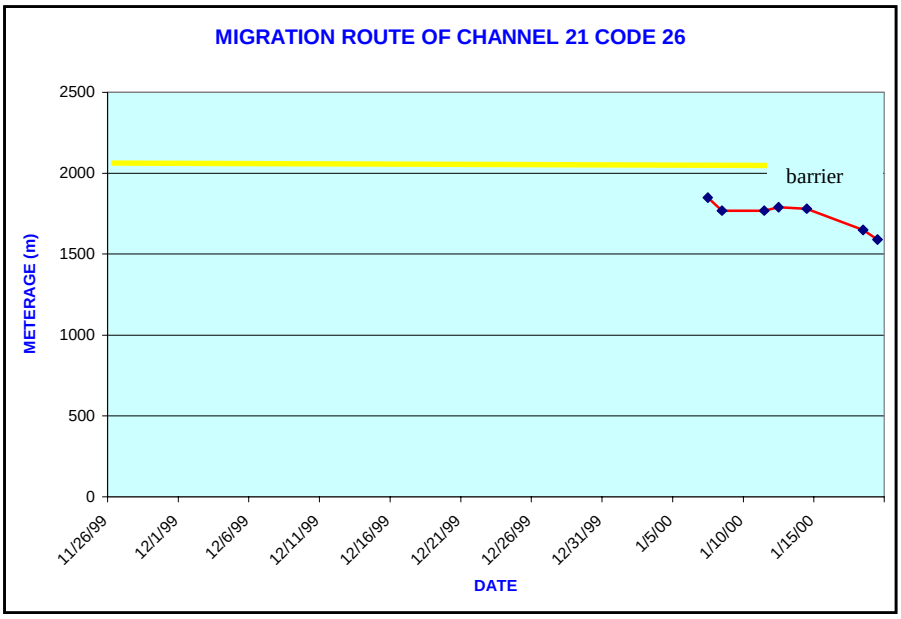

Figure 21: Data for Channel 21 Code 26

Channel 21 Code 25

Fish #21/25 was released at 1850m (below the fish ladder) and was located once more the following day at 1780m.

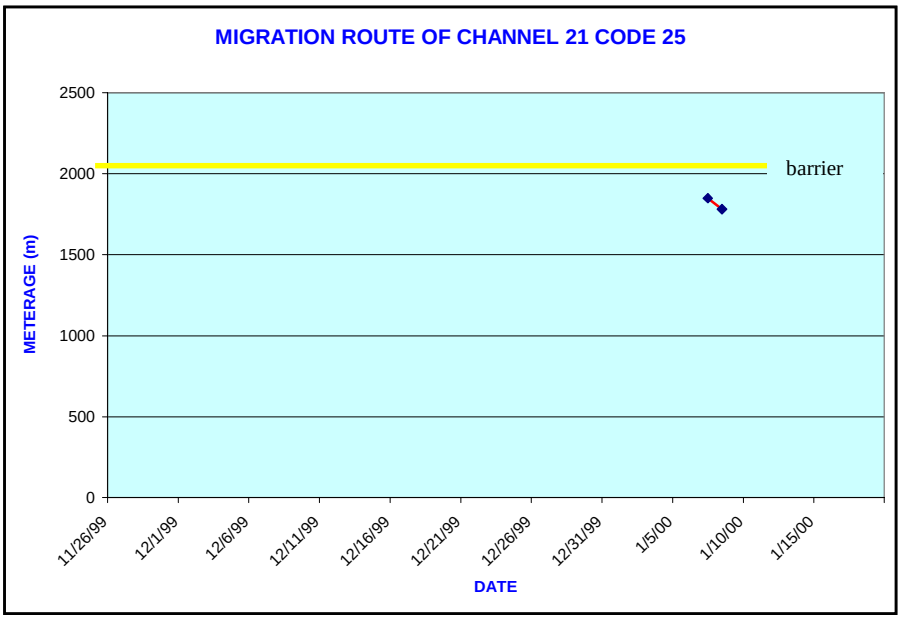

Figure 22: Data for Channel 21 Code 25

Channel 21 Code 27

Fish #21/27 was released at 2020m (below the barriers) and was located once more the following day at 1790m.

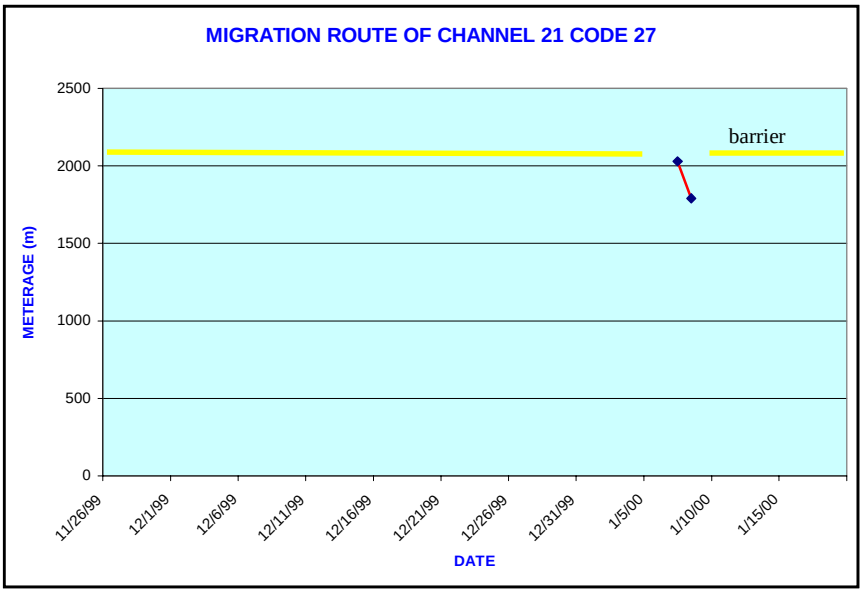

Figure 23: Data for Channel 21 Code 27

Channel 22 Code 29

Fish #22/29 was released at 1850m (below the fish ladder) and was located once more the day in the same area.

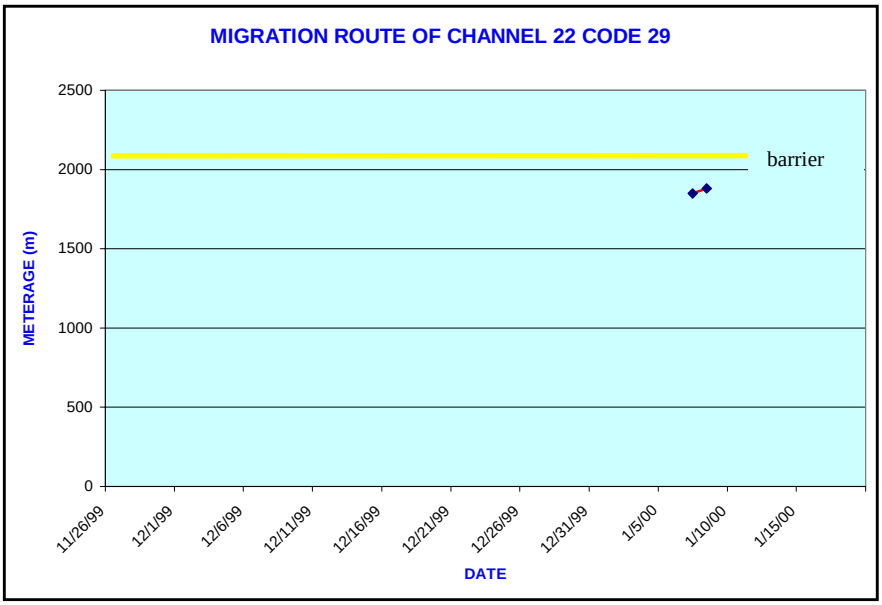

Figure 24: Data for Channel 22 Code 29

Channel 02 Code 13 (second time in use)

Fish # 02/13 was released at 520m and was located in the same area the following day. It was then located two and a half weeks later at 300m.

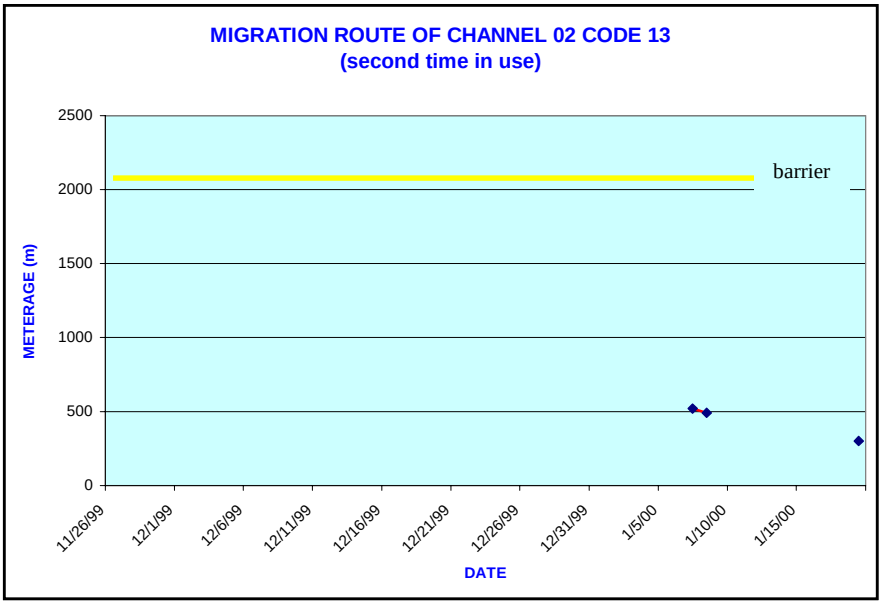

Figure 25: Data for Channel 02 Code 13 (second time in use)

Channel 04 Code 18 (second time in use)

Fish #04/18 was released at 520m and was not located again.

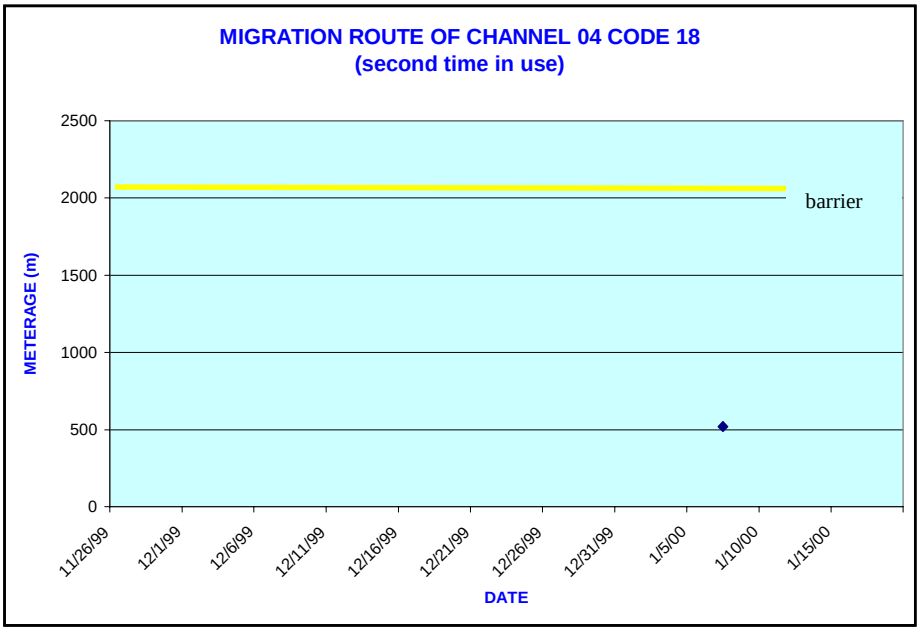

Figure 26: Data for Channel 04 Code 18 (second time in use)

5.0 Recommendations

The following recommendations concerning the bias of radio-telemetry were made after the monitoring was completed on the Millstone River:

- The saline waters in the Nanaimo estuary should be taken into consideration when monitoring. Fish that drop down to the estuary will not be located because the telemetry equipment does not work in salt water.

