OCEANOGRAPHY OF STRAIT OF MAGELLAN, SOUTHERN CHILE

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OBJECTIVES:

The main objective of this project was to understand flow dynamics and mixing in the Strait of Magellan, southern Chile, to evaluate its potential for generating clean energy for Patagonia, depending on future scenarios of global climate change and local human activities. This environmentally unique region is currently changing its ecological balance due to anthropogenic stressors of excessive fishing, offshore oil production, and recently increased operations of surface coal mining and newly leased areas for aquaculture. The project results will create a new framework to investigate delicate environments in sub-Antarctic regions, providing foray for future multidisciplinary studies of physical, biogeochemical and ecological processes in the coastal regions of southern Chile.

Our specific goals included:

- Identification and description of relevant governing processes that affect mass and momentum transports in coastal channels of the Strait of Magellan, Chile.
- Conducting field measurements of currents, stratification and turbulence (mixing) at specified locations of the Strait (collaboratively Notre Dame and Pontificia Universidad Católica de Chile groups) to characterize exchange processes in the water column across and along several sections of the Strait. The measurements

provide critical information for understanding of physical processes that can be used to verify outputs of numerical modeling.

- Understanding flow dynamics in coastal channels of Patagonia and evaluate effectiveness of tidal energy for possible use of green energy production (by Chilean scientists).

Approach and Methods

The main essence of the project was to conduct measurements of (i) turbulence (small scale velocity gradients, followed by calculation of the turbulent kinetic energy dissipation rate ε) and (ii) background hydrological variables such as temperature, salinity, density and buoyancy frequency in the waters of the Strait of Magellan at a series of representative oceanographic stations. The measurements have been taken using a Vertical Microstructure Profiler (http://rocklandscientific.com/products/profilers/vmp-500/), which carried airfoil (turbulence) probes to estimate the small scale shear and then the dissipation rate ε, accelerometer, pressure sensor, and a temperature-conductivity unit to obtain precise salinity, temperature and potential density profiles. The VMP-500 was successfully employed at nine stations in the Strait by the Notre Dame team in close collaboration with Pontificia Universidad Católica de Chile (PUC) scientists and a crew of R/V Marypaz II, which is a large fishing boat that has been rented by Chilean team for the research cruise. The ship (Fig 1a) was equipped by A-frame at the rear deck, which was used to launch the VMP measurements (Fig. 1b). The PUC research team provided an acoustic Doppler current profiler (ADCP) with both a mounting rod for the shipboard measurements, and a weighted tripod for mooring installation. Multiple GPS systems were on board including the ship navigation unit, another one connected to the ADCP data-logger, and cell phone GPS.

Field Measurements in the Strait of Magellan

The research cruise of R/V Marypaz II started on March 2, 2019 at 6:30 am. Prof. Cristian Escauriaza was the Chief Scientist of the cruise; the research personnel onboard are

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a)

b)

Figure 1. a) R/V Marypaz II at sea; b) VMP measurements (a working moment)

On March 2, the ship headed out from the port into a narrow section of the Magellan Strait to the north from Punta Arenas. The weather was calm with some light fog, waves were less than 0.5 meter height. We enjoyed the visiting sea lions and dolphins while getting all the instruments ready. The weather conditions in the area were highly variable, which is shown in Fig. 2 for March 2 – 8, 2019.

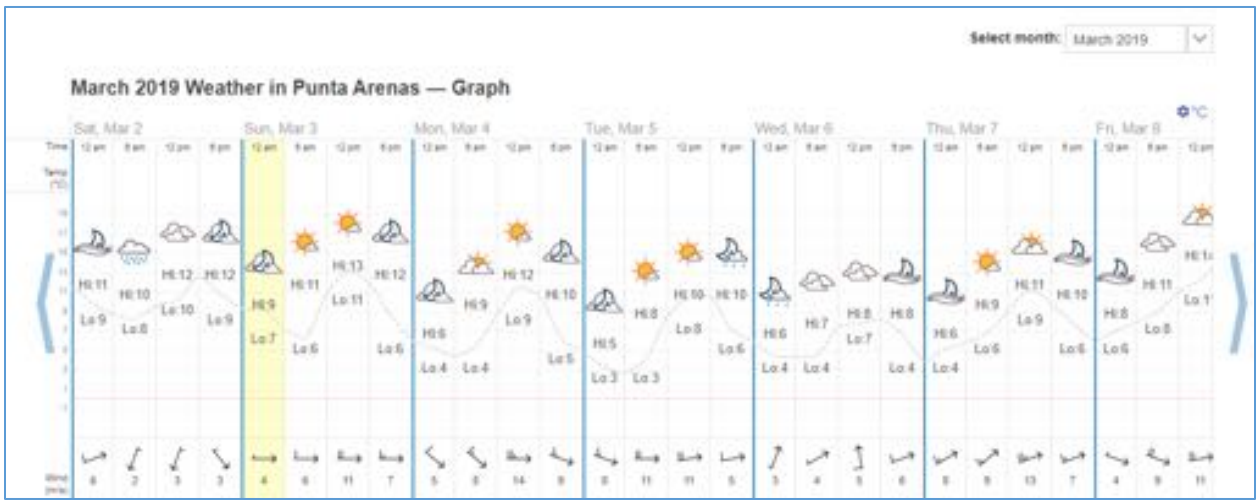
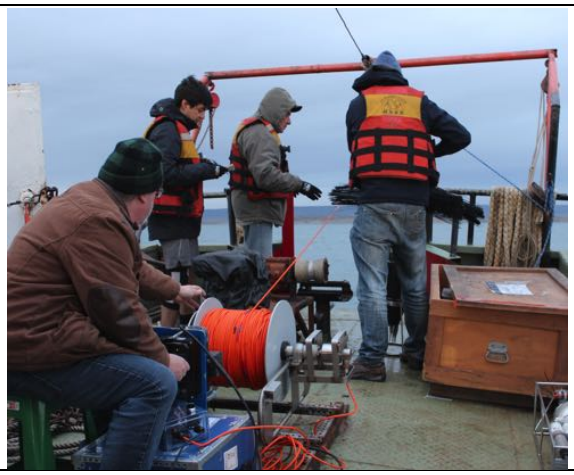


