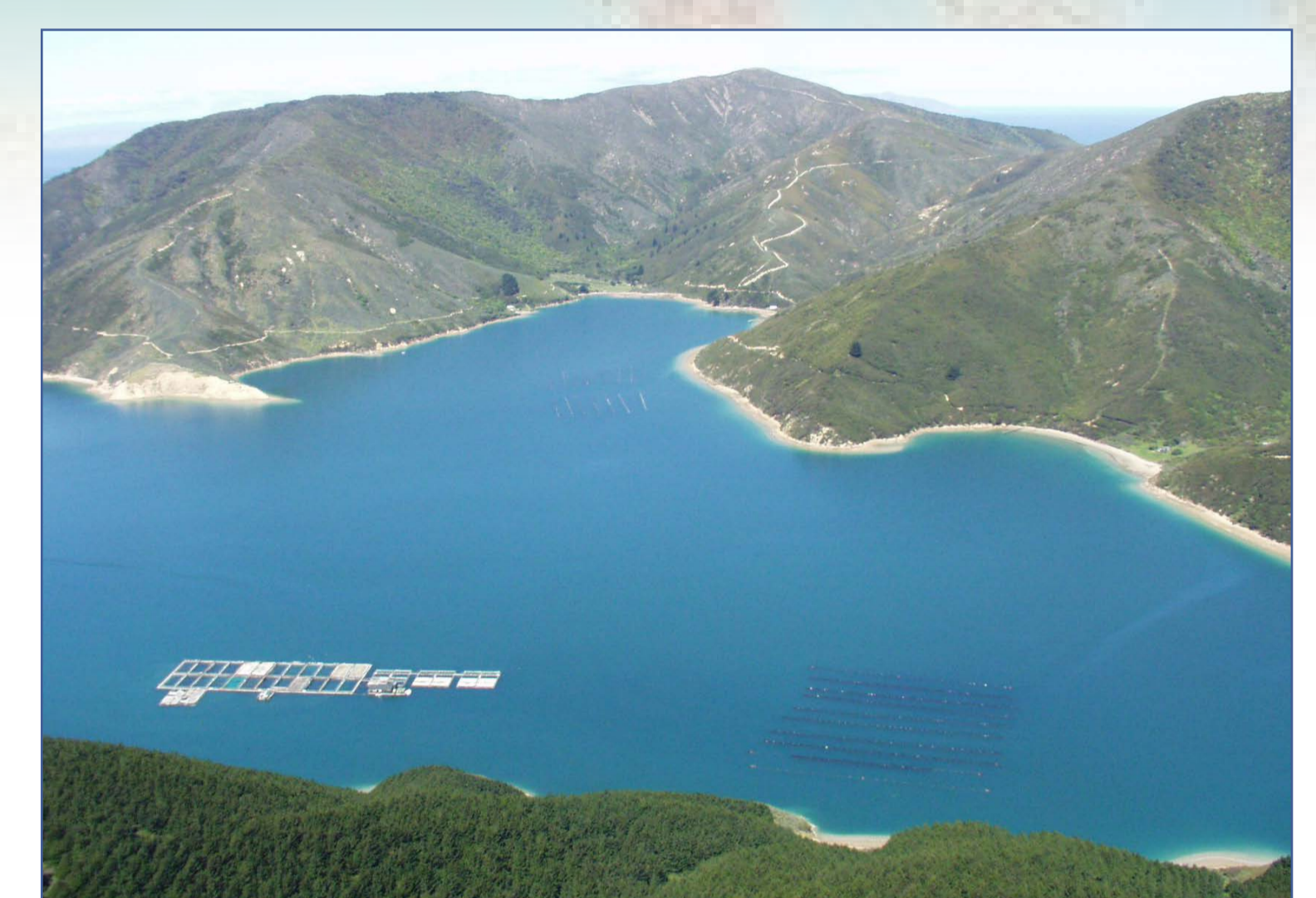