- The fish were taken from the Nanaimo River. Because these fish are not in their natal stream, migration may be abnormal.

- Because so many people are involved in monitoring, an education or training session may reduce bias.

6.0 Conclusions

From the data, information and observations obtained from the Millstone River Radio-tagging Project, it is apparent that the barriers in the stream are impeding the migration of coho salmon. To ensure that coho may reach upstream spawning habitat, a chain of fishways is necessary.

Continuing the Millstone River Radio-tagging project into the second year has strengthened the validity of the results from the previous year. It is evident that coho introduced into the Millstone system from the Nanaimo River will use the River and attempt to migrate upstream. This shows that coho use the habitat and could possibly establish a population in the Millstone system.

7.0 List of References

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Bookhout, T. A., 1996. Research and Management Techniques for Wildlife and Habitats. The Wildlife Society. Bethesda, Maryland: pp370 – 418

Bidgood, B.F., 1980. Field Surgical Procedure for Implantation of Radio Tags in Fish. Fisheries Research Report. 20: 3-8

Radio Telemetry Equipment & Techniques. AVM Instrument Company. Champaign Illinois {information packet}, no date

Appendices

3.0 RESULTS

3.1 Individual Movement Patterns

3.1.1 Fish Released Below the Barrier

Channel 20 Code 64

Fish #20/64 was the only fish caught and released in the Millstone estuary. This fish was never tracked in the Millstone after release and was assumed to have dropped out of the system. On Dec. 8 and 10, it was later tracked in the Nanaimo River. The behaviour of this fish may indicate that it was a Nanaimo River fish that had strayed into the Millstone estuary. As a result of this fish's behaviour and information from previous radio-tagging studies, it was decided to release subsequent fish further upstream to allow for fall back due to tagging stress.

Channel 4 Code 79

Fish #4/79 showed strong upstream movement after release (see Fig. 7). Its movements are significant in that it passed through the existing fish ladder (1800 m) and proceeded to the base of the first barrier (1960 m). The fish held immediately below the barrier for five days before dropping back. This behaviour indicates that the existing fish ladder is still passable by salmonids and that the fist barrier appears to be an obstacle to migration.

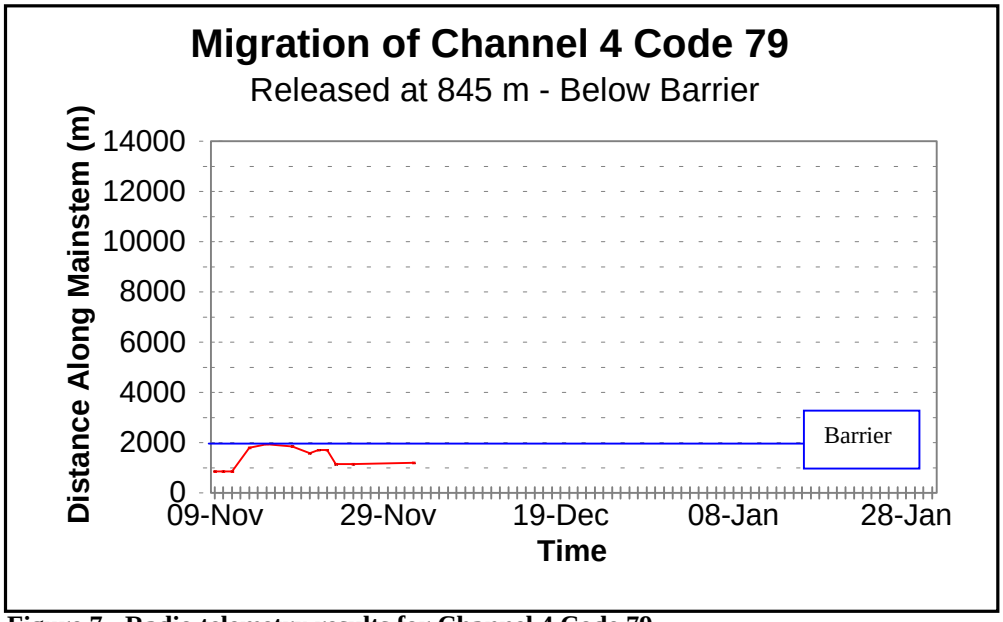
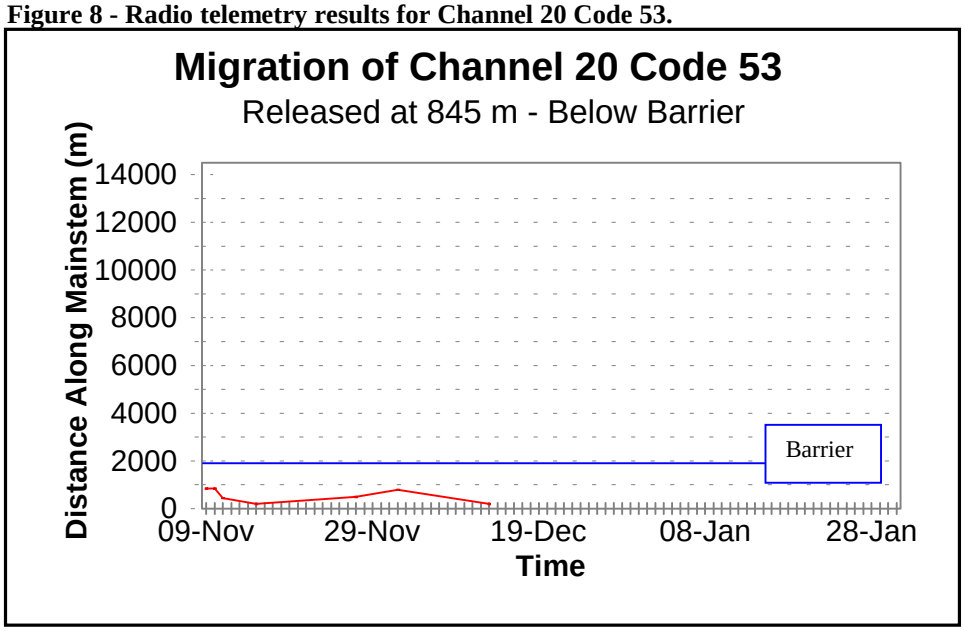


Figure 7 - Radio telemetry results for Channel 4 Code 79

Channel 20 Code 53

Fish #20/53 initially fell back after release as a result of tagging stress (see Fig. 8). It then progressed upstream but never exceeded the point of release. The fish was tracked in the river for five weeks after which time it is believed to have left the system.

Figure 8 - Radio telemetry results for Channel 20 Code 53.



Channel 2 Code 79

Fish #2/79 initially fell back after release as a result of tagging stress (see Fig. 9). It then briefly returned to the area of release before apparently leaving the system although the cause of its disappearance is unknown.

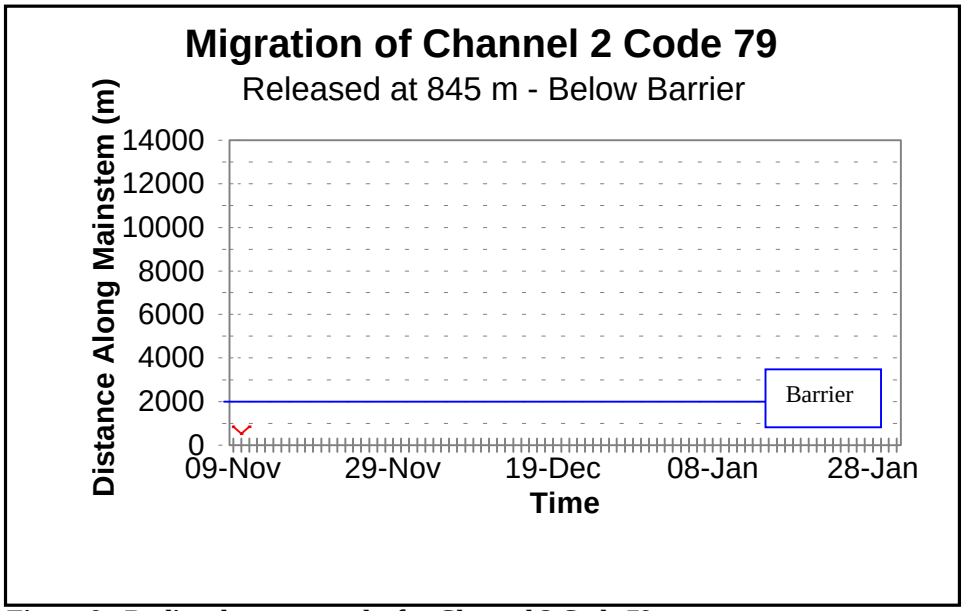


Figure 9 - Radio telemetry results for Channel 2 Code 79.

Channel 20 Code 63

Fish #20/63 held in the area of its release for three days before falling back and apparently leaving the system (see Fig. 10).

