4. Didymo: An Otago context

The Didymo infected watercourses of Otago can be separated into three main categories: flow regulated rivers, unregulated rivers, and lakes.

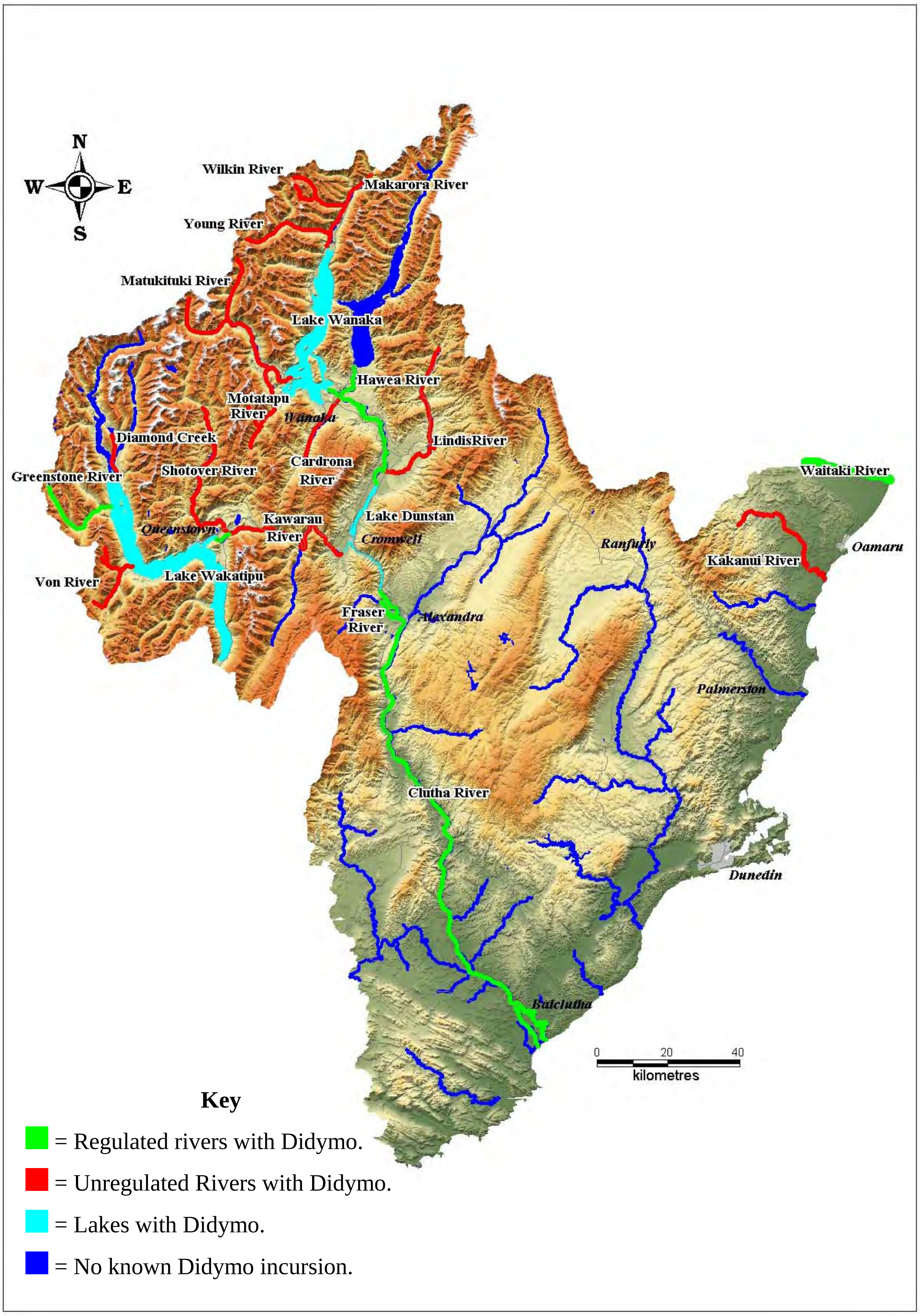

Figure 4.1 **Otago Rivers infected with Didymo. Unregulated rivers with Didymo are shown in red, regulated rivers with Didymo are shown in green, infected lakes are in light blue**

4.1 Didymo and flow regulated rivers of Otago

Flow regulated rivers are those that have a relatively stable flow regime. Such rivers tend to have some form of control structure such as a dam or weir or a flow controlling lake. The five flow regulated rivers in Otago infected by Didymo are Diamond Creek and the Hawea, Greenstone Clutha River/Mata-Au and Fraser Rivers. Though not in Otago, the Waitaki River also needs to be acknowledged as large amounts of water are taken from it and used in the Otago region for irrigation (Figure 4.1).

4.1.1 Hawea River

The Hawea River was the first river in Otago to be identified as infected by Didymo (September 2005) and is located in the upper Clutha catchment (Figure 4.1). The Hawea River flows from Lake Hawea and joins the Clutha River/Mata-Au at Albert Town. Flows in the Hawea River are controlled at Hawea Dam and vary between 8 and 200 cumecs.

Due to large flow fluctuations in the Hawea River, Didymo is only present in the permanently wetted area of the river (Figure 4.2) and not visible from the bank during high flows.

Figure 4.2 Thick cover of Didymo in the Hawea River visible at low flows (G. Martin)

There have been several observations of unusual thin grey mats of Didymo in the lower Hawea River near Hawea Domain. Laboratory analysis revealed that the mats were comprised almost entirely of dead stalk material and cells. It is likely that these mats were baked onto rocks during lower than normal flows when they were exposed to the air for an extended period of time (Figure 4.3). A subsequent high flow event appears to have caused a moderate amount of bed movement as shown by the clean rocks in Figure 4.3.

Figure 4.3 The unusual growth form of Didymo observed in the lower Hawea River (G. Martin)

There are six consented water takes from the Hawea River; four for irrigation, one for town supply and one for communal stock water.

4.1.2 Clutha River/Mata-Au

Once Didymo was established in the Hawea River, it was inevitable that the infestation would move down the catchment to the Clutha River/Mata-Au. By the time the Hawea incursion was discovered, Didymo was already present in the Clutha River/Mata-Au and had moved down to Lake Dunstan.

The Clutha/Mata-Au between Alexandra and Lake Roxburgh was infected during the summer of 2006. By July 2006, Didymo was observed in the lower Clutha River/Mata-Au at Roxburgh and Beaumont and is now believed to infest the entire river (Figure 4.2). It is interesting to note that Didymo appears to have moved through or around two lakes (Dunstan and Roxburgh) as it has moved down the system. It is unknown if it simply drifted through the lake or was transported below the lakes by human activity. Monitoring is currently being undertaken by the Otago Regional Council in an attempt to answer this question.

There are 50 consented water takes from the main stem of the Clutha River/Mata-Au, the majority of which are used for irrigation. It should also be noted that takes of under 100 l/s are a permitted activity under the Otago Regional Council Regional Plan: Water and do not require formal consent. So the actual number of irrigation takes on the Clutha River/Mata-Au is likely to be much higher than 50. There have been reports from the Upper Clutha River/Mata-Au of Didymo clogging intake screens and center pivot nozzles (T Banks, G Martin, pers. comm.).

