ADCP velocity profiles analisys in the Castellammare gulf

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ABSTRACT

Velocity profiles have been collected in three points within the Castellammare gulf at around 1500 m far from the coastline. This area is characterized by the presence of an aquaculture farm that positioned 5 floating cages in this zone. The impact of this activity on the environment strictly depends on the currents and water exchange. The general aim of this research is the characterization of the circulation characteristics of this area. The analysis of the free surface oscillations shows the typical behaviour of tide forcing, with high minima and maxima during the night, due to the higher moon attraction during these hours compared with the morning hours. A prevalent current direction from South-West to North-East has been recorded at each depth. This direction is almost parallel to the coastline. This behaviour is probably determined by morphology of the area and the general circulation of the Castellammare gulf.

KEYWORDS

Acoustic Doppler Profile; Coastal measures; gulf current; Sicily; velocity profiles.

INTRODUCTION AND STUDY AREA

The numerical modelling of the hydrodynamics in coastal areas requires a sound knowledge of the in-situ dynamical behaviour of the simulated variables (velocities, water elevations, etc). These measurements are essential in calibration and validation procedures (Cioffi et al., 2005) and they are also important to understand the physical system. In the past our research group carried out a number of field surveys aimed to understand the hydrodynamics of coastal water bodies (Nasello and Ciraolo, 2004; Nasello et al., 2005, 2006) and to plan possible actions to prevent the loss of the local species. Moreover, numerical models have been set up in order to reproduce the water levels and average velocities as function of the external tidal forces and of the coastal area physical parameters.

This paper illustrates results of field measurements carried out in a coastal Gulf, called Golfo di Castellamare, in the north-west part of Sicily (Italy), at around 1500 m far from the coastline. The area is seasonally influenced by continental inputs and, which originate from nearby rivers. This area is characterised by the presence of an aquaculture farm that positioned 5 floating cages in this zone. The impact of this activity on the environment strictly depends on the currents and water exchange.

METHODS

Velocity profiles have been collected in three points within the Castellammare gulf at around 1500 m far from the coastline (depths 28-38 m). This area is characterised by the presence of

an aquaculture farm that positioned 5 floating cages in this zone. The impact of this activity on the environment strictly depends on the currents and water exchange. The general aim of this research is the characterization of the circulation characteristics of this area. The data collected will be used to calibrate and to validate numerical mathematical models of circulation in coastal areas.
The distances between the ADCP systems range from 525 to 980 m (Fig. 1). The ADCP instruments have been positioned by scuba divers on concrete blocks. All the ADCP were up-looking systems.

Figure 1. a) The location of the study area (Castellammare gulf), b) locations of the 3 ADCP.

The instruments characteristics are reported in tab. 1. An average velocity profile every 20 min. has been recorded: each velocity is the averaged value of 50-273 measured values.

Table 1. ADCP measurement systems characteristics.

	Aquadop Nortek	*Aquadop Nortek*	*ADP SonTek*	*ADP SonTek*	*Workhorse Monitor RDI*
Water depth (m)	27.7	27.7	37.9	37.9	33.5
Number of profiles	3593	728	4169	4408	1873
Time of first profile	07/05/2008 12.00	26/06/2008 11.20	07/05/2008 12.20	30/07/2008 12.00	08/08/2008 8.55
Time of last profile	26/06/2008 09.40	06/07/2008 13.40	04/07/2008 11.00	29/09/2008 17.00	03/09/2008 8.55
Profile interval (s)	1200	1200	1200	1200	1200
Number of cells	14	27	10	38	35
Cell size (m)	2	1	4	1	1
Average interval (s)	90	120	120	120	--
Pings per ensemble	--	--	273	273	50

FREE SURFACE OSCILLATIONS (TIDE)

The first dataset we analysed is the free surface oscillations. The free surface oscillates according with the tide forcing, with high minima and maxima during the night, due to the higher moon attraction during these hours compared with the morning hours (fig. 2a). Of course these oscillations are higher during the full moon or new moon periods (fig. 2b). Fig. 2a shows recorded levels, recorded every 20 min, and the same signal filtered using a 1^{st} order Butterwoorth digital filter with 4 hours cut off period.