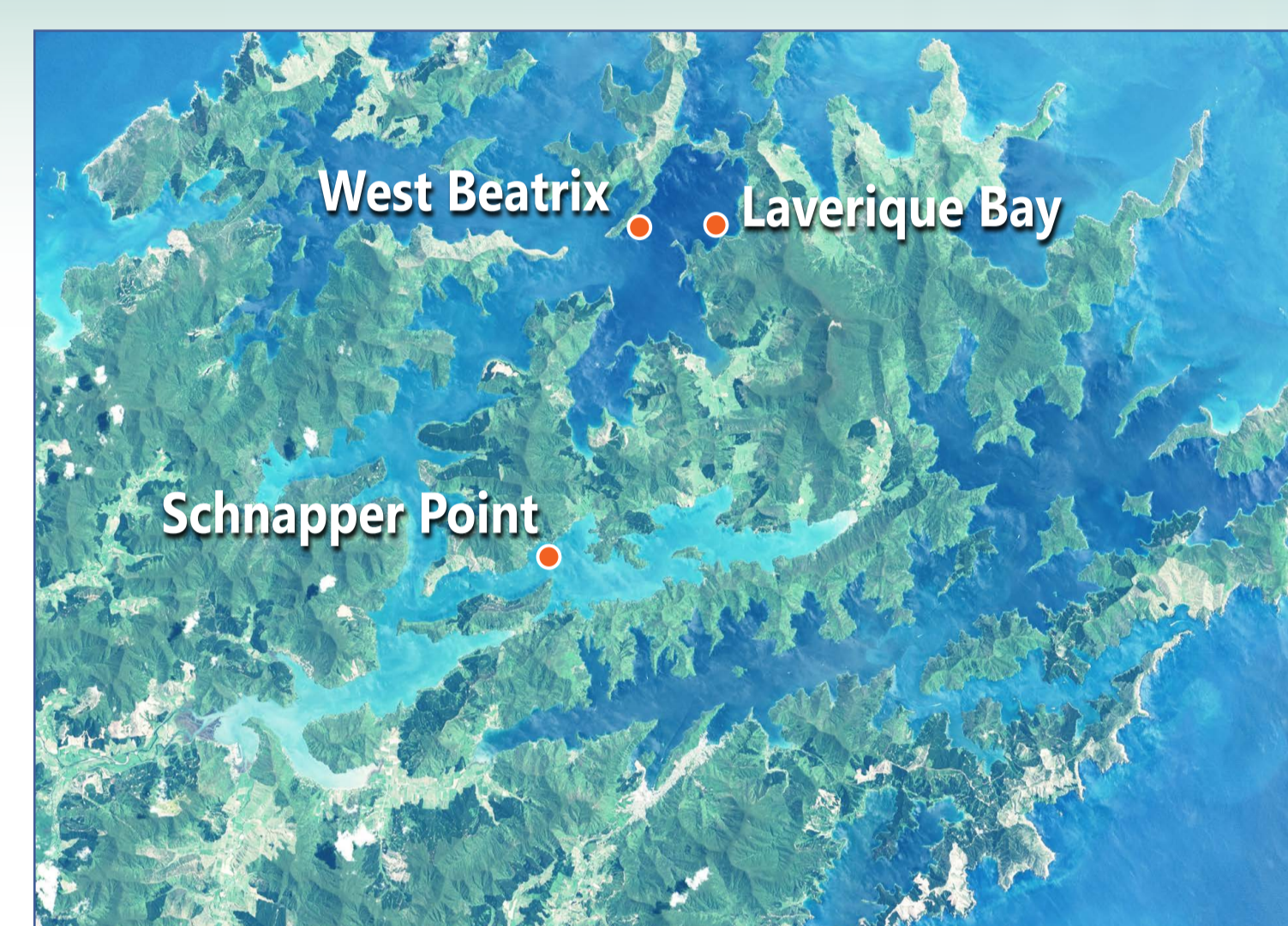