4.1.3 Fraser River

Didymo cells were first found in the Fraser River in early May 2006, before any visible colonies were present. A detailed drift net survey undertaken in July 2006 found that Didymo was only present downstream of a pipe that brings water into the river from Lake Dunstan (Figure 4.2 & Figure 5.4), indicating that Didymo had in fact moved through the lake and that the lake was the source of the infection. A detailed description of Didymo in the Fraser River is provided in the Fraser River Monitoring Study (Chapter 5.2).

There are six consented water takes from the Fraser River, all of which are for irrigation and frost fighting.

4.1.4 Waitaki River

Although the Waitaki River is not within the Otago Region, there is a substantial amount of water taken from the river to irrigate land in North Otago. The three largest Otago water takes from the Waitaki River are the Waitaki Plains Irrigation Scheme, North Otago Irrigation Company and Horse Gully Irrigation Scheme.

4.1.5 Diamond Creek

Diamond Creek is an outlet of Lake Reid and is a tributary of the Rees River in the Queenstown Lakes District. Didymo was first discovered in Diamond Creek in January 2007 approximately 200 m upstream of the Rees confluence at a fishing access point. Flows in Diamond Creek are likely to be relatively stable as it is lake-fed, but the severity of the bloom is unclear. There are no consented water takes from Diamond Creek.

4.1.6 Greenstone River

The Greenstone River is an outlet of Lake McKellar and is a tributary of Lake Wakatipu. It is characterised by a high degree of naturalness and is relatively free of disturbance from human activities. The Greenstone is a highly valued trout fishery and is also a popular tramping destination. There are four consented water takes from the Greenstone River to provide drinking water to Department of Conservation huts.

4.2 Didymo and unregulated rivers in Otago

Unregulated rivers are those that do not drain a lake or have no upstream control structure and typically have much more variable flow regimes. The 10 unregulated rivers in Otago that are currently infected with Didymo are the Von, Matukituki, Makarora, Wilkin, Lindis, Motatapu, Young, Cardrona, Kakanui and Dart Rivers. As yet there have been no reports received by ORC of Didymo reaching nuisance levels in any of Otago’s unregulated rivers.

4.2.1 Von River

The Von River flows into Lake Wakatipu and was the first unregulated river known to be infected in Otago (October 2005). The Von is a highly valued trout fishery and it is more than likely that this incursion was a result of anglers using contaminated gear from the nearby Mararora River in Southland. There are no consented abstractions in the Von catchment.

4.2.2 Matukituki River

The Matukituki River flows into the west side of Lake Wanaka and is popular with anglers, trampers and jet boaters. Although there are no consented takes for irrigation from the Matukituki main stem, there are takes from tributaries of the Matukituki for power generation, domestic supply and snow making.

4.2.3 Makarora River

The Makarora River flows into the head of Lake Wanaka and is frequently used by anglers, kayakers and jet boaters. There are no consented takes for irrigation on the Makarora main stem, though a small amount of water is taken from some of its tributaries for domestic supply.

4.2.4 Wilkin River

The Wilkin River is a tributary of the Makarora River, with its confluence approximately five km upstream of Lake Wanaka, which is heavily used by jet boaters, anglers, kayakers and trampers. There are no consented abstractions in the Wilkin catchment.

4.2.5 Motatapu River

The Motapatu River is a tributary of the Matukituki River and is used mainly by anglers, trampers and kayakers. There are no consented water takes from the main stem of the Motatapu River, though there are takes from some of its tributaries for the purposes of domestic supply and snow making.

4.2.6 Young River

The Young River is a tributary of the Makarora River, is used mainly by trampers and anglers and has no consented water takes. It is likely that Didymo was brought into the Young catchment by anglers or jet boaters moving up from the Makarora River.

4.2.7 Lindis River

The Lindis River is a tributary of the Clutha River/Mata-Au and is used mainly by anglers. Water abstraction from the Lindis for irrigation is extremely high, with the lower reaches completely drying for several weeks during the irrigation season. Didymo was first found in the Lindis River in January 2007 at Ardgour Rd Bridge, although the full extent of the infection is not known at this stage.

4.2.8 Cardrona River

The Cardona River is a tributary of the upper Clutha River/Mata-Au, and is heavily abstracted for irrigation. There are 38 consented water takes from the Cardrona Catchment. The Cardrona River is also an important spawning river for brown and rainbow trout from the Clutha River/Mata-Au and Lake Dunstan.

4.2.9 Dart River

The Dart is a glacial-fed river that flows into the head of Lake Wakatipu, and is used heavily by jet boaters and trampers. There is a substantial amount of glacial flour suspended in the water column, giving the water a milky appearance. There are no consented water takes in the Dart River.

4.2.10 Kakanui River

The Kakanui is a coastal river that flows into the Pacific Ocean approximately 10km south of Oamaru. The Kauru River, which is the main tributary of the Kakanui, supports the largest population of New Zealand's most endangered freshwater fish, the lowland long-jawed galaxiid. The Kakanui supports an adult brown trout fishery and is also heavily allocated, with 32 consented surface water takes.

4.3 Didymo and lakes in Otago

Didymo colonies have been observed growing in two Otago lakes, Wakatipu and Dunstan. Lake Wanaka is also considered infected due to inflows from the Matukituki and Makarora Rivers (Figure 4.1). As yet there have been no reports received by ORC of Didymo reaching nuisance levels in lakes except where it is washed in from tributaries.

4.3.1 Lake Dunstan

Didymo was first found in Lake Dunstan in November 2005, presumably having moved down the Clutha River/Mata-Au from the Hawea infestation. Following blooms in the Clutha River/Mata-Au, masses of dead stalk material have been observed settling in the upper sections of the lake and smothering large beds of the invasive macrophyte *Lagarosiphon major*. In areas with reasonable flow, Didymo has also been observed growing on *Lagarosiphon*, causing significant dieback (G Martin, pers. comm.). Although there have been several reports of Didymo drifting into Lake Dunstan from the Clutha/Mata-Au and becoming a nuisance to anglers, this does not seem to have adversely affected the trout fishery (M Trotter, pers. comm.). It is apparent that most of the Didymo biomass that enters Lake Dunstan from the Upper Clutha River/Mata-Au settles out relatively quickly once flow is reduced.

There are 17 consented water takes from Lake Dunstan, most of which are used for irrigation. As with the Clutha/Mata-Au, any takes under 100 l/s are considered a permitted activity and so the actual number of takes is likely to be greater than this figure.

4.3.2 Lake Wakatipu

Didymo was first observed growing on the margins of Lake Wakatipu near the mouth of the Von River in November 2005. Subsequent colonies have also been found opposite the mouth of the Greenstone River near Pigeon Island and Queenstown Bay (Figure 2.5). There are nine consented takes from Lake Wakatipu; three for irrigation and six for domestic or communal supply. As with Lake Dunstan and the Clutha/Mata-Au, water takes less than 100 l/s are considered a permitted activity under the Regional Plan: Water so the actual number of takes from the lake are likely to be substantially higher.