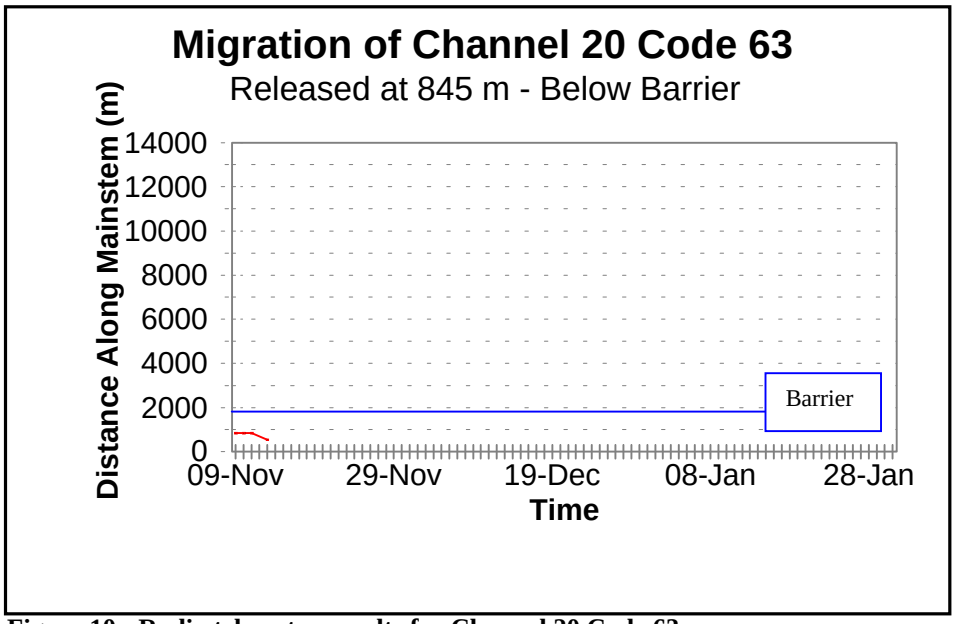
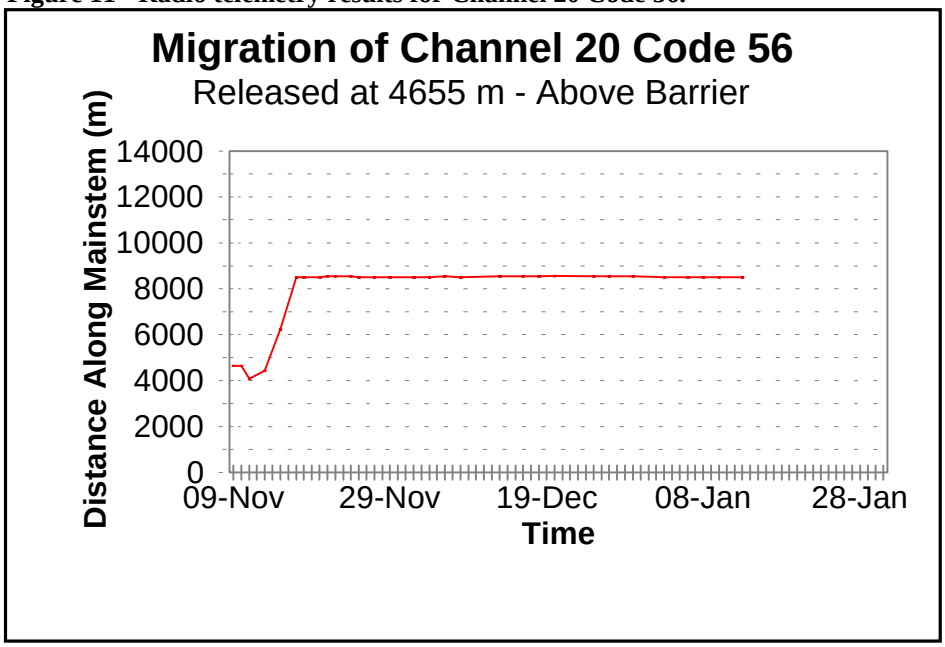


Figure 10 - Radio telemetry results for Channel 20 Code 63.

3.1.2 Fish Released Above the Barriers

Channel 20 Code 56
Fish #20/56 initially fell back after release as a result of tagging stress (see Fig. 11). It then proceeded upstream into an area previously surveyed as prime spawning habitat and remained there for an extended period.

Figure 11 - Radio telemetry results for Channel 20 Code 56.



Channel 20 Code 80
Fish #20/80 showed marginal attempts at holding in the area of its release before proceeding to fall out of the system (see Fig. 12).

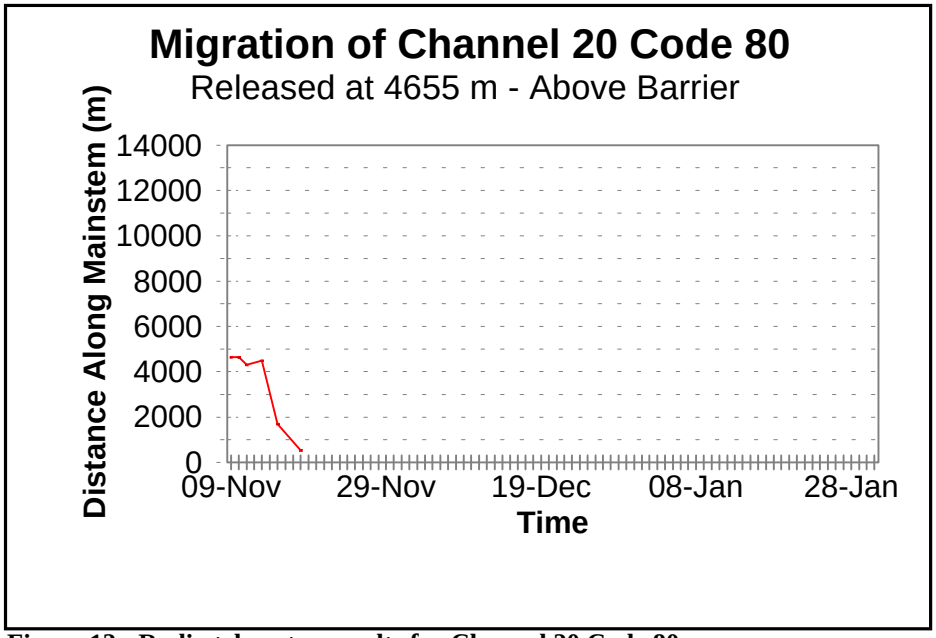


Figure 12 - Radio telemetry results for Channel 20 Code 80.

Channel 4 Code 51

Fish #4/51 fell back immediately after release (see Fig. 13). This fish showed no upstream movement and was last located at 1200 m before the telemetry signal was lost.

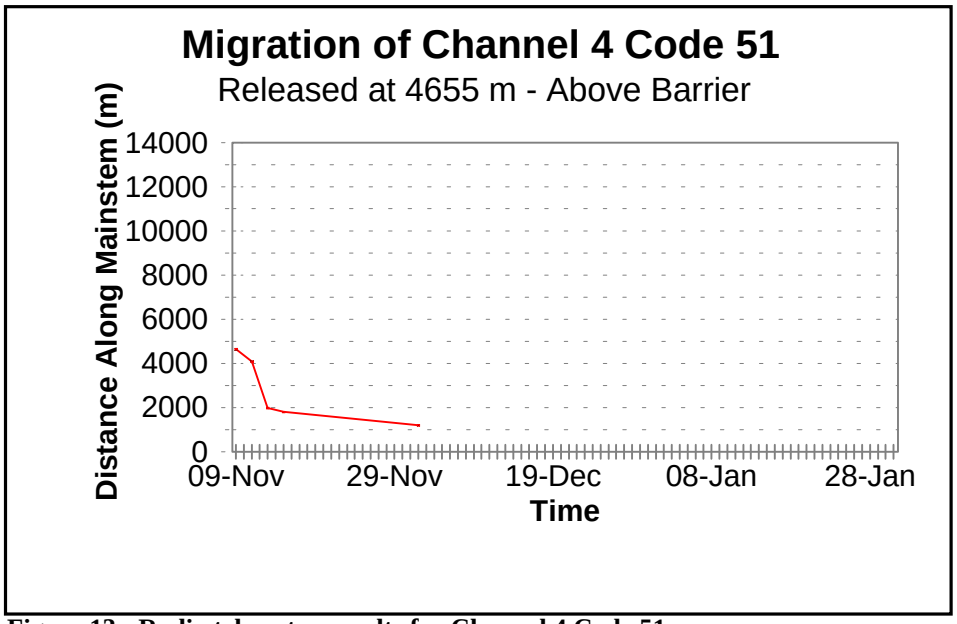


Figure 13 - Radio telemetry results for Channel 4 Code 51.

Channel 20 Code 62

Fish #20/62 is significant as its movements were tracked through the entire study duration (see Fig. 14). It appears to have remained alive during this time as it demonstrated significant variability in position which is unlikely to be tracking error. This behaviour may indicate suitable spawning habitat between 4000 and 5000 metres.

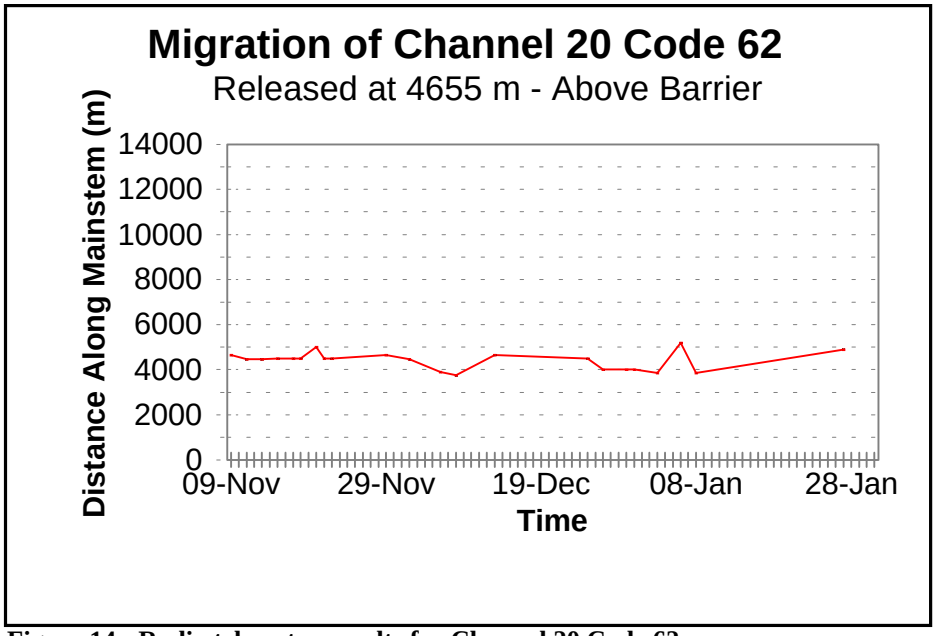


Figure 14 - Radio telemetry results for Channel 20 Code 62.

Channel 20 Code 52

Fish #20/52 maintained its position between 4000 and 5000 metres (see Fig. 15). This behaviour may indicate suitable spawning habitat in this area. It should be noted that this fish was found holding in the vicinity of another tagged fish of the opposite sex (Ch. 20 Code 62).

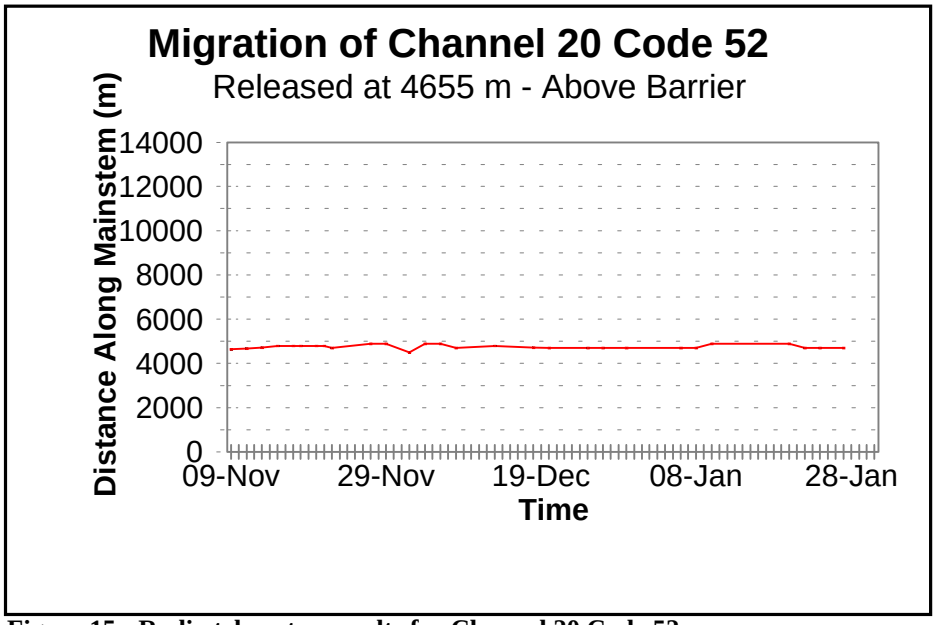


Figure 15 - Radio telemetry results for Channel 20 Code 52.

