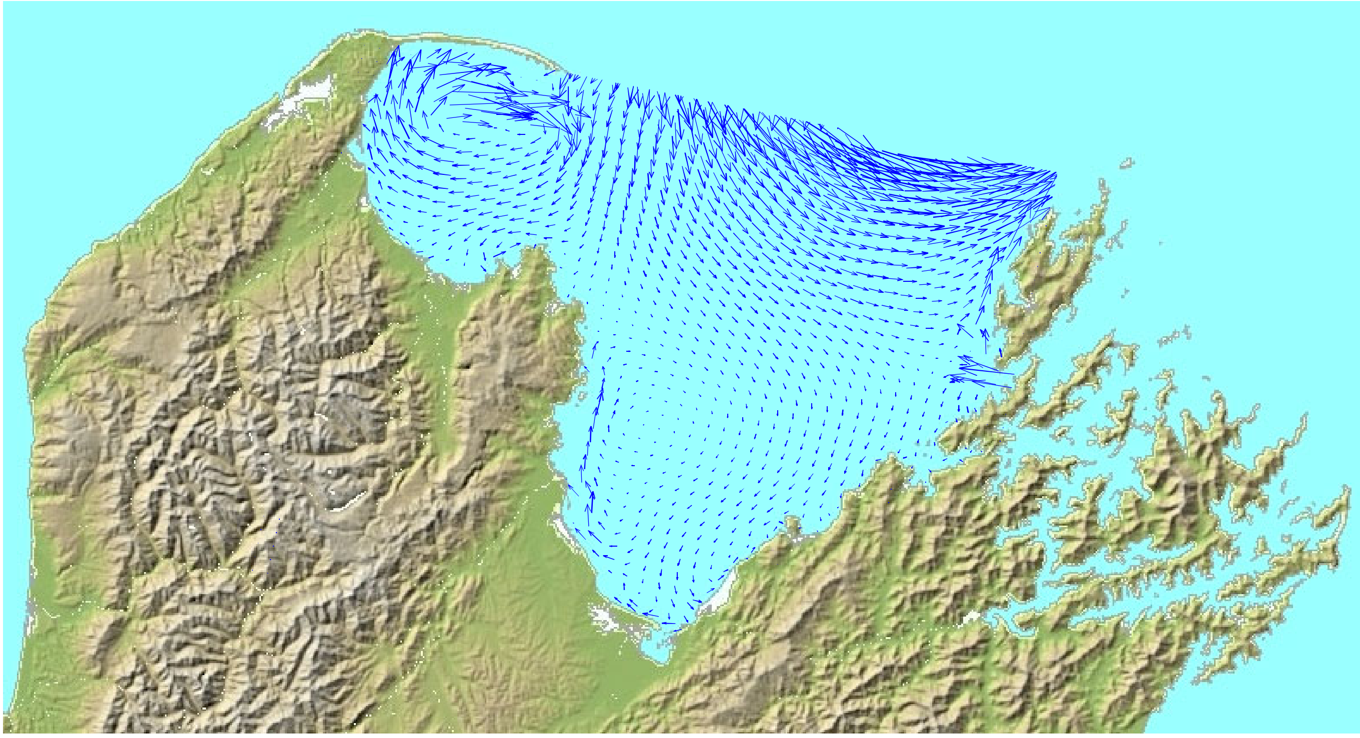
Cawthron Report No. 851

Progress of Hydrodynamic and Ecosystem Model Development for Tasman and Golden Bays



Prepared for

Stakeholders of the
Motueka Integrated Catchment Management Programme

Manaaki Whenua
Landcare Research

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CAWTHRON

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Progress of Hydrodynamic and Ecosystem Model Development for Tasman and Golden Bays

Motueka Integrated Catchment Management (Motueka ICM) Programme Report Series

by

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PREFACE

An ongoing report series, covering coastal-sea components of the Motueka Integrated Catchment Management (ICM) Programme, has been initiated in order to present preliminary research findings directly to key stakeholders. The intention is that the data, with brief interpretation, can be used by coastal managers, environmental groups and users of coastal marine resources to address specific questions that may require urgent attention or may fall outside the scope of ICM research objectives. We anticipate that providing access to marine environmental data will foster a collaborative problem-solving approach through the sharing of both ICM and privately collected information. Where appropriate, the information will also be presented to stakeholders through follow-up meetings designed to encourage feedback, discussion and coordination of research objectives.