5. Otago Regional Council Didymo projects

5.1 Photographic monitoring of Didymo in selected rivers in Otago

5.1.1 Introduction

Although several large research projects on the ecological effects of Didymo have been funded by Biosecurity New Zealand, much of its basic ecology is still unknown. Seasonal growth patterns, preferred habitat and growth rates have been based on reports from the northern hemisphere. Much of the anecdotal evidence available from New Zealand does not support these assumptions. With this in mind, the Otago Regional Council established a series of reference photo sites in an attempt to track changes in Didymo growth in the Hawea River after it was discovered there in November 2005. Although uninfected at this time, a site was also established on the Fraser River in April 2006 on the assumption that Didymo would move down the Clutha River/Mata-Au and enter the Fraser River through the Lake Dunstan augmentation pipe.

The photographic records for the Clutha River/Mata-Au, Fraser and Hawea River were combined with hydrographs for each river to provide an indication of the flow conditions at each sampling time.

5.1.2 Hawea River

Flows in the Hawea fluctuated between 100 and 200 cumecs from mid June to 12 August when they dropped to approximately 50 cumecs (Figure 5.1). From 30 September, flows reduced further to approximately 12 cumecs and remained stable until mid-January.

The photographs (Appendix 1) show that no Didymo could be seen on the substrate at the beginning of monitoring in early April. The photograph taken on the 23 June shows streamers of Didymo caught up in vegetation, but it is not until late July that live Didymo colonies are first visible. A substantial increase in visible Didymo colonies coincides with the beginning of the stable flow period in September. There was also a significant increase in biomass during early January, which is clearly shown on 12 January and 22 January photographs (Appendix 1).

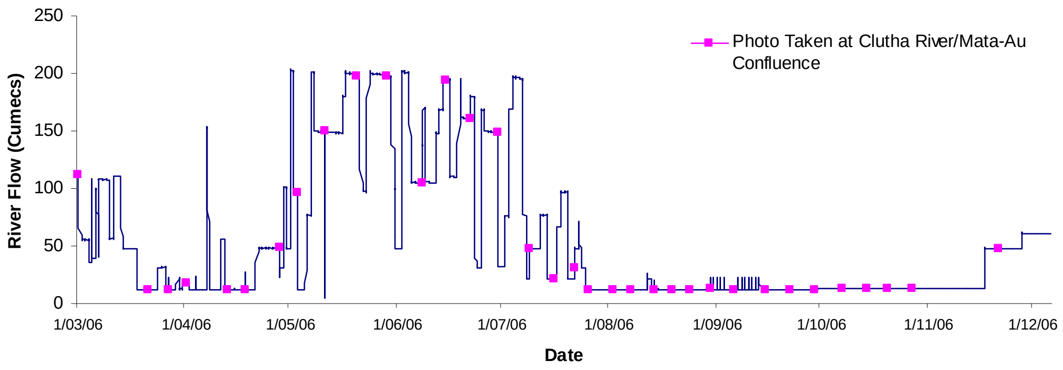

Figure 5.1 Hydrograph of the flow in the Hawea River. Pink squares indicate when the photographs in Appendix 1 were taken

5.1.3 Clutha River/Mata-Au at Maori Point Rd

The flow patterns in the Clutha River/Mata-Au (Figure 5.2) were largely driven by inflows from the Hawea River until 1 September 2006. After this flows in the Hawea River were minimal and constant, with most of the flow variability of the Clutha River/Mata-Au being driven by inflows from Lake Wanaka and the Cardrona River.

Didymo was evident in the photographs (Appendix 2) from the initial monitoring in April 2006. The May 12 photograph shows a distinct increase in biomass which can be seen to be sloughing off by 2 June.

On 21 July small colonies are once again visible, which are seen to grow rapidly. The photograph of August 14 again shows a high biomass which is evident throughout the September photographs. After September flows are high and it is difficult to gauge the extent of Didymo cover, although the photograph of October 3 shows Didymo caught around the stake which suggests sloughing had occurred. The photograph taken on October 9 still shows a substantial amount of Didymo attached to rocks. By 15 December it appears new colonies are forming which have spread to cover the entire rock surface by January 12.

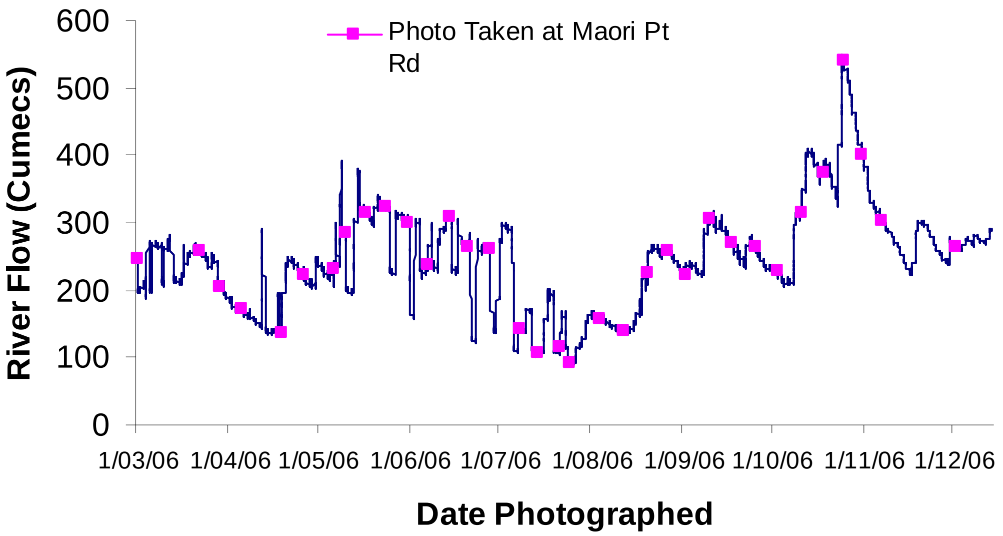

Figure 5.2 Hydrograph of the flow in the Clutha River/Mata-Au. Pink squares indicate when the photographs in Appendix 2 were taken

5.1.4 Fraser River at Marshall Rd

The Fraser River was subject to very stable flows (between 2 and 3 cumecs) from January 2006 and the end of September 2006 (Figure 5.3), as much of the water from the upper catchment was captured by the Fraser Dam. Flows from October through to January 2007 were highly variable as the Fraser Dam overtopped, with several flood events between 10 and 18 cumecs.