Channel 20 Code 55

Fish #20/55 was only tracked once (Dec. 25, 1998) after its release date. It is impossible to interpolate the movements of this fish between these two readings. The tag was not picked up after this point and its whereabouts are unknown (see Fig. 16).

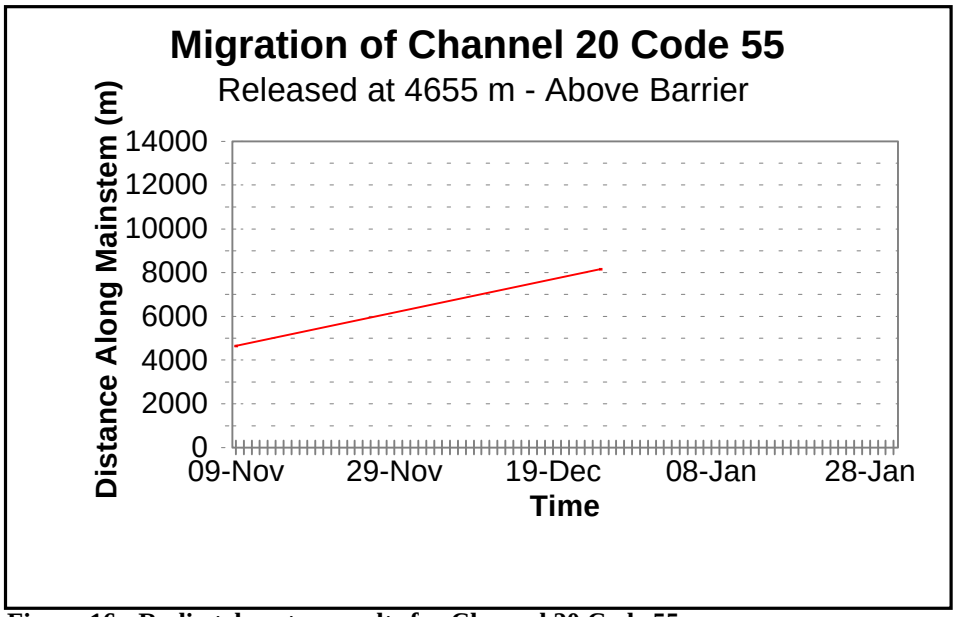


Figure 16 - Radio telemetry results for Channel 20 Code 55.

Channel 20 Code 66

Fish #20/66 is believed to have regurgitated its tag immediately after release due to the lack of movement (see Fig. 17).

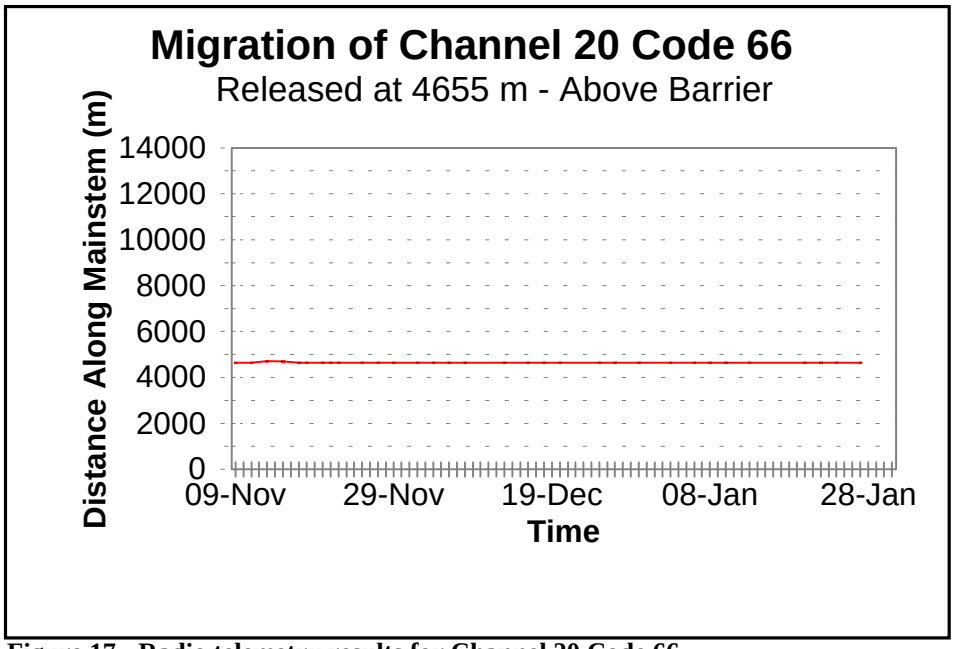


Figure 17 - Radio telemetry results for Channel 20 Code 66.

Channel 20 Code 54

Fish #20/54 showed significant downstream movement immediately after release and is believed to have left the system (see Fig. 18).

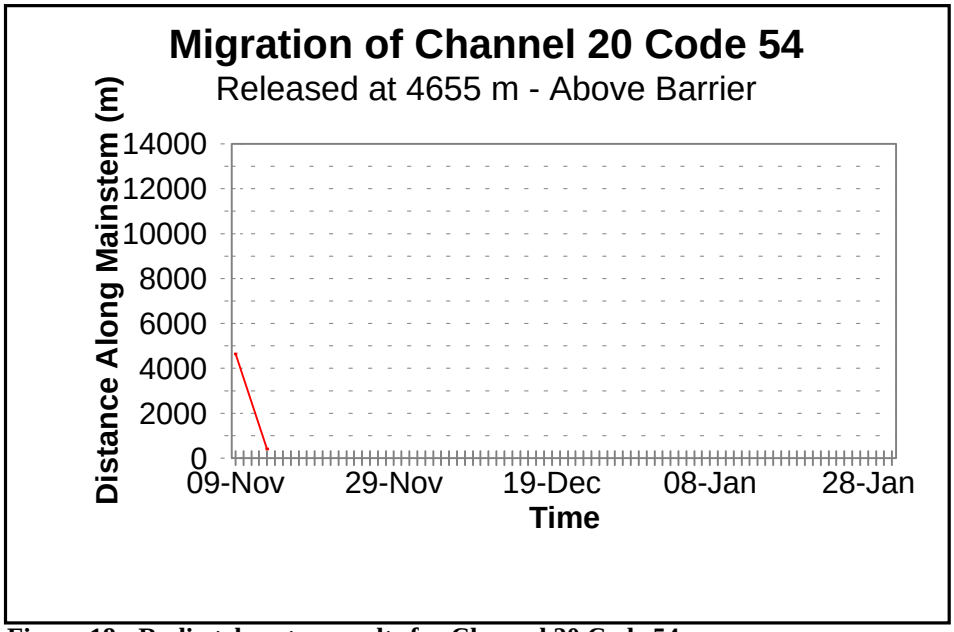


Figure 18 - Radio telemetry results for Channel 20 Code 54.

Channel 20 Code 60

Fish #20/60 showed strong upstream movement after release (see Fig. 19). This fish was one of four individuals that spent time in McGarrigle Creek. After exiting McGarrigle Creek this fish moved upstream to an area with suitable spawning habitat at approximately 13,000 metres. After Dec. 20, 1999, the signal was lost. As there are significant signs of otters in this area, it is believed that the fish was predated and the tag removed from the river.

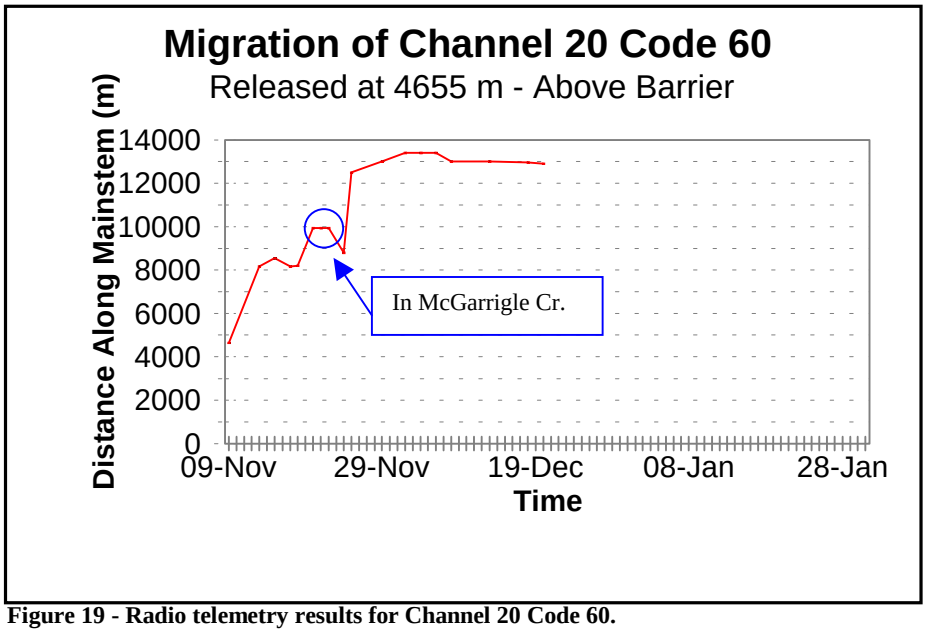


Figure 19 - Radio telemetry results for Channel 20 Code 60.

Channel 20 Code 59

Fish #20/59 showed strong upstream movement after release (see Fig. 20). This fish was the second of four individuals that spent time in McGarrigle Creek. After exiting McGarrigle Creek this fish moved upstream to approximately 13,000 metres before immediately moving back downstream. The fish was most likely predated at 1050 metres, as the tag remained stationary at this point and was later recovered six metres up the stream bank.

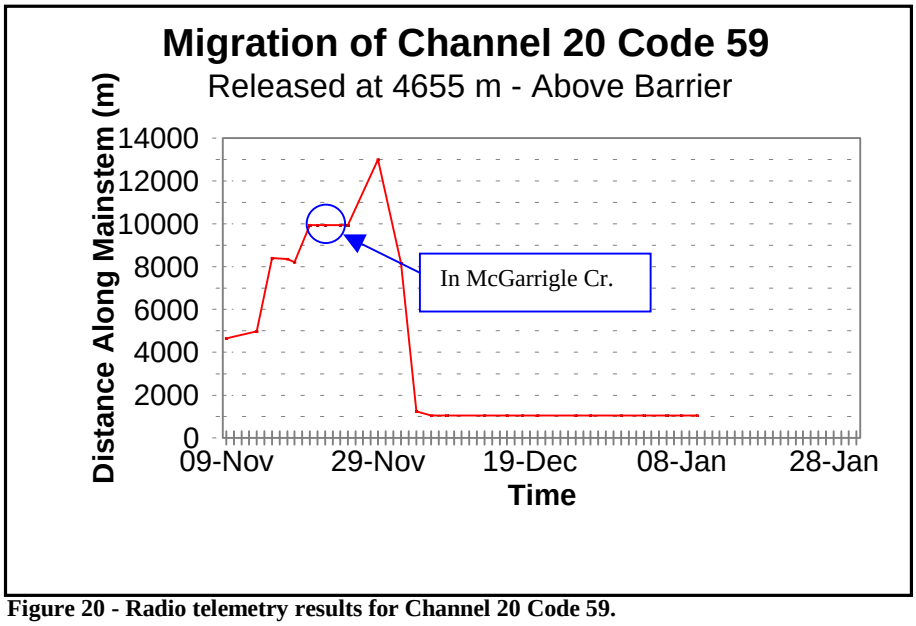


Figure 20 - Radio telemetry results for Channel 20 Code 59.