Niall Broekhuizen, Ken Grange and Lincoln MacKenzie

Water quality trends in Pelorus Sound over the past 20-35 years

Marine farming has expanded in Pelorus Sound over the past 35 years. At the same time the catchment has been modified by native forest clearance, pastoral farming, plantation harvest, and subsequent restoration. Furthermore, the sea floor has been altered by trawling and dredging. There has been speculation that these activities have had adverse impacts on water quality.



Methods

There have been several field campaigns dedicated to studying the water quality of Pelorus Sound over the past 35 years. All have collected water samples from the upper few meters of the water-column, and adopted similar laboratory techniques to analyse those samples.

At Schnapper Point and two locations in Beatrix Bay (West Beatrix and Laverique Bay), it is possible to concatenate two or more data-sets to yield longer time-series. We sought to determine whether there is any evidence for long-term trend in the data by:

- Calculating the so-called Sen slope for each time-series.
- Testing two different null hypotheses about the Sen-slope:
 - a) The slope is not significantly greater than zero.
 - b) The slope is not significantly less than zero.

In the event that neither hypothesis is rejected, we conclude that the trend direction cannot be reliably determined (i.e., the nature of any trend cannot be determined). If one or other hypothesis is rejected, we conclude that the direction of the trend can be determined with high (95%) confidence.

Results

For all variables, the size of the long-term change in concentration is very small in comparison with seasonal and year-to-year fluctuations. With these large, short-term variations, any trends over several years are hard to identify. Nonetheless, for some characteristics, the direction of the trend can confidently be determined:

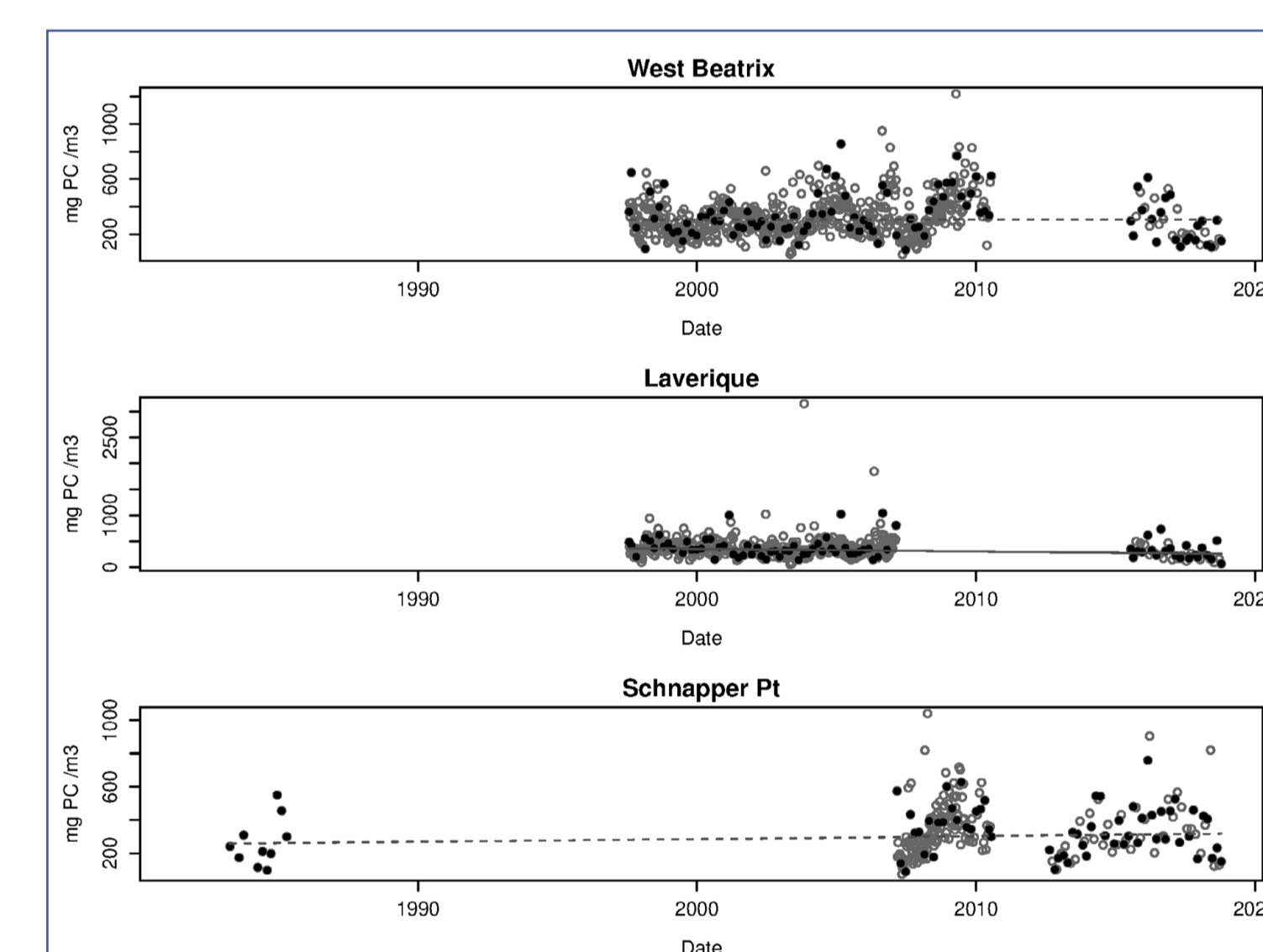
- For both particulate carbon and particulate nitrogen we conclude that, with high probability, concentrations have tended to decline at the Laverique Bay site. In contrast, on the western side of Beatrix Bay and at Schnapper Point, the directions of trend cannot confidently be determined.
- For chlorophyll, we conclude that, with high probability, concentrations have tended to decline at both western Beatrix Bay and Laverique Bay (i.e., on both sides of Beatrix Bay). The direction of trend cannot be confidently determined at Schnapper Point.
- For turbidity, we conclude that, with high probability, turbidity has tended to increase at Schnapper Point. It appears to have declined slightly at Laverique Bay. On the western side of Beatrix Bay, the direction of trend cannot confidently be determined.