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1. INTRODUCTION

The marine component of the Integrated Catchment Management (ICM) Programme was developed to further understanding of how natural and anthropogenic activities in the Motueka catchment affect ecological processes in Tasman Bay. A major component of the marine section of the ICM programme consists of a modelling project with the primary aim of developing a hydrodynamic circulation and ecosystem model of the Tasman/Golden Bay system. A validated model can then be used to provide insight into the major ecological processes occurring in the Bays. The model will eventually be able to simulate different scenarios, and the results from the model can then be used as a tool to predict the impact of both land and marine based events and activities on the Bays.

2. PROGRESS OF HYDRODYNAMIC CIRCULATION MODEL DEVELOPMENT

The hydrodynamic circulation model is still under development; it is currently able to simulate wind generated and tidally forced water flows within the Bays. The current focus is on determining how precisely the model flows reproduce water movement within the Bays and adjusting the model so that the simulated and real flows compare well. To validate the model, simulated current data extracted from the model were compared with real current data collected from the locations indicated in Figure 1. A Comparison of real and simulated data found that for all sites, the magnitude of the currents produced by the model are slightly larger than those of the real current data, however the directions of the currents from the ebb and flood tides match closely for the real and simulated data (Figures 2 and 3). This is especially evident for Site C in eastern Tasman Bay, where flood tidal flows are primarily directed southwards along the western coast of D'Urville Island and the ebb flows are directed slightly more to the east as a result of flow through French Pass (Figure 2). This highlights the importance of the eastern open boundary of the model as the phase difference between the northern and eastern open boundary will effect the direction of the ebb tidal flow.

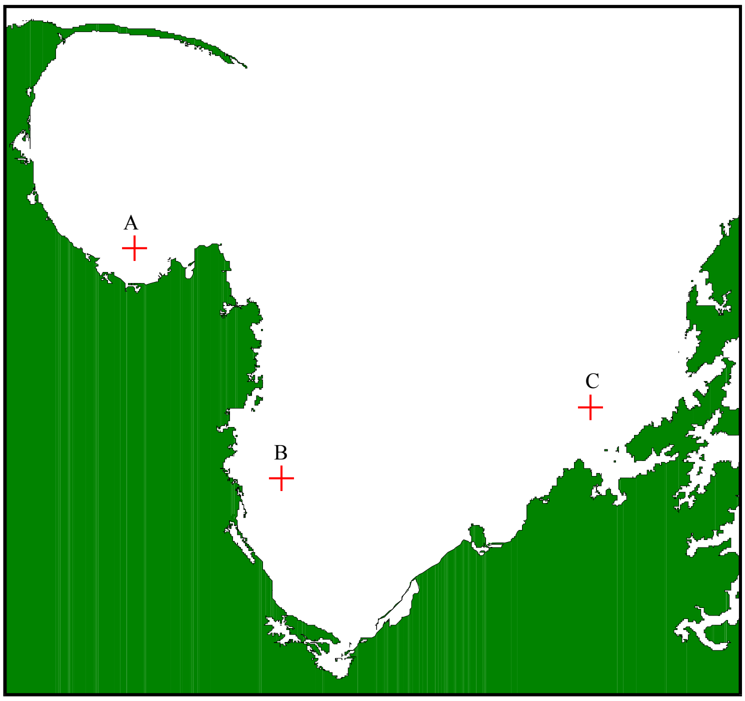

Figure 1. Map showing the deployment locations (red cross) of a Acoustic Doppler Profiler (ADP) and current meters within Tasman and Golden Bays.