Channel 20 Code 57

Fish #20/57 showed strong upstream movement and was tracked once in McGarrigle Creek (see Fig. 21). It then returned to the mainstem and held in suitable spawning habitat around 8000 to 9000 metres. The signal was stationary after Dec. 7, 1998, possibly indicating mortality.

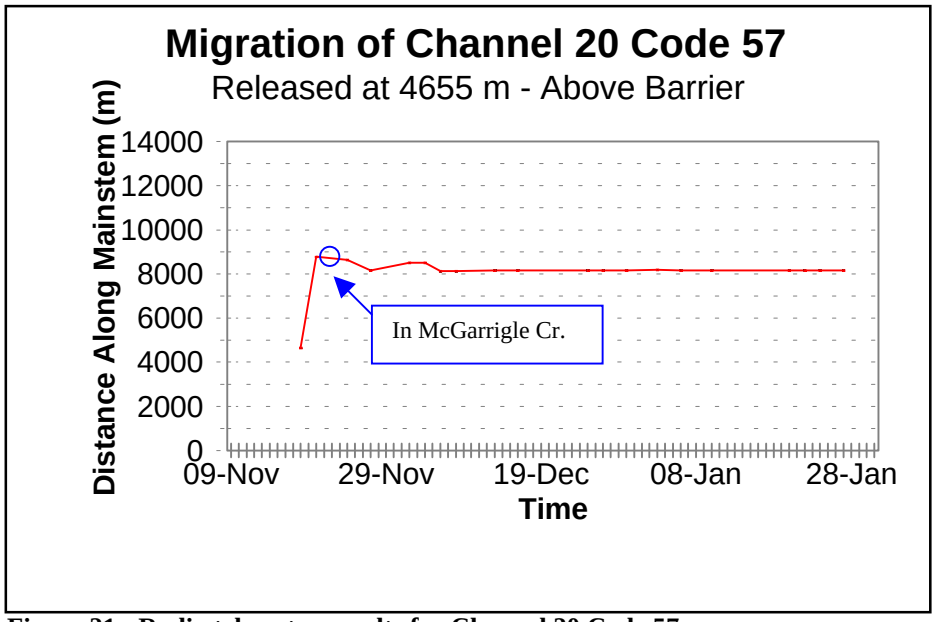


Figure 21 - Radio telemetry results for Channel 20 Code 57.

Channel 4 Code 9

Fish #4/9 showed strong upstream movement after release (see Fig. 22). Of all tagged fish that resided in McGarrigle Creek, this fish spent the longest period of time. After leaving the creek, the fish spent an extended period between 8500 and 8600 metres, where its tag was later recovered. This area has good quality spawning substrate.

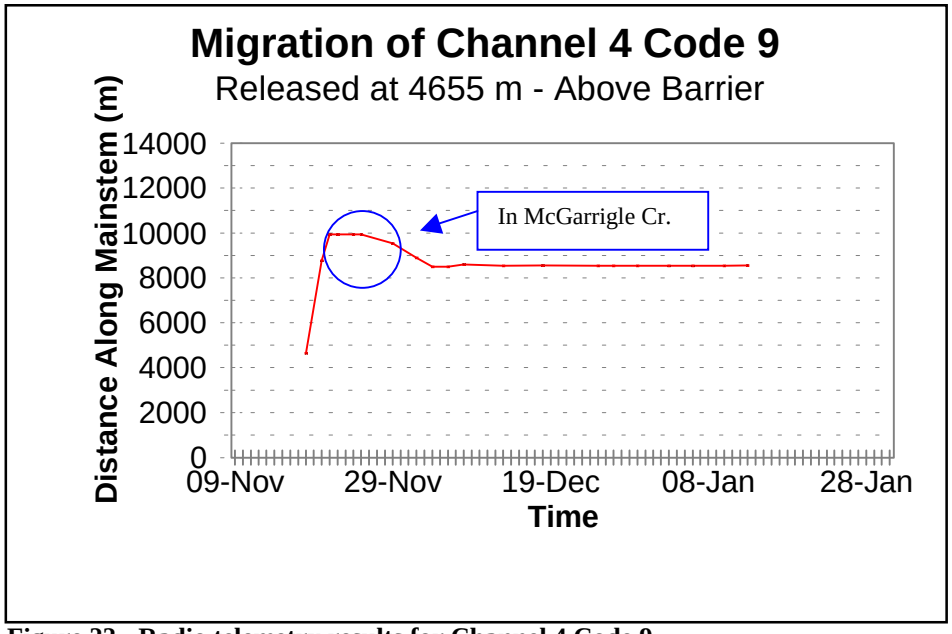


Figure 22 - Radio telemetry results for Channel 4 Code 9.

Channel 10 Code 75

Fish #10/75 showed significant upstream movement after release (see Fig. 23). It held for three days in habitat deemed suitable for spawning then progressed steadily downstream. It is believed that the fish died around 3,900 metres and that variation in its position after Dec. 13, 1998 is a result of tracking error due to this area's inaccessibility.

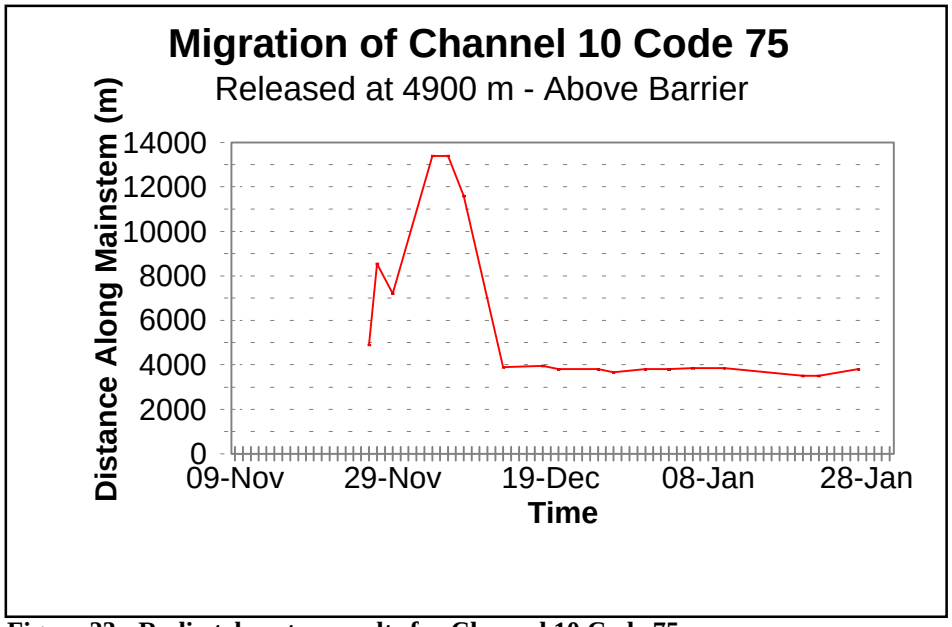


Figure 23 - Radio telemetry results for Channel 10 Code 75.

Channel 10 Code 72

Fish #10/72 fell back immediately after release, probably due to tagging stress (see Fig. 24). It subsequently visited two areas of suitable spawning habitat, at 5000 and 8000 metres. By the end of the study, the fish was likely moribund and holding around 4800 metres.

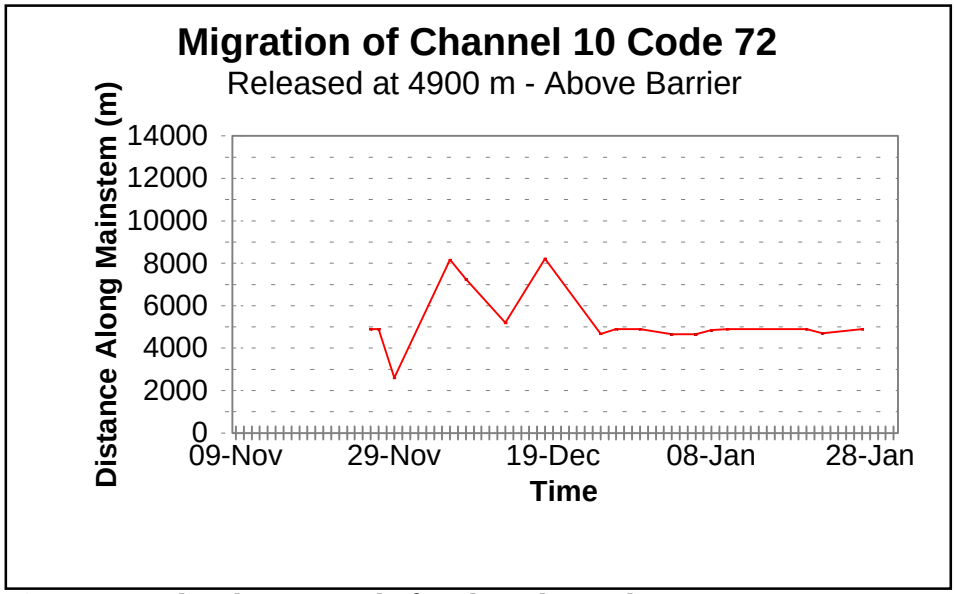


Figure 24 - Radio telemetry results for Channel 10 Code 72.

Channel 10 Code 52

Fish #10/52 fell back immediately after release (see Fig. 25). It appears that this fish was either predated around 650 metres or left the system. Seals were seen in this vicinity during this time period and may have ingested the tag, removing it from the system.

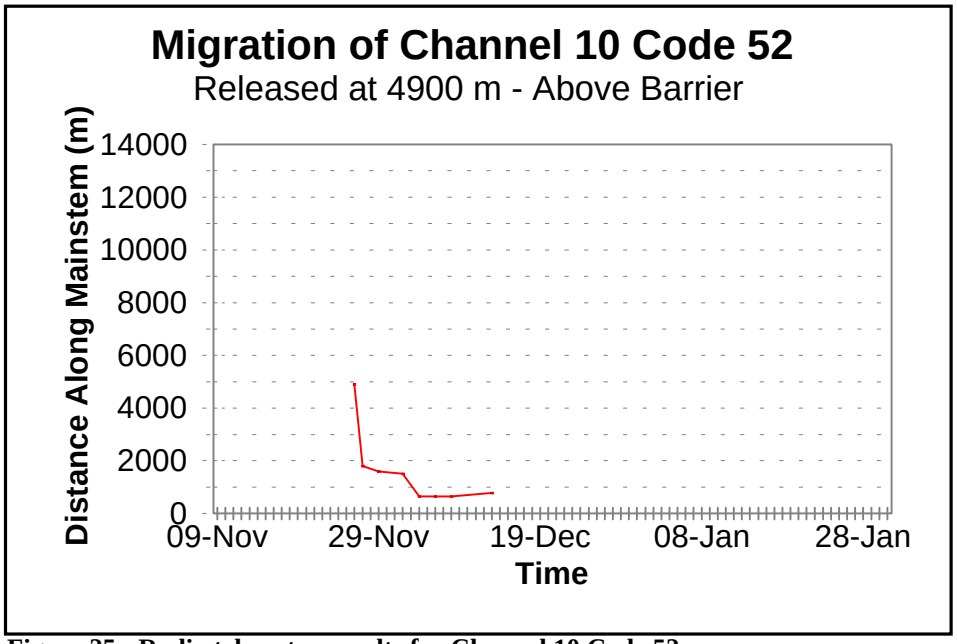


Figure 25 - Radio telemetry results for Channel 10 Code 52

Channel 10 Code 73

Fish #10/73 showed significant upstream movement after release (see Fig. 26). It then held for an extended period between 12,500 and 13,500 metres in an area containing suitable spawning habitat.