Conclusion

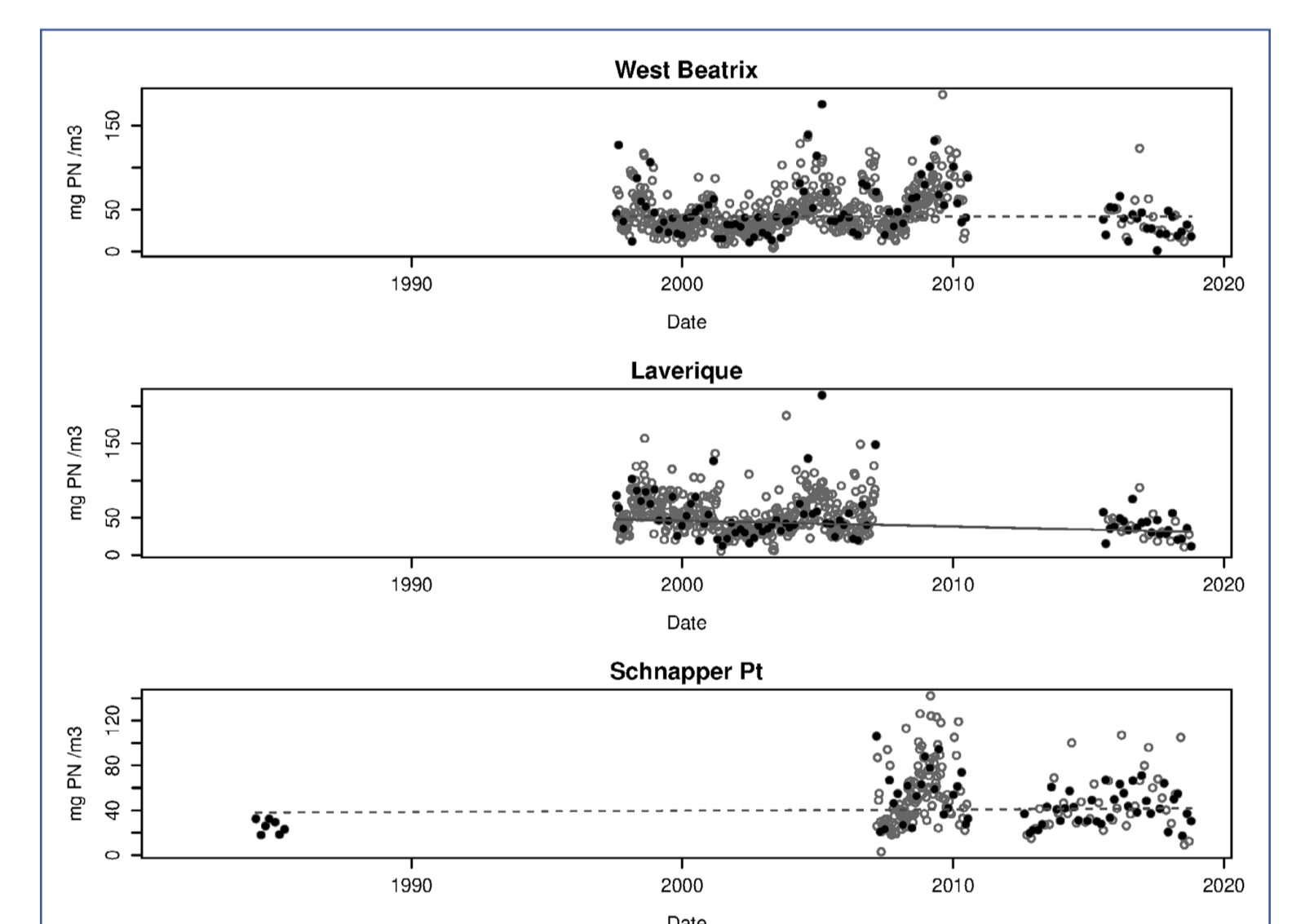
The data indicate that, where long-term water-quality trends are detectable, they have been small in comparison with shorter-term fluctuations. The fact that trends can be distinguished in the historical data need not imply that they are ecologically, economically or sociologically meaningful. It also does not mean that they are caused by human activities, or that the present trends will continue into the future.