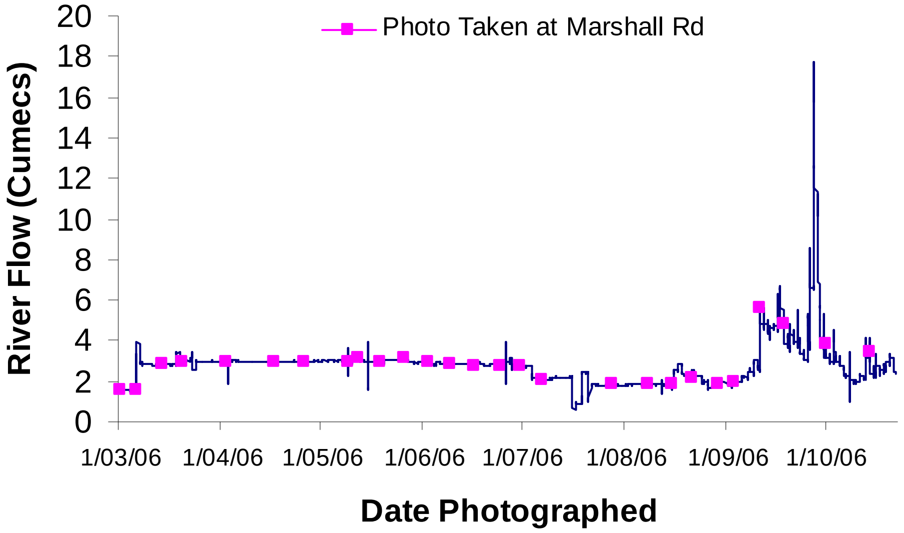

Figure 5.3 Hydrograph of the flow in the Fraser River. Pink squares indicate when the photographs in Appendix 3 were taken

Didymo was initially absent from the Fraser River, but can clearly be seen in the photographs (Appendix 3) from May 12. The July 24 photograph shows the presence of small colonies, and by August 14 it can be seen that there has been a substantial increase in biomass. There was a large increase in flow on October 13 (3 to 17 cumecs), which is depicted in the photographs. However, this didn't seem to have affected Didymo on the channel margins. Field observations during this period indicate a substantial amount of sloughing and bed moving occurred mid-channel during this event.

5.1.5 Conclusions

Although analysis of reference photos is difficult during high flows, the results indicate that Didymo growth is favoured by periods of stable flow and is not necessarily affected by seasonal limitations (e.g. temperature or photoperiod).

High Didymo biomass was not observed in the Hawea River until stable flows in September after four months of highly variable flows. In the Fraser River, Didymo reached its highest biomass after an extended period of stable flow from January to the end of September. Highly variable flows from October to January caused a significant decrease of Didymo biomass in the middle of the channel; this was less pronounced closer to the margins. High Didymo growth was also observed in the Clutha River/Mata-Au during periods of stable flow. However, large flow fluctuations at this site made discerning any strong patterns difficult.

5.2 Growth patterns of Didymo: A case study of the Fraser River

Since Didymo was discovered in New Zealand in 2004, intensive research has been undertaken by a variety of organisations in an attempt to ascertain its effects on river ecosystems and assess methods of detection and control.

However, several areas of basic ecology of Didymo in New Zealand have not been reported. These include two questions:

- What are the seasonal growth patterns of Didymo?
- What conditions trigger a Didymo bloom?

By July 2006, there had been no studies completed in response to this knowledge gap, or to track a new incursion in a NZ context. In response to this, photo reference work on the Fraser River was upgraded to a more detailed monitoring study to help answer some of these basic questions and allow for better informed management decisions in the future.

5.2.1 The Fraser River environment

Water from the upper Fraser River is substantially regulated by Pioneer Energy at Fraser Dam. Water is released from Fraser Dam to a smaller secondary dam at the top of Fraser Gorge, and from here is piped to a turbine at the bottom of the gorge. This drastically reduces flows through the Fraser Gorge except during periods of high flow in the upper catchment when the dam is over-topped. Water is dropped through the turbine where it enters the river again at the bottom of the gorge. Downstream of the turbine outlet most of the water is directed into an irrigation raceway operated by the Earnscleugh Irrigation Company (EIC). To augment flows below the EIC take during the irrigation season, up to 1 m^3/s is piped from Lake Dunstan to maintain flow in the lower Fraser River (Figure 5.4).

Because of the differing physio-chemistry and hydrology of the upper and lower sections of the Fraser River it is not feasible to establish control sites above the Didymo incursion. The lack of control sites makes an impact assessment of Didymo invasion difficult, but still provides an excellent opportunity to undertake a descriptive study of growth and colonisation of Didymo over time in a newly infected system.

5.2.2 Monitoring sites

Initial water column sampling indicated that Didymo was not present upstream of the Lake Dunstan pipe outlet at Fraser Domain. Four monitoring sites were selected between the Fraser Domain and the confluence of the Fraser and Clutha River/Mata-Au; Fraser Rd, Laing Rd, Earnscleugh Rd and Marshall Rd (Figure 5.4).

Figure 5.4 **Fraser River monitoring sites (shown in red) and Lake Dunstan augmentation discharge (shown in blue)**

5.2.3 Site descriptions

The Marshall Rd monitoring site (Figure 5.5) is located approximately 300m upstream of the confluence of the Fraser River and Clutha River/Mata-Au Rivers. This site differs from those further upstream by its relatively narrow confined channel (≈ 6m) and high velocities towards the middle of the channel. It is also the most shaded of the sites, with willows lining most of the bank.

Figure 5.5 Marshall Rd monitoring site

The Earnscleugh Rd site (Figure 5.6) is located approximately 50m upstream of the Earnscleugh Rd Bridge, with a relatively wide channel (≈ 10 m). Shading is minimal and channel velocities are low with more laminar flow across the entire channel.

Figure 5.6 Earnscleugh Rd monitoring site

The Laing Rd monitoring site (Figure 5.7) is located approximately 50m downstream of the Laing Rd Bridge and is characterised by its shallow, wide (>15 m), and un-shaded channel.

Figure 5.7 Laing Rd monitoring site

The Fraser Rd site (Figure 5.8) is located 30m upstream of the Fraser Rd Bridge and is characterised by its narrow (<8 m) channel and large substrate size (Figure 5.9). Due to this narrow channel, flows are relatively high but the substrate is very stable with minimal bed movement during high flows.

Figure 5.8 Fraser Rd monitoring site

5.2.4 Substrate composition

Substrate composition was sampled using a Wolman sampler (Wolman, 1954) and the percentage of each size class calculated (Figure 5.9). The substrate at Earnscleugh Rd is comprised mainly of medium gravels, which is homogeneous across the entire channel. The substrate composition at Fraser Rd consists predominantly of a well-armoured layer of large cobbles and boulders (85% of total bed composition) with small pockets of gravel. The substrate at Laing Rd is dominated by small gravels and sand which is largely homogeneous across the entire channel. Marshall Rd is characterised by having stable margins comprised of cobbles and a largely mobile mid-channel area of cobbles interspersed with sand and small gravels.