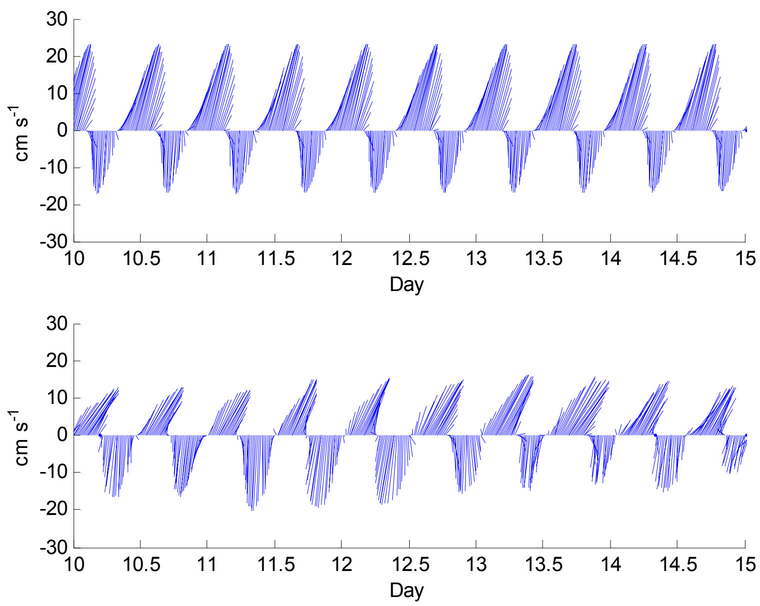

Figure 2. Current stick velocity plot for eastern Tasman Bay (Site C in Figure 1) model data (top) real data (bottom). Ebb flows have positive velocities and flood flows have negative velocities.

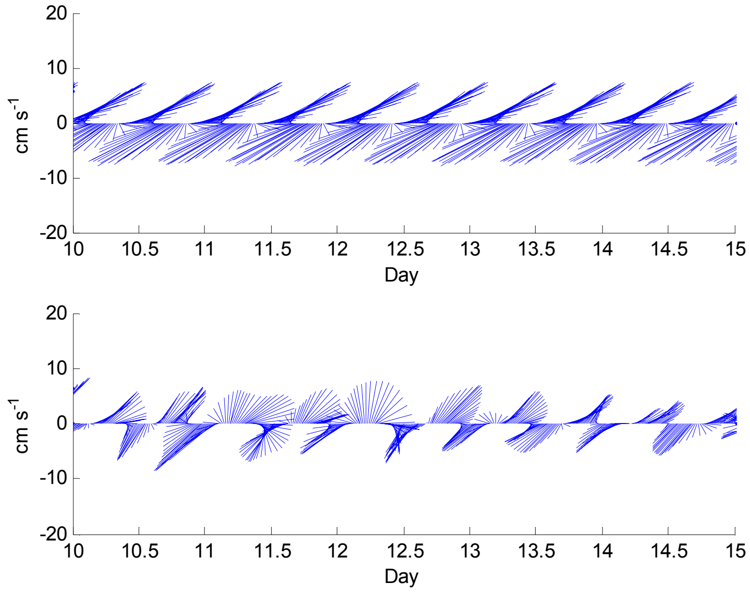

Figure 3. Current stick velocity plot for Golden Bay (Site A in Figure1) model data (top) real data (bottom).

As a means of validating the model, calculations of the phase difference of the maximum current velocity between Sites A, B and C were made for the real data and for the simulated data. These comparisons suggest that the circulation of both Tasman and Golden Bays currently produced by the model is not completely accurate at present. Our conclusion is that the boundary conditions (phase and amplitude forcing of tide) of the open ocean boundaries require additional attention, especially the French Pass open ocean boundary which appears to have a large influence on the circulation of the bays. A major difficulty in constructing any ocean circulation model is setting up the open ocean boundary conditions, especially when dealing with large phase differences, as is the case across the entrance of Tasman/Golden Bay. There is little information available in the literature regarding investigation of the phase and amplitude of the tide across the northern open ocean boundary and no current data have been found to date. Due to the lack of information, the boundary conditions have been set using previous Cook Strait modelling work (Bowman *et al*., 1980 and a Cawthron Cook Strait model) as a starting point.

The current ICM model only includes the M_2 tidal constituent since a spectral analysis of the real current data indicated that the M_2 tide is the dominant tide and any influence from the other tidal constituents appears minimal. If, after a significant time, we find adjusting the boundary conditions does not improve the comparison between the phases of the real and simulated data, we may have to contemplate including the other tidal constituents and see if their inclusion improves the circulation. The residual circulations produced by the model have so far been contrary to the widely accepted residual circulation for the Bays described by Heath (1969). Heath suggests that a flow, the D'Urville Current, flows eastwards past Farewell Spit and then divides into two currents off Separation Point. One branch flows clockwise around Golden Bay while the other flows counter clockwise around southern Tasman Bay, where it is opposed by a south flowing current close inshore on the eastern shore of Tasman Bay. All attempts to reproduce the residual circulation described by Heath (1969) have failed. The model suggests that the residual circulation of the bays is more likely to resemble the circulation shown in Figure 4.