Some of NIWA's ongoing research seeks to determine the veracity and causes of the long-term trends that have been inferred in our preliminary, deliberately naïve analysis of the data.

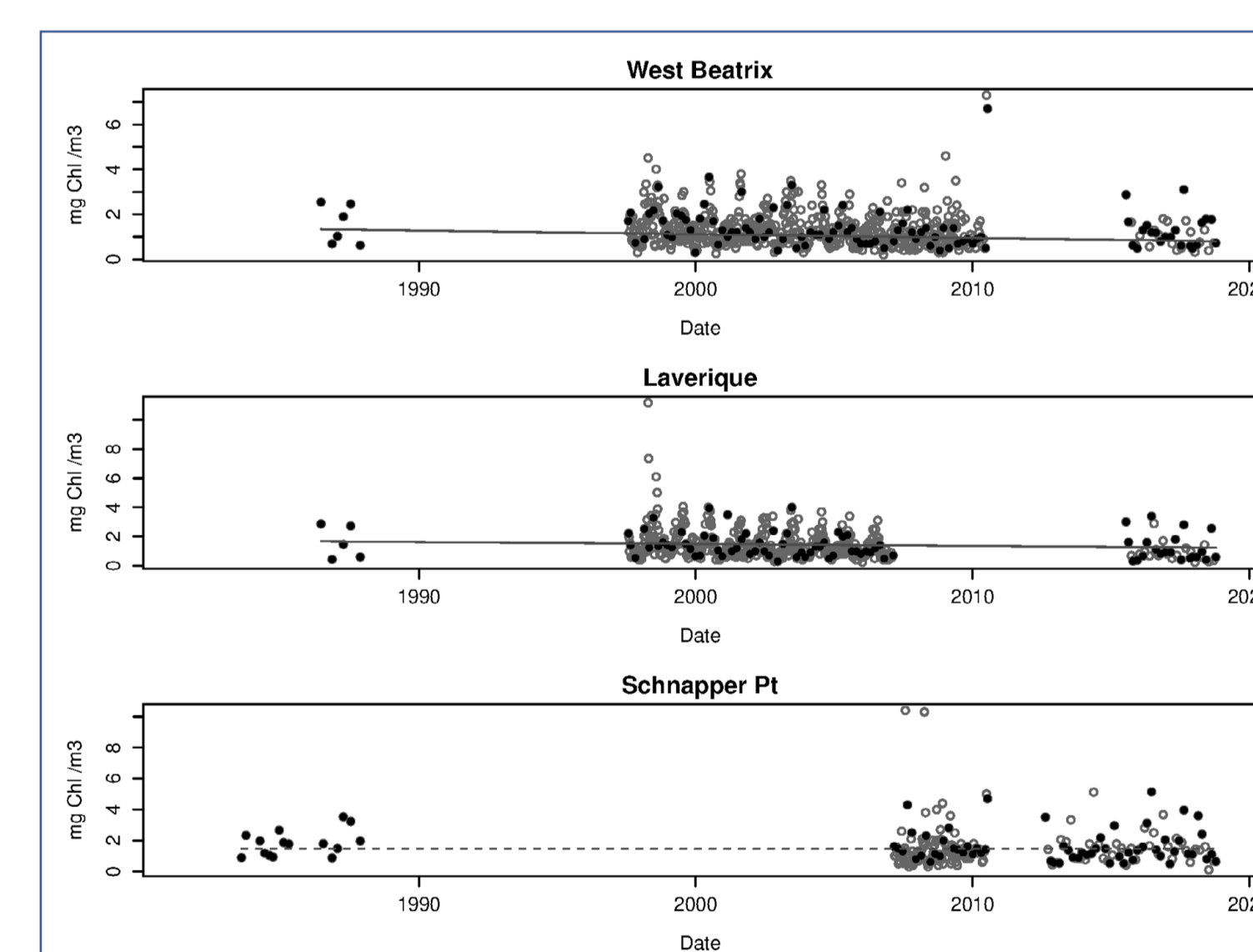
Here, we show the raw data and trend-lines for four variables: Particulate Carbon, Particulate Nitrogen, Chlorophyll and Turbidity. Particulate carbon, nitrogen and chlorophyll are different components of seston. Seston is composed of small organic particles – both living and dead. It is an important food resource for many filter-feeders, including zooplankton and shellfish. Turbidity is an inverse measure of water clarity, an important determinant of water-quality. Turbid waters are often considered less pleasurable to look at and light penetrates less far into the water-column. Thus, turbid waters tend to be less biologically productive than otherwise similar clear waters.