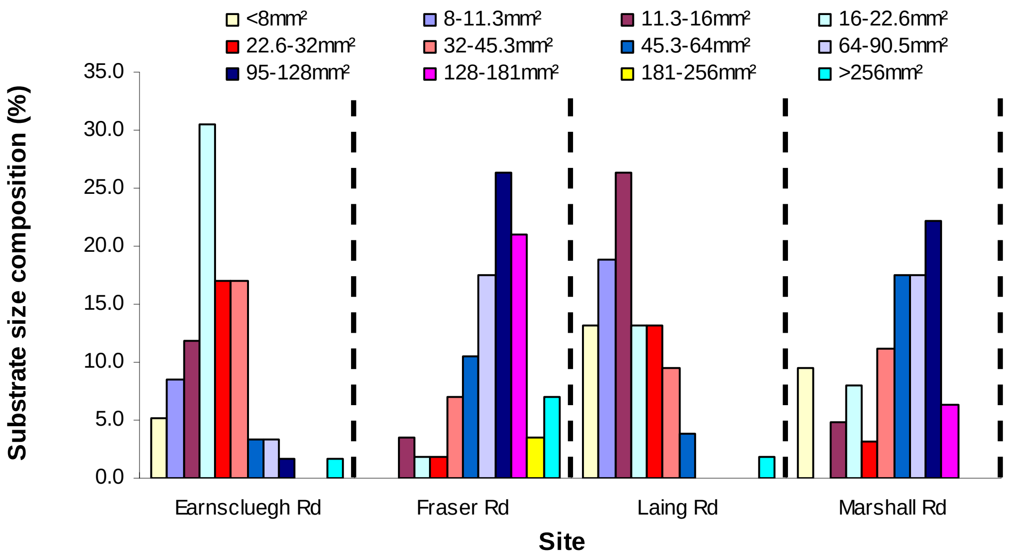

Figure 5.9 Substrate composition of monitoring sites

5.2.5 Near-bed velocities

A transect of 5 velocity measurements were taken at a depth of 0.05m from the stream bed during each sampling run (Figure 5.10). Results indicate that near-bed velocity is driven largely by the interaction of channel width and substrate size. Earnscleugh Rd, with its wide channel and moderate substrate size has the lowest mean near-bed velocity of 0.30 m/s. Although Fraser Rd has a narrow channel and high surface velocities, the large substrate size creates significant turbulence closer to the bottom which drastically reduces near-bed velocities to an average of 0.31 m/s. Although Laing Rd has the widest channel of all four monitoring sites, its shallow riffled nature and small substrate size produce a relatively high average near-bed velocity of 0.50 m/s. The high near-bed velocities measured at Marshall Rd (0.6 m/s) are largely due to the relatively steep gradient and narrow channel width of this site as well as the lack of stable mid-channel substrate.

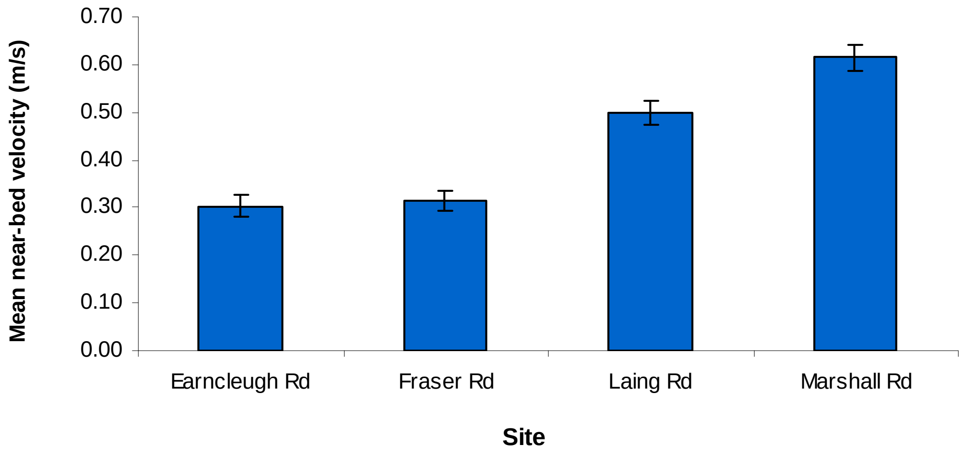

Figure 5.10 Mean near-bed velocities at all sites

5.2.6 Temperature

The temperature logger placed at Marshall Rd shows an overall increasing trend in temperature over the study period (Figure 5.11), although overall temperatures remained relatively stable. This is most likely due to the influence of the Lake Dunstan flow augmentation.

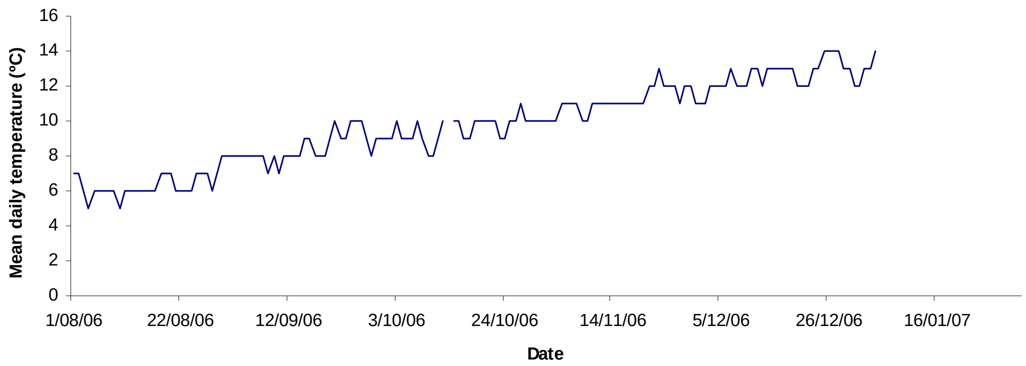

Figure 5.11 Mean daily temperature at Marshall Rd

5.2.7 Hydrology

Flows in the Fraser River were very stable from January to late August, with the exception of two small fluctuations during maintenance of the augmentation pipe. The Fraser Dam overtopped in early September due to snow melt and an increase of over 2 cumecs occurred (Figure 5.12). Flows varied between 3.5 and 6.5 cumecs throughout early October before a 17 cumec event on October 13. Since that event until the end of the study the Fraser Dam continued to overtop and flows varied between 2.2 and 12.2 cumecs (Figure 5.12).