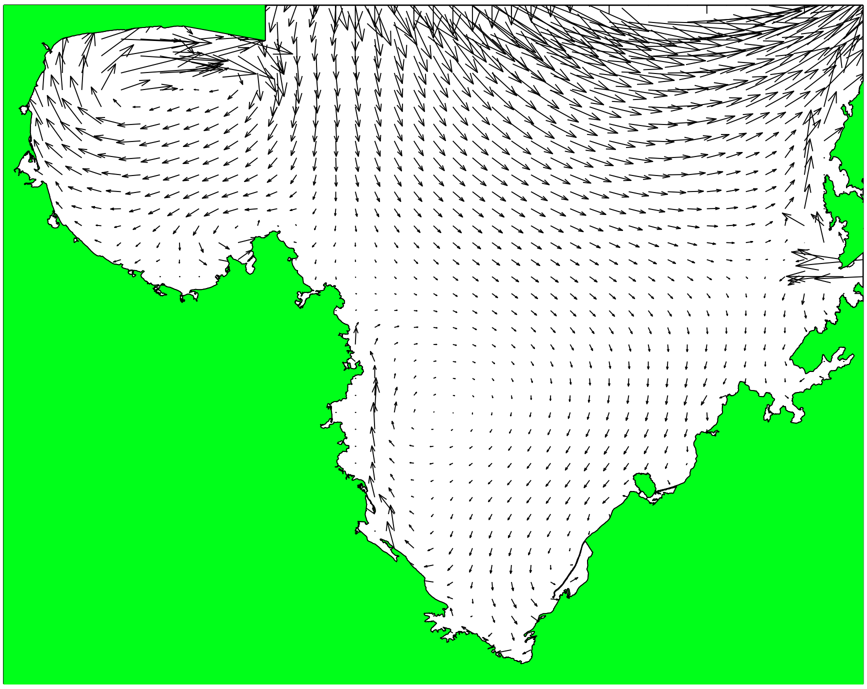

Figure 4. Simulated residual circulation for Tasman/Golden Bay model.

Work has commenced looking at the riverine physical/chemical and biological inputs into the model and at sedimentation, suspension and resuspension within the Bays. This has included a literature review and initial testing of the freshwater inputs and sediment transfer components of the model.

3. PROPOSED FUTURE DATA COLLECTION SYSTEM

Newly available technology now provides a cost effective means of collecting real-time marine environmental data. Previous satellite-based telemetry has been superseded by lower cost broad-band cellular-based data transfer for many applications. In order to facilitate validation of our Tasman/Golden Bay hydrodynamic and ecosystem models, we are evaluating the use of a buoy-mounted, multi-parameter, telemetered data collection system.

The system would monitor:

- Current velocity & direction
- Conductivity (salinity)
- Temperature
- Depth
- Chlorophyll *a* (optional)

Ongoing costs of the cellular-based telemetry would be minimal (*i.e*. $10 per month), however initial setup and hardware costs, including the buoy, telemetry modem and the above sensor array are still relatively costly (*e.g*. ~$50,000 for a single depth). Since the water column of the Motueka plume region of Tasman Bay is normally stratified (Gillespie 2003), data should ideally be collected from multiple depths. This would result in an additional cost of $40,000 to $50,000 per depth. Alternatively it would be possible to use a combination of the above telemetered data sensors at one depth with a string of less expensive data logging thermisters and conductivity sensors to evaluate profile characteristics. Additional chl *a* monitoring units could also be deployed at strategic locations using newly available detectors at a cost of ~ $5000 each.

Access to the data by stakeholders could be provided in several different formats. Password-protected web access to real-time data, as either plots or spreadsheets, is seen as the most efficient way to disseminate the data since it doesn't require intervention from the data provider, and stakeholders can download the data at any time. As telemetry data are received at Cawthron, the information on the webpage will automatically be updated, allowing the quickest means of retrieval for time critical data. Alternatively, monthly time series summaries could also be provided as either plots or spreadsheets.

In addition to providing data for model validation, this system would allow long term collection of environmental data as a basis for shellfish management requirements. Industry-linked data collection systems could be used to identify boundary effects between plume-affected regions within the Aquaculture Management Areas (AMAs) and offshore regions or to compare the productive potentials of different regions within the Nelson bays. Relationships between environmental conditions and shellfish growth and condition could be assessed through stakeholder partnership with a goal of developing predictive capabilities.

4. REFERENCES

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