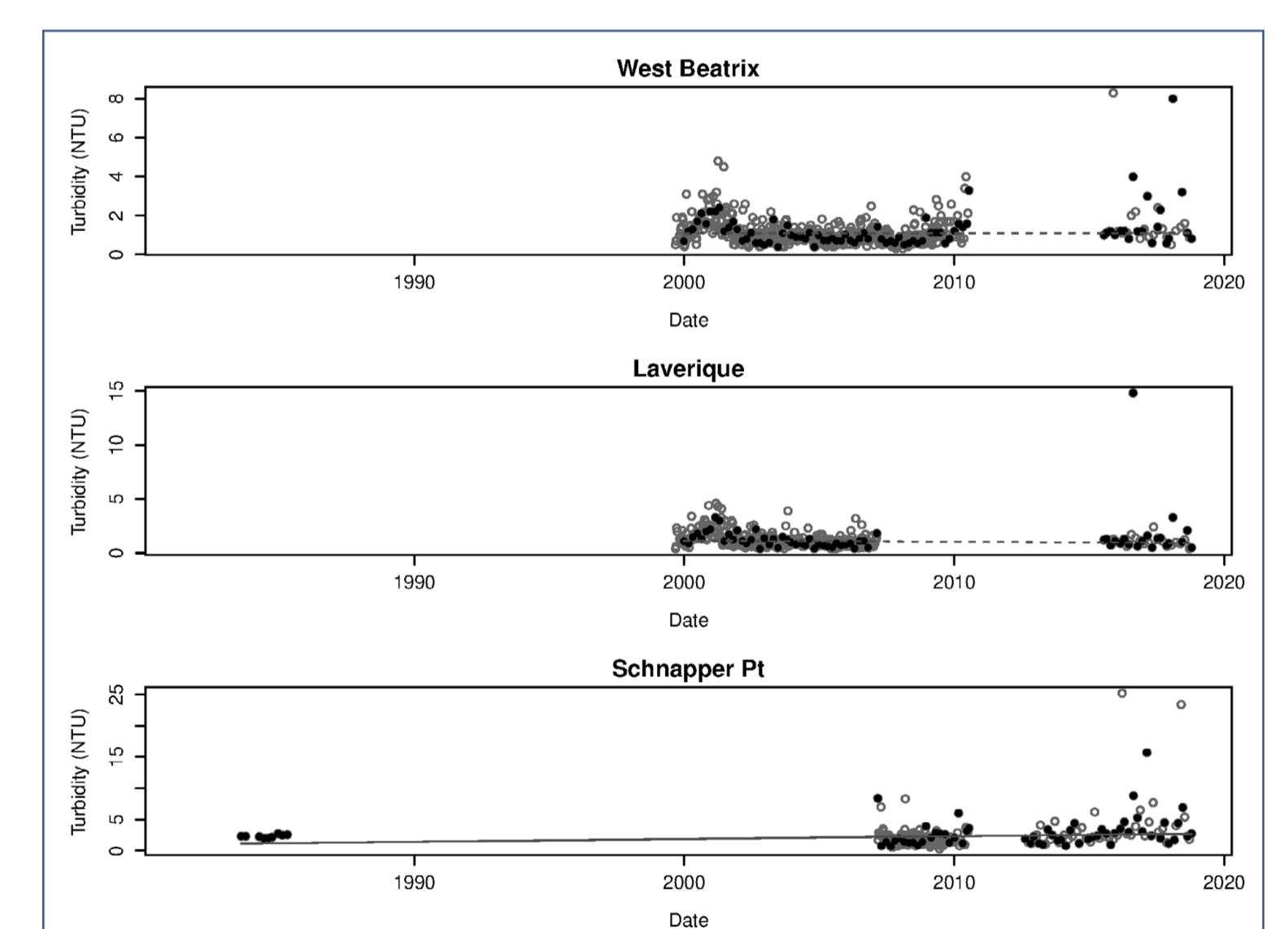
Time-series of particulate carbon in the three regions of Pelorus.