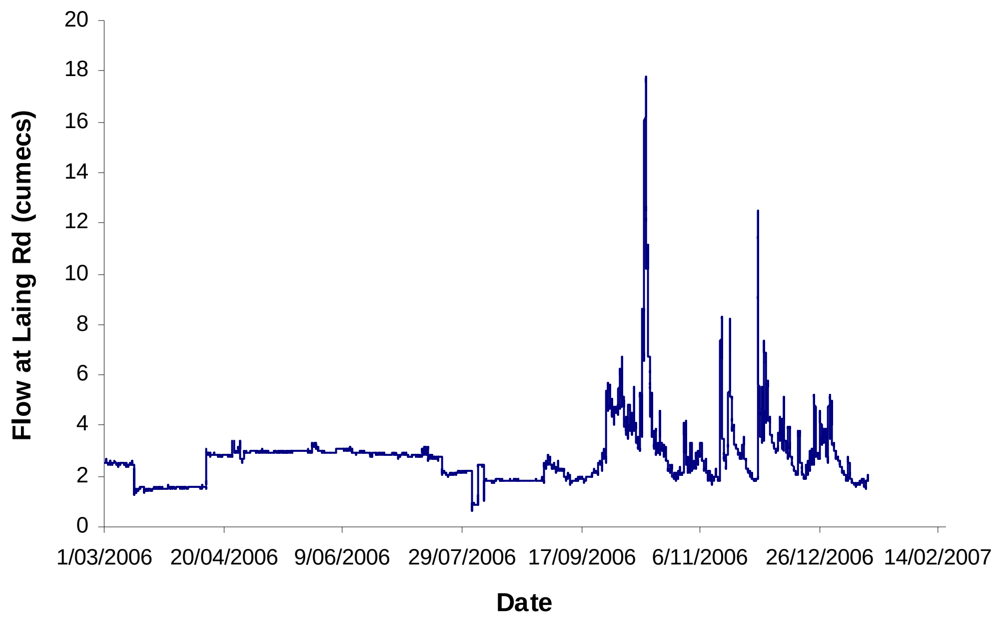

Figure 5.12 Flows in the Fraser River at Laing Rd

5.2.8 Fortnightly monitoring of Didymo distribution and biomass

The monitoring program was initiated to map distribution of Didymo as it colonises the river and to assess the speed and severity of infection at each site. Visual estimations of the percentage cover of Didymo, native periphyton and bare rock have been made and biomass has been estimated using the Quantitative Visual Biovolume Index (QVBI – Appendix 1).

To calculate QVBI, five rocks are selected from three transects at each site and the percentage cover of Didymo for each of the colony thickness categories (0, <1mm, 1-5mm, 6-15mm, 16-30mm, >30mm) is estimated as well as the percentage cover of native periphyton. Each of the colony thickness categories is allocated a index number (Native = **0,** 0 = **0**, <1mm = **1**, 1-5mm = **2**, 6-15mm = **3**, 16-30mm = **4**, >30mm = **5**), and the QVBI for each rock is calculated by multiplying the percentage cover of each colony thickness class by its corresponding index number, giving a value of between 0 (no Didymo present) and 500 (100% cover of >30mm colonies). This figure is then averaged between the 15 rocks at each site to give an overall QVBI for the site.

The QVBI differs significantly from the Visual Biovolume Index (VBI) and the Quantitative Visual Index (QVI) used in previous studies by Kilroy (2005b). The QVI uses up to 16 size classes, to the nearest mm for colonies less than 10 mm thick and to the nearest 5 mm thereafter. Although the QVBI only uses six size classes, its advantage is that the percentage of each size class per rock is calculated as opposed to a measuring the mat thickness at one point in the centre of each rock. The VBI also uses six size classes, but as with the QVI, only one measurement of mat thickness is made at the centre point of each rock.

Reference photos of five quadrats were taken at each site. These quadrats were located on Didymo colonies so that their growth could be monitored. If no colonies were present at the beginning of the study the quadrats were relocated as new colonies appeared.

Drift sampling was undertaken using drift nets (43 µm mesh size) and Ash Free Dry Mass (AFDM) was calculated for each sample as a measure of Didymo biomass in the water column.

Didymo colonisation rates were measured by taking scrapings from artificial substrates placed at each site. Three paving blocks were placed at each site with sheets of artificial substrate secured to their upper surface. On a fortnightly basis these sheets were replaced by clean substrates and Didymo cells per cm² were calculated.

Temperature loggers were placed at the Fraser Rd and Marshall Rd sites and NIWA's flow recorder at Laing Rd was used to provide flow data. pH and conductivity (as a measurement of dissolved nutrients) were also measured at each site.

5.2.9 Results

Results indicate that high Didymo biomass is very closely linked to stable flows (Figure 5.13) and native algae is more suited to variable flow regimes (Figure 5.14 and Figure 5.15). Interaction between substrate composition, channel width, and velocity also strongly influences Didymo biomass.

5.2.9.1 Benthic Didymo biomass

Reference photos taken in early May have shown that small Didymo colonies were present at Marshall Rd as early as May 2006. A site visit in July 2006 showed small colonies were still present at Marshall Rd, as well as Laing Rd, Earnscleugh Rd and Fraser Rd (Figure 5.13).

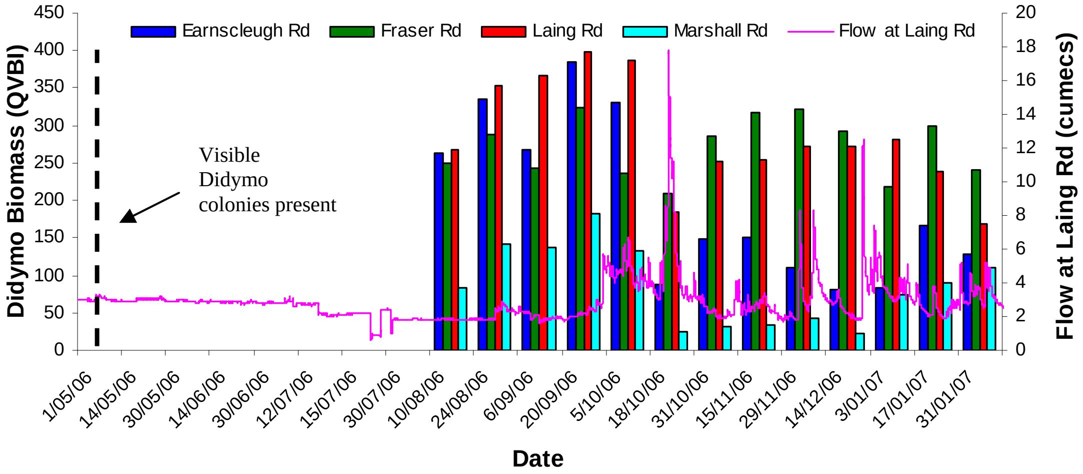

Figure 5.13 Changes in Didymo biomass plotted over river flow at Laing Rd

Benthic biomass of Didymo was very closely linked to flow at Marshall Rd, Earnscleugh Rd and Laing Rd, with biomass decreasing in response to high flow variability (Figure 5.13). The same trend was not observed at Fraser Rd, with only moderate response to October's high flows and no observable response to subsequent flow variations.

5.2.9.2 Marshall Rd

QVBI values were much lower at Marshall Rd than at any other site in the river for the entire duration of the study. Although biomass did not respond strongly to the small increase in flow in early September, the 16 cumec event in mid-October caused biomass to drop as low as 25 QBVI and did not recover significantly until the completion of the study in February.