Figure 2. Meteorological data observed in Punta Arenas on March 2 -8.

The first station of microstructure measurements was taken on *March* 2, at 10:16 UTC at LAT: 52°45’ 2” S, LON: 70°37’48” W, the water depth was 21m (Fig. 3).

On *March* 3, 2019, after setting a mooring in a cove overnight, the ship headed out to the Strait to take VMP casts at 10:43 UTC, LAT: 52°39’ 45” S, LON: 70°14’ 9” W at a water depth of 38 m. The weather was again calm and sunny, with air temperatures around 10 C (Fig. 4)

Calm sea at the beginning of the cruise



The VMP team (Scott, Cristian, Iossif, and Leandro, from left to right)

Figure 3. VMP measurements under calm seas on March 2.

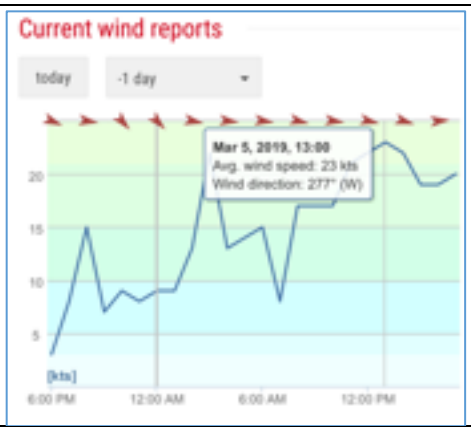
a)

b)

Figure 4. Dolphin escorting our ship (a) and a discussion on the rear deck (Iossif, Cristian, and Megan) how and where to run VMP measurements on March 3 (b)

March 4: The VMP measurements were attempted, but aborted due to rough waves and high winds (Fig, 5). The winds periodically exceeded 10-12 m/s and the wave height above 2 m (Fig. 6) precluded microstructure measurements from such small ship as Marypaz II. While we were waiting for the sea to settle down, the ADCP was deployed off the coast of a small peninsula for tidal measurements; extensive scientific discussions were taken onboard (Fig. 7).

a)



b)

Figure 6. High waves (a) during sunset on March 4 and strong variable winds on March 4 afternoon and in the morning of March 5 (b)

a)

b)

Figure 7. a) Megan prepares ADCP for mooring measurements; b) onboard discussion during a break of VMP measurements due to stormy weather on March 4.

March 5 and 6, 2019: The VMP measurements were restarted after the storm making two sections across narrow channels of the Strait. Four stations were taken on *March 5* between 23:03 and 23:57 UTC, at LAT 52° 39’58” - 52° 42’7” S, LON 70°19’0” - 70°15’51” W with a water depth of varying from 30 to 57 m. Three successful VMP stations were carried out on March 6, between 14:47 and 15:42 UTC at LAT 52°53’54” - 52°49’5” S, LON 70°49’59” 70°38’58” W with a water depth o varying from 26 to 57 m. In several cases, the profiler reached the bottom. The VMP was showing some electrical problems during the casts, so it was brought in for electrical diagnostics. It was found later to have an intermittent wire splice in the power cable. After the end of the expedition, the VMP shear sensors were sent for recalibration at the manufacturer facility http://rocklandscientific.com, showing almost the same characteristics as prior to the cruise.

March 7, 2019: The Notre Dame team completed VMP measurements. The instruments were off loaded and taken to the airport for shipping.