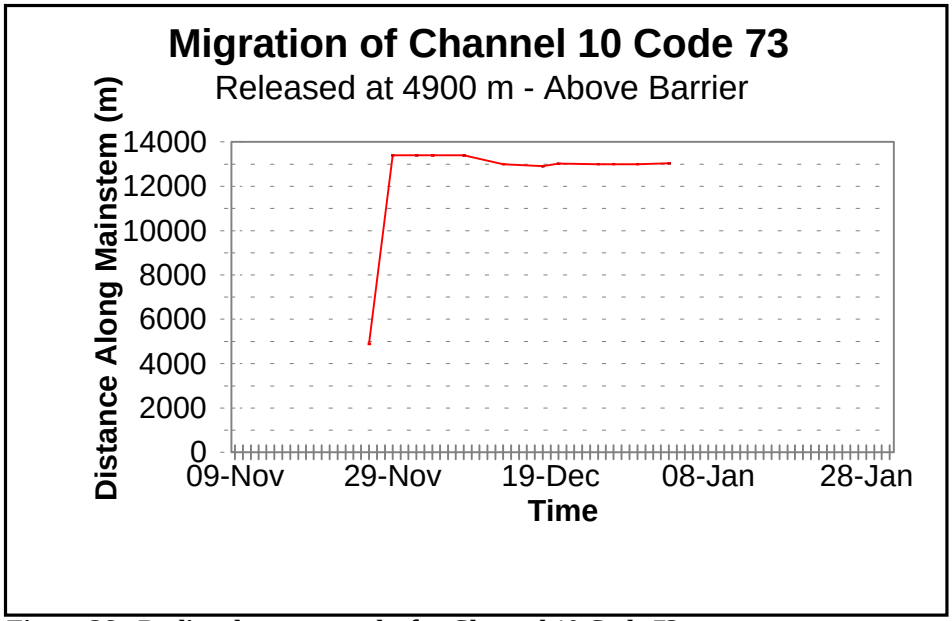


Figure 26 - Radio telemetry results for Channel 10 Code 73.

Channel 20 Code 51

Fish #20/51 immediately left the system after being released (see Fig. 27).

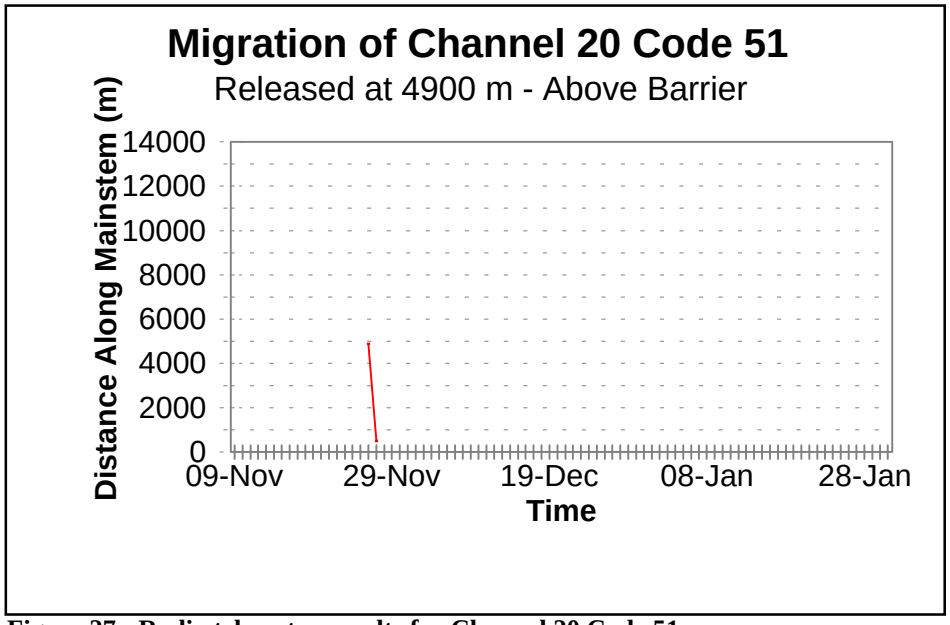


Figure 27 - Radio telemetry results for Channel 20 Code 51.

Channel 20 Code 65

Fish #20/65 is believed to have left the system after a short time period, although predation may occurred (Fig. 28).

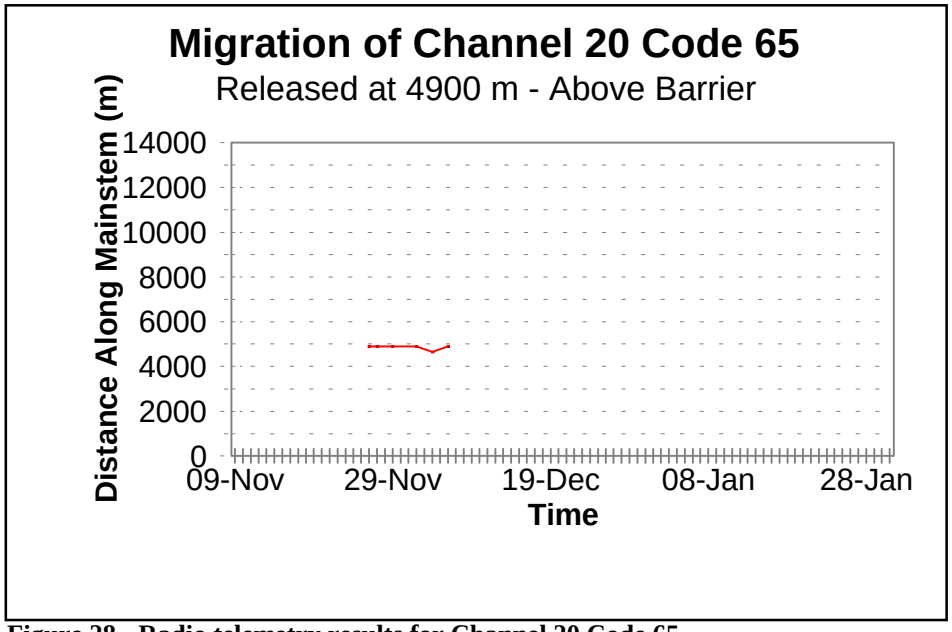


Figure 28 - Radio telemetry results for Channel 20 Code 65.

Channel 20 Code 67

Fish #20/67 showed significant upstream movement after release (see Fig. 29). This fish moved into good spawning habitat and remained there until the end of the study.

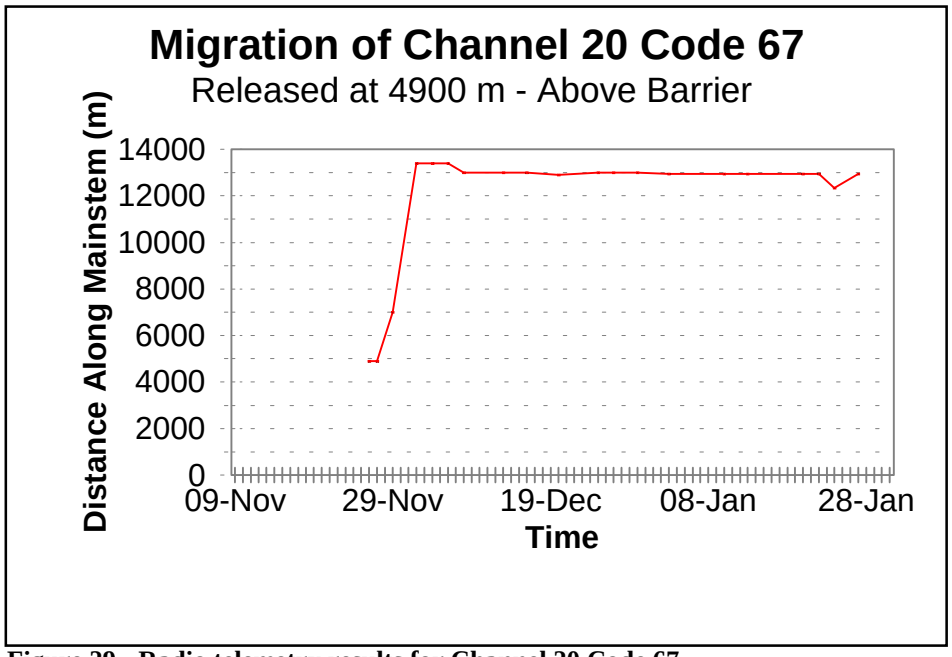


Figure 29 - Radio telemetry results for Channel 20 Code 67.

Channel 13 Code 51

Fish #13/51 is believed to have left the system after a short time period, although predation may have occurred (Fig. 30).

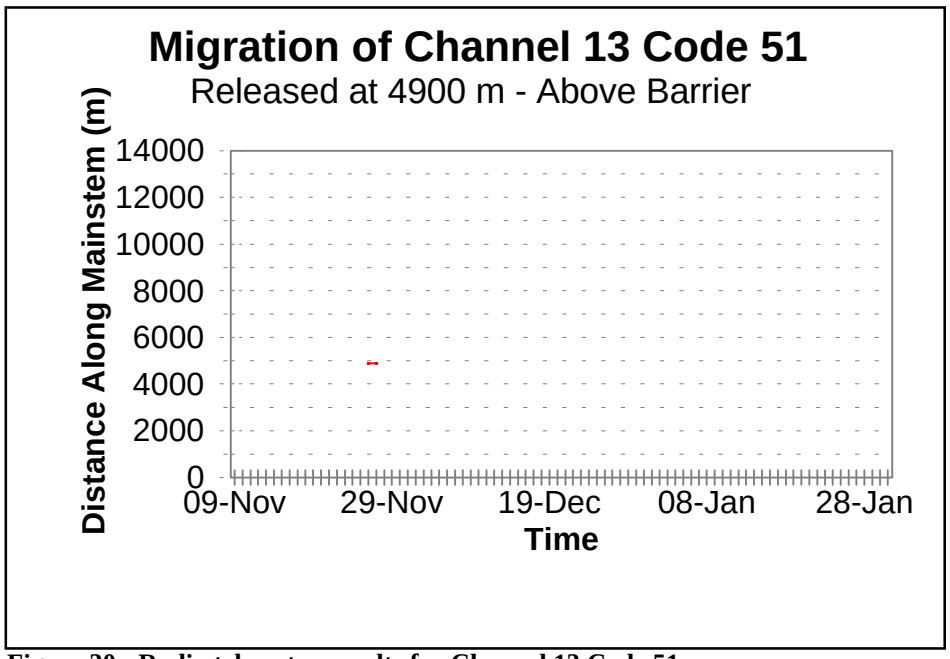


Figure 30 - Radio telemetry results for Channel 13 Code 51.

Channel 10 Code 63

Fish #10/63 held near its release site between 7500 and 8500 metres and appeared to still be alive at the end of the study (see Fig. 31).