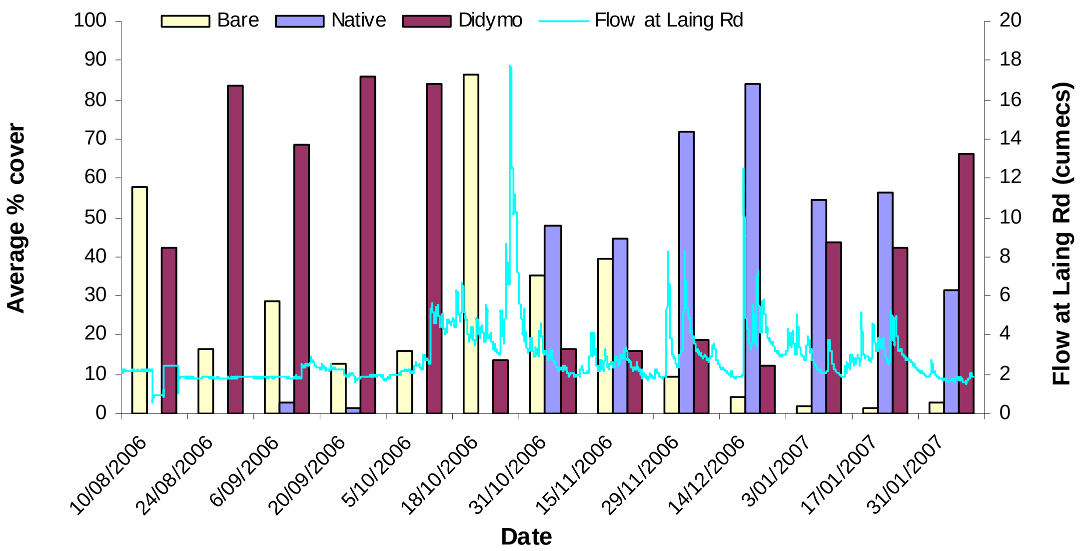

Figure 5.14 Percentage cover of Didymo and native algae at Marshall Rd

As can be seen in Figure 5.14, native periphyton colonised the substrate very quickly after Didymo is removed by high flows. Following the large bed-moving event in early October, native algae became the dominant component of the periphyton community under a variable flow regime, covering up to 85% of the available substrate in December. As flows stabilised over January, percentage cover of Didymo increased, although native algae was still dominant when the last sample was taken on 17 January.

5.2.9.3 Earnscleugh Rd

Didymo biomass at Earnscleugh Rd responded very strongly to increases in flow throughout the monitoring period. Even the one cumec event in mid-September caused a decrease in QVBI from 335 to 265, which is more than twice that of any other site. The 16 cumec event in mid-October caused a large decrease in biomass at Earnscleugh Rd from 330 to 90 QVBI. Variable flows from October to January kept Didymo biomass below 170 QVBI with a noticeable recovery in mid-January due to slightly more stable flows.

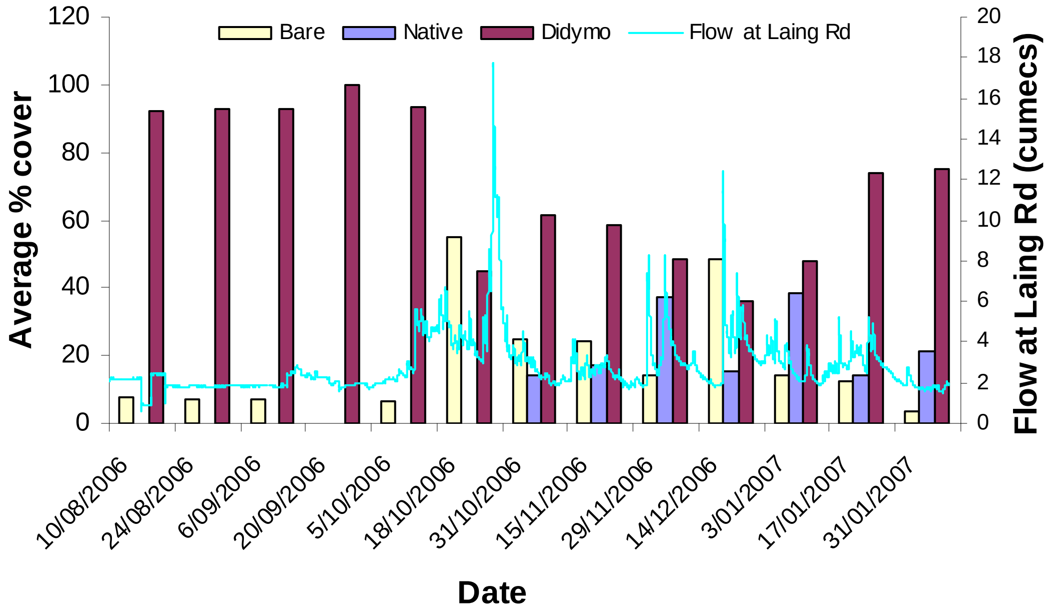

Figure 5.15 Percentage cover of Didymo and native algae at Earnscleugh Rd

Didymo cover at Earnscleugh Rd remained above 90% from August to September before the 16 cumec event on October 13 scoured most of the substrate clean. During the period of variable flow following this event, native algae has re-colonised 15% to 40% of the available substrate, while Didymo cover has remained below 60% for most of this time. The variable flows have also caused a relatively high proportion of bare substrate, which is most likely due to high bed mobility at the sampling site.

5.2.9.4 Laing Rd

Although Didymo biomass at Laing Rd showed a minimal response to the one cumec event in September, high flows in October caused a substantial decrease in biomass of 200 QVBI (Figure 5.13). During the subsequent period of high flow variability, Didymo biomass at Laing Rd was relatively stable at around 250 QVBI, showing much less fluctuation than at any other site along the river.

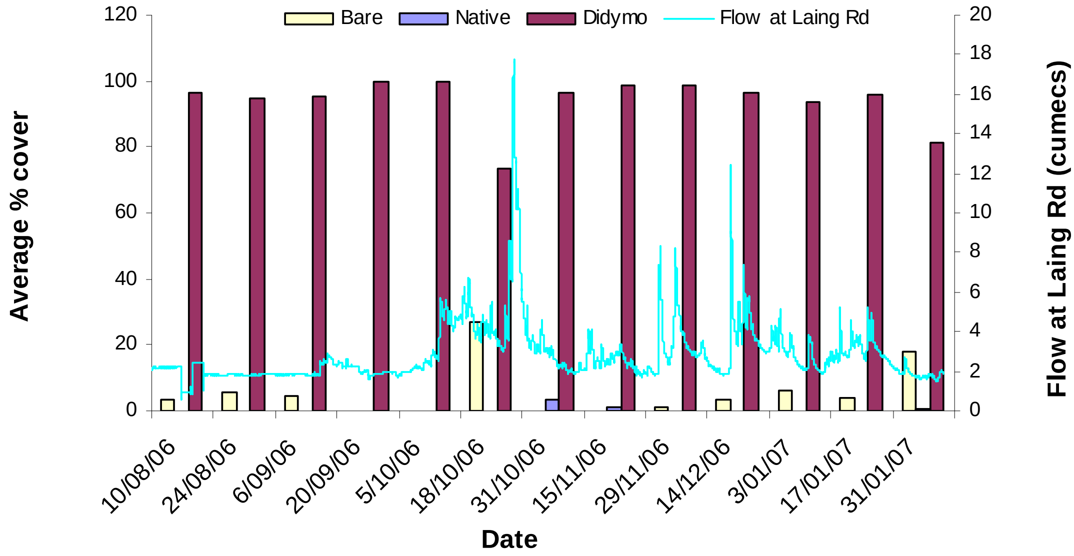

Figure 5.16 Percentage cover of Didymo and native algae at Laing Rd

Total cover of Didymo at Laing Rd was above 90% throughout most of the study with the exception of September 18, when a substantial amount of sloughing and bed movement occurred after the 17 cumec flood event on September 13. Unlike the Marshall Rd and Earnscleugh Rd sites, very little native algae has been present at any time during study.