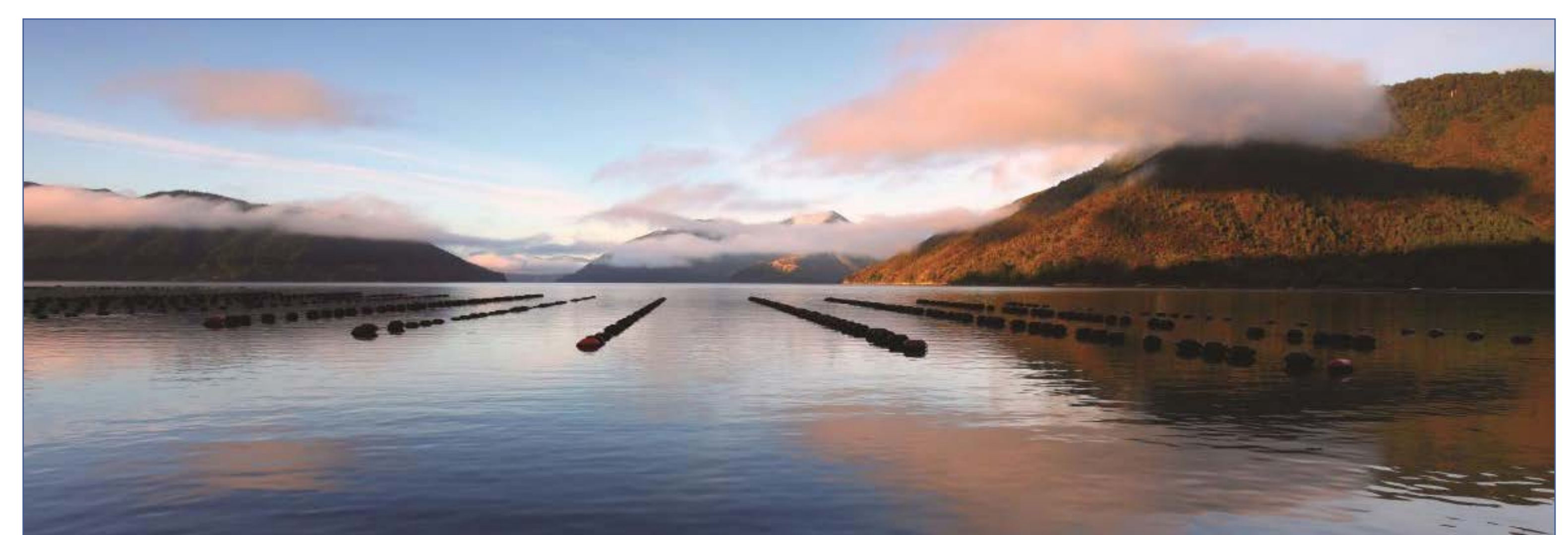
Time-series of particulate nitrogen in the three regions of Pelorus.



Time-series of chlorophyll in the three regions of Pelorus.



Time-series of turbidity in the three regions of Pelorus.



Acknowledgements:

We are grateful to the Marlborough District Council and Marlborough Sounds Quality Program for making their monitoring data from Schnapper Point available to us and for collecting samples at West Beatrix and Laverique on our behalf over the past two years. Similarly, we are grateful to the Marlborough Sounds Quality Program for collecting data on NIWA's behalf during 1997-2010 at Schnapper Point, West Beatrix and Laverique Bay. We are also grateful to Dr Lincoln MacKenzie (Cawthron Institute) for making his data from a 1986/87 sampling campaign available for this analysis. This analysis was funded by MBIE. Photographs are by Peter Hamill (Marlborough District Council), AquacultureNZ and NIWA staff.