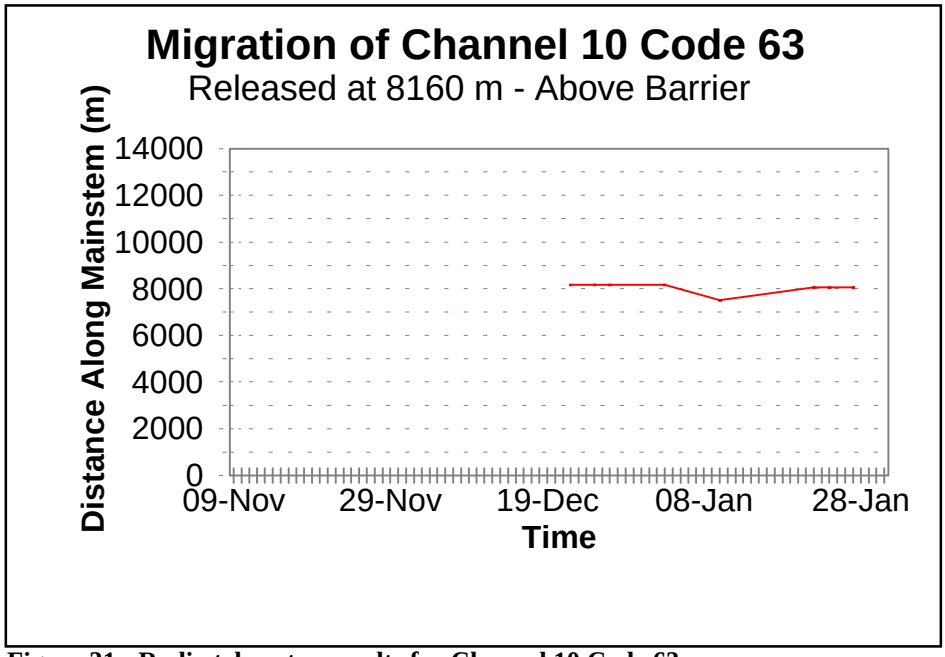


Figure 31 - Radio telemetry results for Channel 10 Code 63.

Channel 20 Code 58

Fish #20/58 is believed to have left the system after a short time period, although predation may have occurred (Fig. 32).

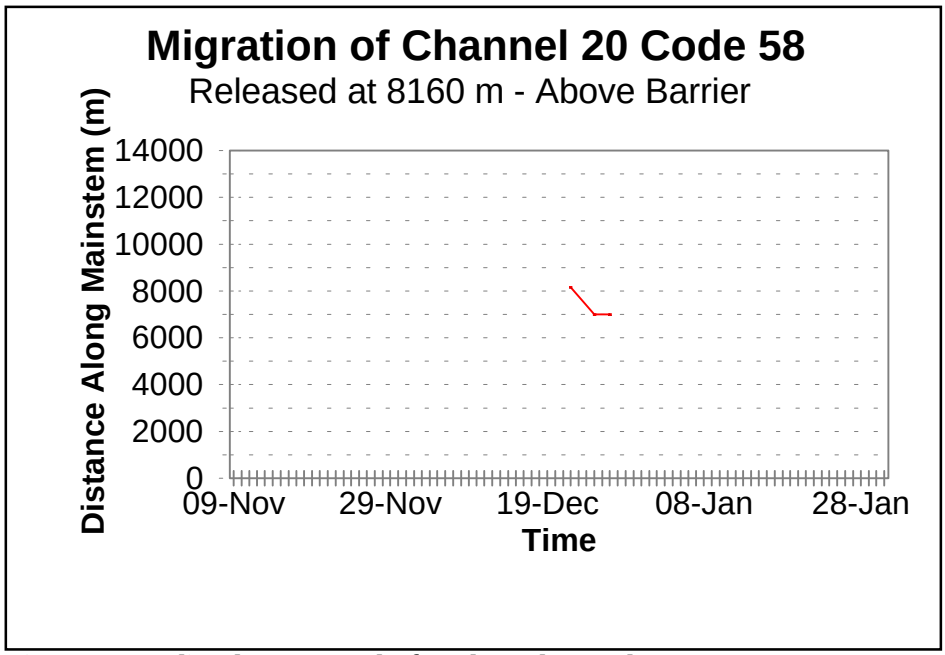
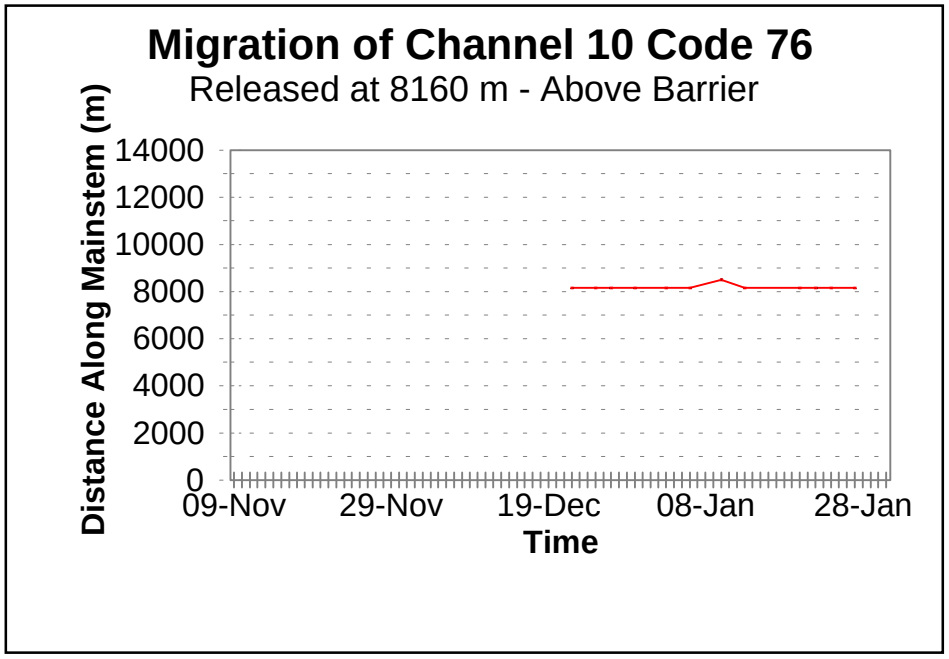


Figure 32 - Radio telemetry results for Channel 20 Code 58.

Channel 10 Code 76

Fish #10/76 held between 8160 and 8500 metres after its release (see Fig. 33). It is believed that there was more fish movement than the graph indicates due to tracking inconsistencies. It should also be noted that this area has suitable spawning habitat and that fish released in other locations were found holding in the vicinity.

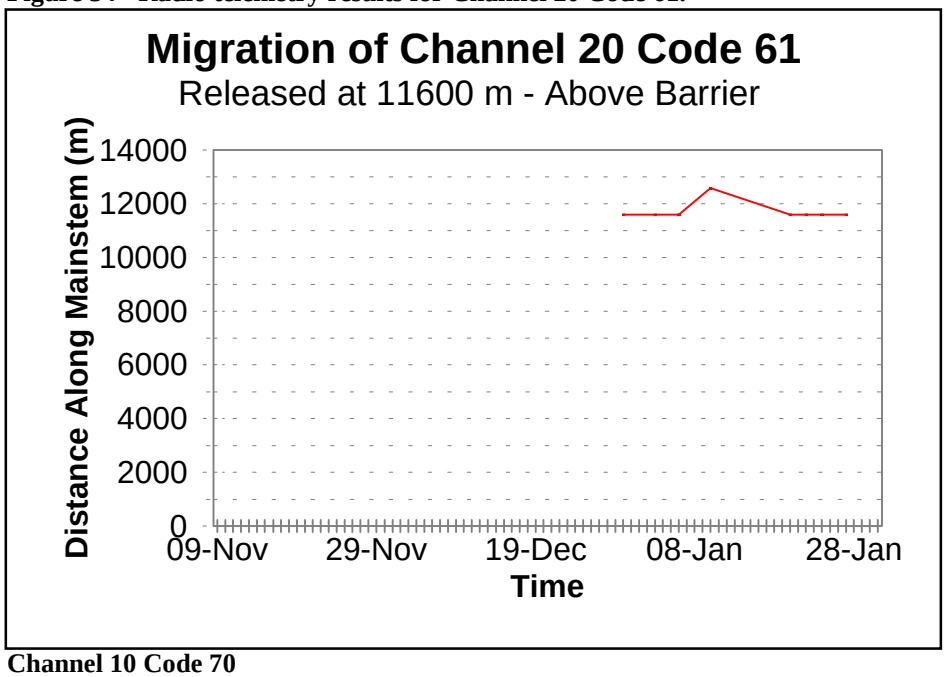
Figure 33 - Radio telemetry results for Channel 10 Code 76.



Channel 20 Code 61

Fish #20/61 showed no signs of tagging stress and continued to hold in the vicinity of its release site (see Fig. 34).

Figure 34 - Radio telemetry results for Channel 20 Code 61.



Channel 10 Code 70

Fish #10/70 moved downstream immediately upon release. It proceeded to hold in habitat suitable for spawning between 8000 and 8500 metres (see Fig. 35). It was unknown if the fish was still alive at the end of the study.

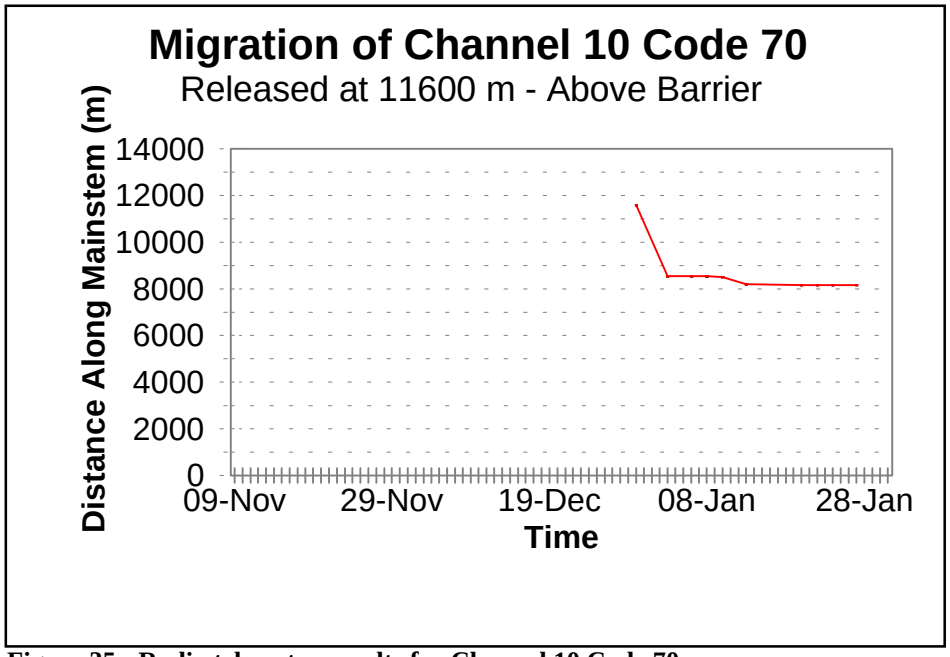


Figure 35 - Radio telemetry results for Channel 10 Code 70.

Channel 10 Code 74

Fish # 10/74 showed minimal upstream movement upon release then proceeded to return to the area of release, where it remained for the duration of the study (see Fig. 36).