5.2.9.5 Fraser Rd

Didymo biomass at Fraser Rd has also remained relatively stable throughout the duration of the study (Figure 5.13). After reaching a peak of 287 QVBI at the end of August, there was only a slight decrease in biomass after the small event in September. The highly variable flows throughout October did not have the dramatic effect that was seen further downstream and Didymo biomass at Fraser Rd has now returned to the peak levels observed in late September.

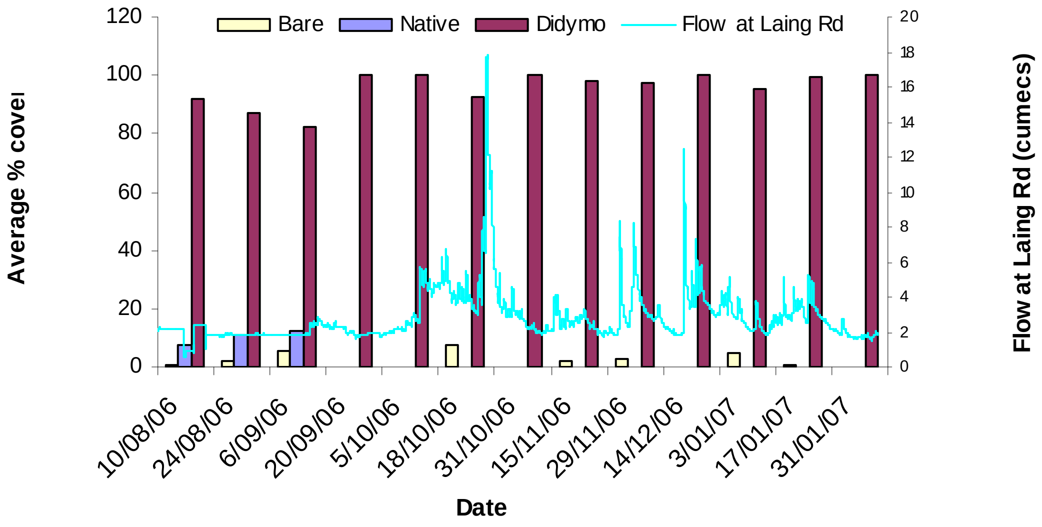

Figure 5.17 Percentage cover of Didymo and native algae at Fraser Rd

Total Didymo cover remained high throughout the study (Figure 5.17), with only small amounts of native algae present throughout August and September. In late September Didymo covered 100% of the available substrate, and although a small amount of scouring occurred from October through to January, no native algae was observed at Fraser Rd during this period.

5.3 Discussion

Although most sites respond strongly to increases in flow, the degree to which the increase in flow affects near-bed velocities is largely driven by the interactions of channel morphology and substrate composition. Temperatures remained relatively stable throughout the study period and did not appear to be limiting Didymo growth.

Substrate composition seems to be the most important of these factors, and it is likely that it can explain most of the biomass variability at each site. Although sloughing of Didymo occurs on larger substrates, the movement of smaller substrates during high flows is likely to have a much greater effect on Didymo biomass. Large substrate also increases the water friction and turbulence close to the stream bed and thus reduces near-bed velocities.

The lack of response of biomass to moderate increases in flow at Laing Rd in September is most likely due to the armoring of the gravel by thick mats of Didymo (Figure 3.3), and the relatively wide channel which reduces near-bed velocity and allows a large buildup of Didymo biomass. Near-bed velocities during the 17 cumec event in October were much higher than at any other time since Didymo's incursion into the Fraser River, and was enough to scour away all but a few fragments of the Didymo-gravel matrix (Figure 5.18).

Figure 5.18 Remnant Didymo-gravel matrix at Laing Rd after high flows in October

The Didymo-gravel matrix did not form at Earnscleugh Rd and is the most likely explanation as to why this site responded more strongly to the small increases in flow observed in September. The near identical response and recovery time after October's high flows is an indication of the very similar substrate size at Laing and Earnscleugh Rd.

The low level of response of Didymo to high flows at Fraser Rd is most likely due to the large substrate size at this site. Although high flows are likely to cause moderate short-term reductions in biomass due to sloughing, the boulders and cobbles at Fraser Rd are very stable and are unlikely to be moved by all but the largest flood events. This stable substrate allows for the persistence of remnant Didymo colonies after a high flow event, allowing for a much faster recovery. The large substrate size also creates a high amount of turbulence and greatly reduces near-bed velocities which allows for a greater persistence of Didymo mats during high flows.

The low Didymo biomass observed at Marshall Rd throughout the study period is most likely due to the high degree of shading from riparian vegetation and the instability of the substrate towards the middle of the channel. Figure 5.13 shows an almost complete lack of recovery of Didymo biomass after the high flows of October, with relatively low QVBI values throughout the period of high flow variability from October to January.

It is possible that this lack of recovery of Didymo at Marshall Rd, and to a lesser extent Earnscleugh Rd, is due to the colonisation of a substantial proportion of the substrate by an unidentified native alga. It is unclear if this algae was responding to the clearing of Didymo by high velocities (and is able to out-compete it under these conditions), or to seasonal factors such as photoperiod or water temperature.

This pattern was also observed at Earnscleugh Rd, which is much less shaded than the Marshall Rd site. This indicates that the native algae is better adapted to the natural flow conditions experienced in October and is able to out-compete Didymo under conditions where the substrate is unstable (Figure 5.14 and Figure 5.15).

5.4 Conclusions

There is a strong indication that Didymo biomass and percentage cover is largely controlled by variations in near-bed velocity, with both of these variables able to attain much greater levels due to the regulated nature of the Fraser River over the winter period while the Fraser Dam is being filled. This is supported by anecdotal observations of extremely large buildups of Didymo in the Hawea, Clutha/Mata-Au, Waitaki, Waiau and Mararoa Rivers (G Martin, G Hughes, S Sutherland, R Fitzpatrick, pers. comm.*)*. Rivers with unregulated flow regimes such as the Von, Matukituki, Motatapu, Makarora and Wilkin Rivers have not experienced these large buildups of Didymo biomass due to the large increases in velocities during high flow periods.

This raises the possibility of using flushing flows in regulated rivers and irrigation races to reduce the buildup of Didymo biomass and prevent it reaching nuisance levels. This study also suggests that native algae may be able to better compete with Didymo under more natural flow regimes.