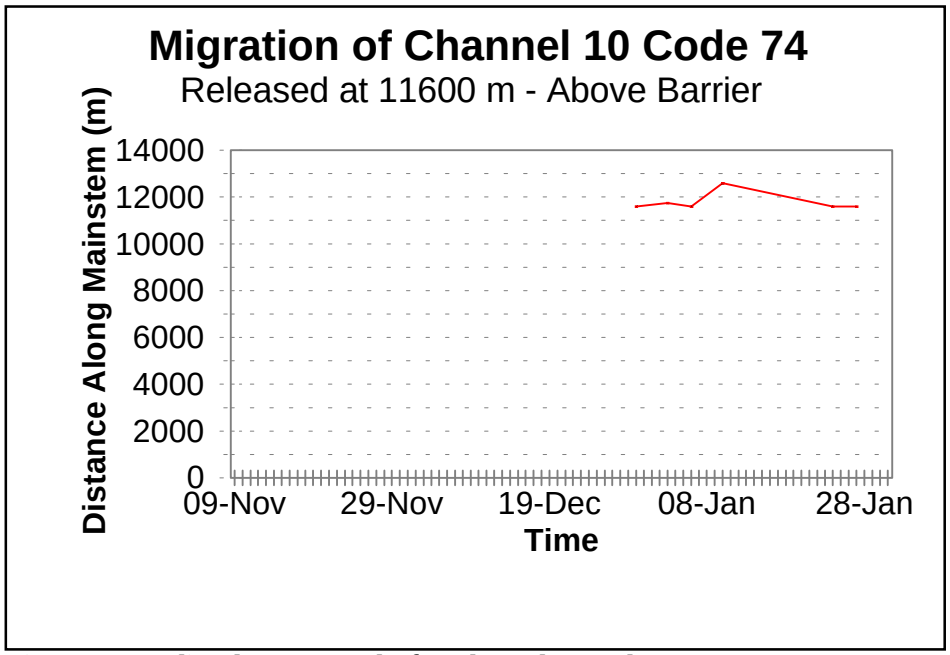
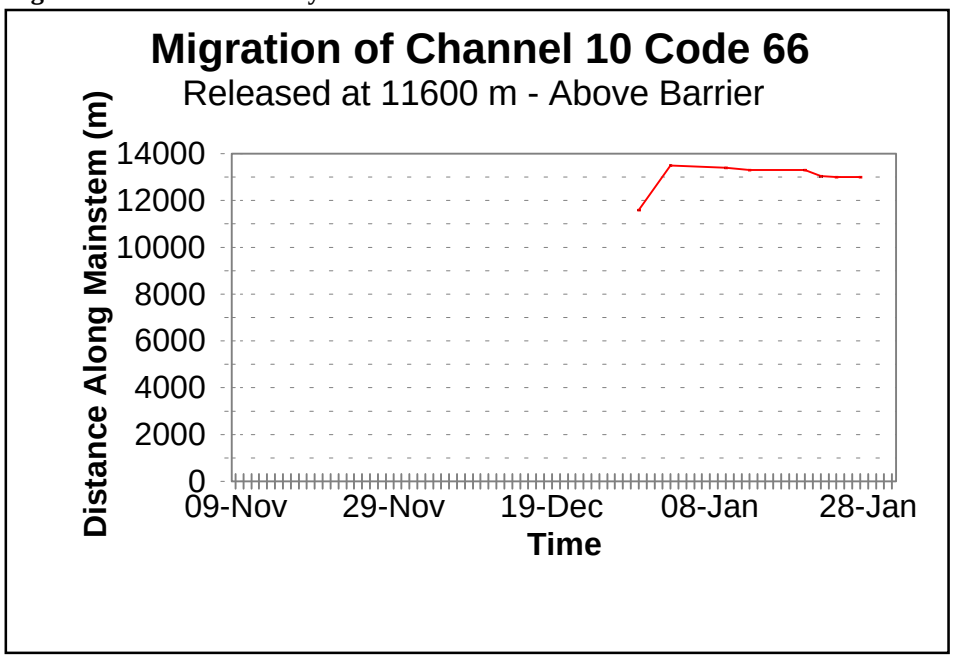


Figure 36 - Radio telemetry results for Channel 10 Code 74.

Channel 10 Code 66

Fish #10/66 moved upstream immediately upon release into an area of suitable spawning habitat at 13,000 to 13,500 metres. This fish was recorded holding in this area in the vicinity of other tagged fish during the same time period (see Fig 37).

Figure 37 - Radio telemetry results for Channel 10 Code 66.



Channel 10 Code 51

Fish #10/51 also moved upstream immediately upon release into an area of suitable spawning habitat at 13,000 to 13,500 metres. This fish was recorded holding in this area in the vicinity of other tagged fish during the same time period (see Fig 38).

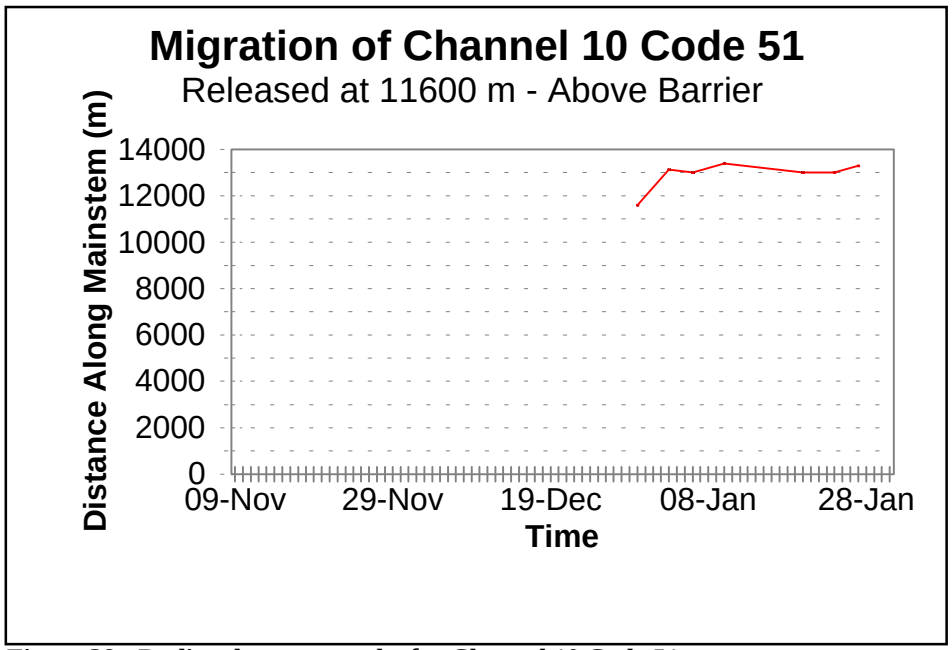


Figure 38 - Radio telemetry results for Channel 10 Code 51.

Channel 10 Code 71

Fish # 10/71 showed minimal upstream movement and subsequently returned to the area of release (see Fig. 39). It was not determined whether the fish was alive at the end of the study.

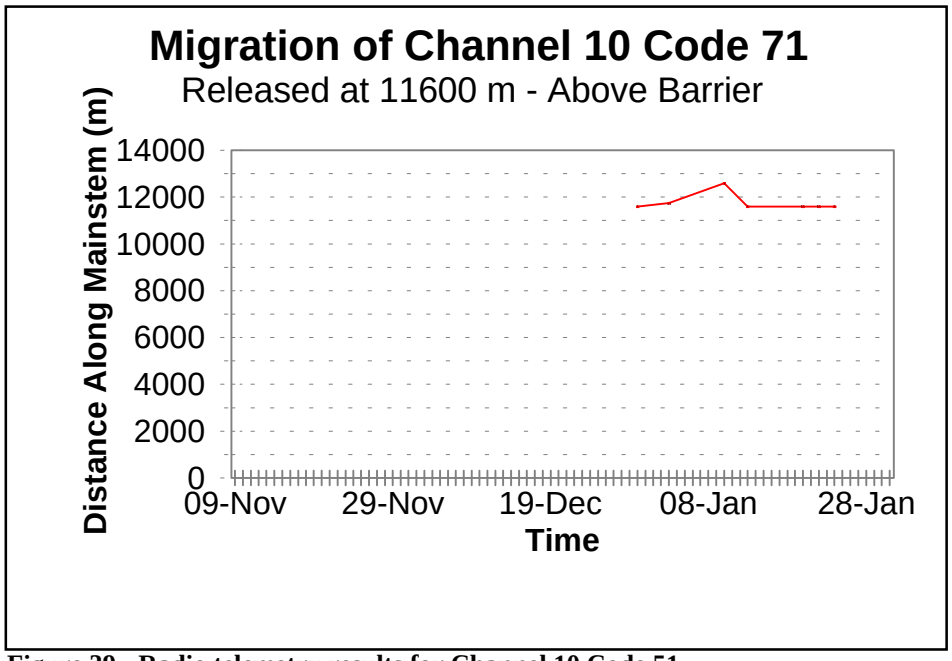


Figure 39 - Radio telemetry results for Channel 10 Code 51.

Channel 10 Code 77

Fish #10/77 also moved upstream immediately upon release into an area of suitable spawning habitat at 13,000 to 13,500 metres. This fish was recorded holding in the same vicinity of other tagged fish during the same time period (see Fig. 40).

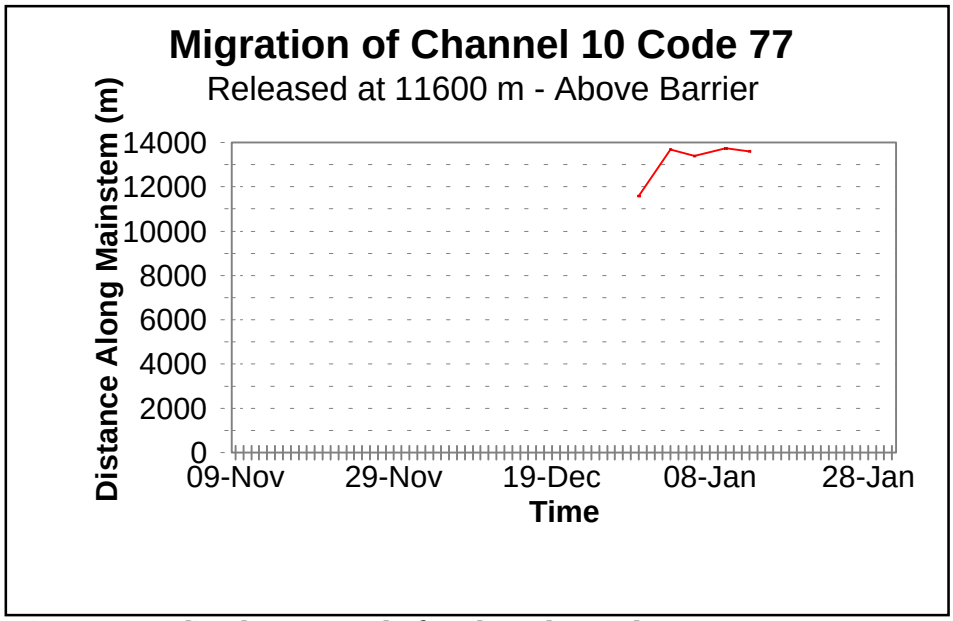


Figure 40 - Radio telemetry results for Channel 10 Code 77.