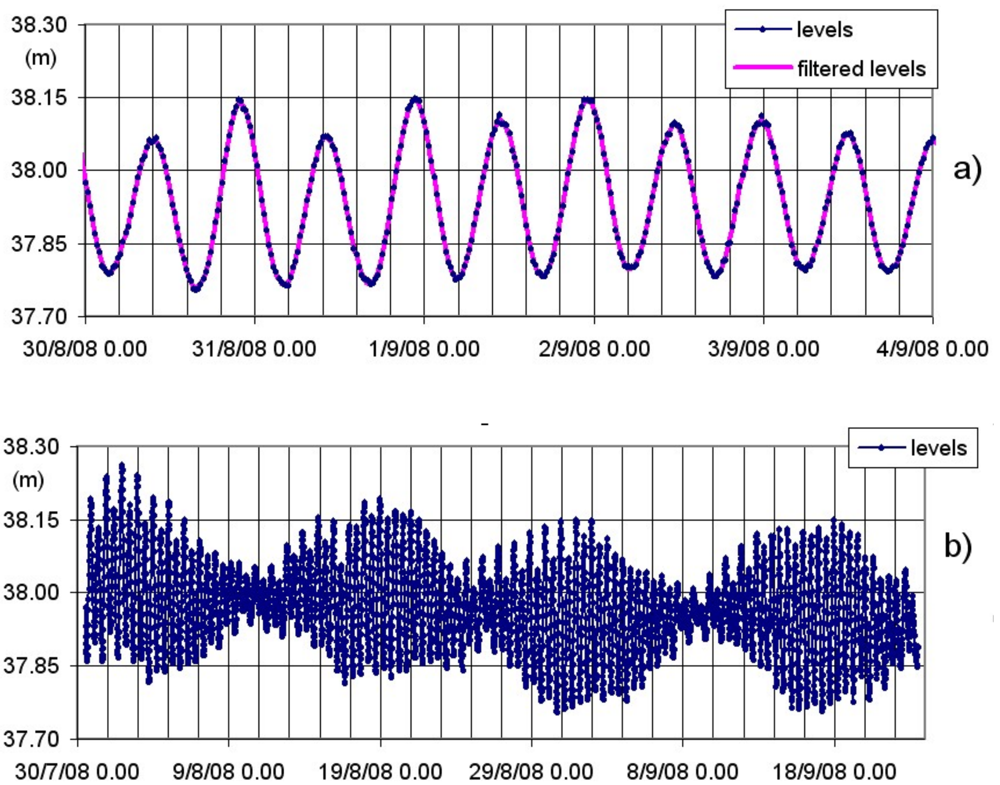

Figure 2. Tide levels recorded by ADP SonTek (38 cells); a) night and morning effect, b) full and new moon effect.

Power spectra of the filtered signal, both for the SonTek and the NorTek ADCP, shows the typical tide peaks (periods 21.5 and 12 hours) (fig. 3a, b).

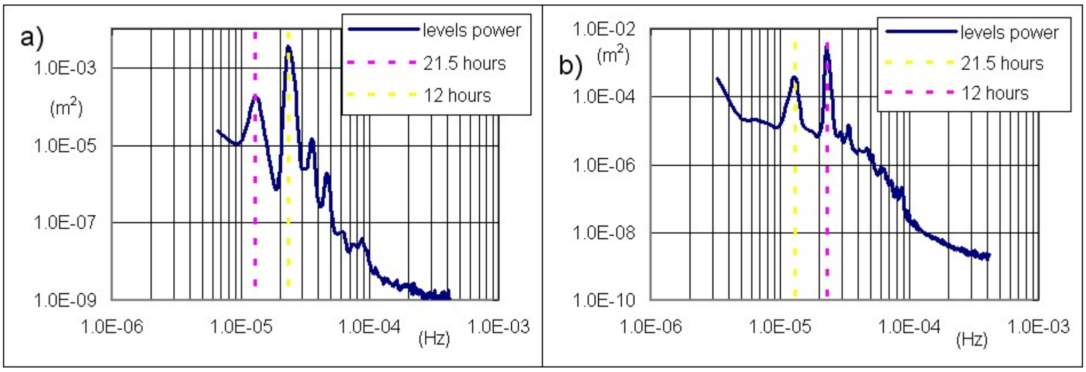

Figure 3. Tide spectra of the signal recorded by a) ADP SonTek (38 cells), b) Aquadop NorTek (14 cells).

VELOCITY MEASUREMENTS

To estimate the validity of velocity measures we considered that there are two sources of interference: the reflection of the acoustic pulse from the boundary, and the side lobe interference. We used the profile of return signal strenght to determine the last good cell where the measurements can be considered accurate (Sontek, 2000, 2009). The profile of signal strenght decays with distance from the trasducers, with a large spike corresponding to the reflection of the surface (fig. 4). For this reason the measurements in the last two cells, near the surface, have been discarded.

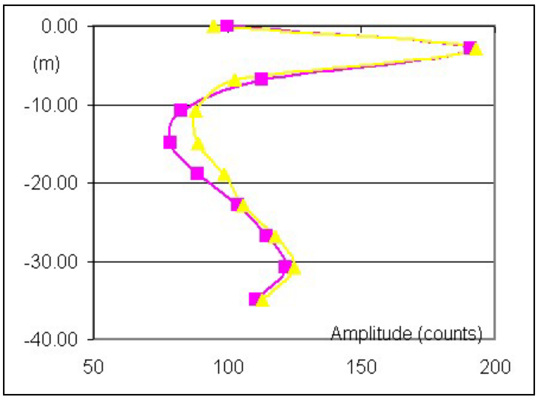

Figure 4. Spikes of profile of amplitude signal near surface (ADP SonTek - 10 cells).

As example we report the velocities recorded in East and North axes system for two days in correspondence of some particular depth h from the surface. On the recorded data we superimposed the original signal with a 1st order Butterwoorth filter (4 hours cut-off) (fig. 5).

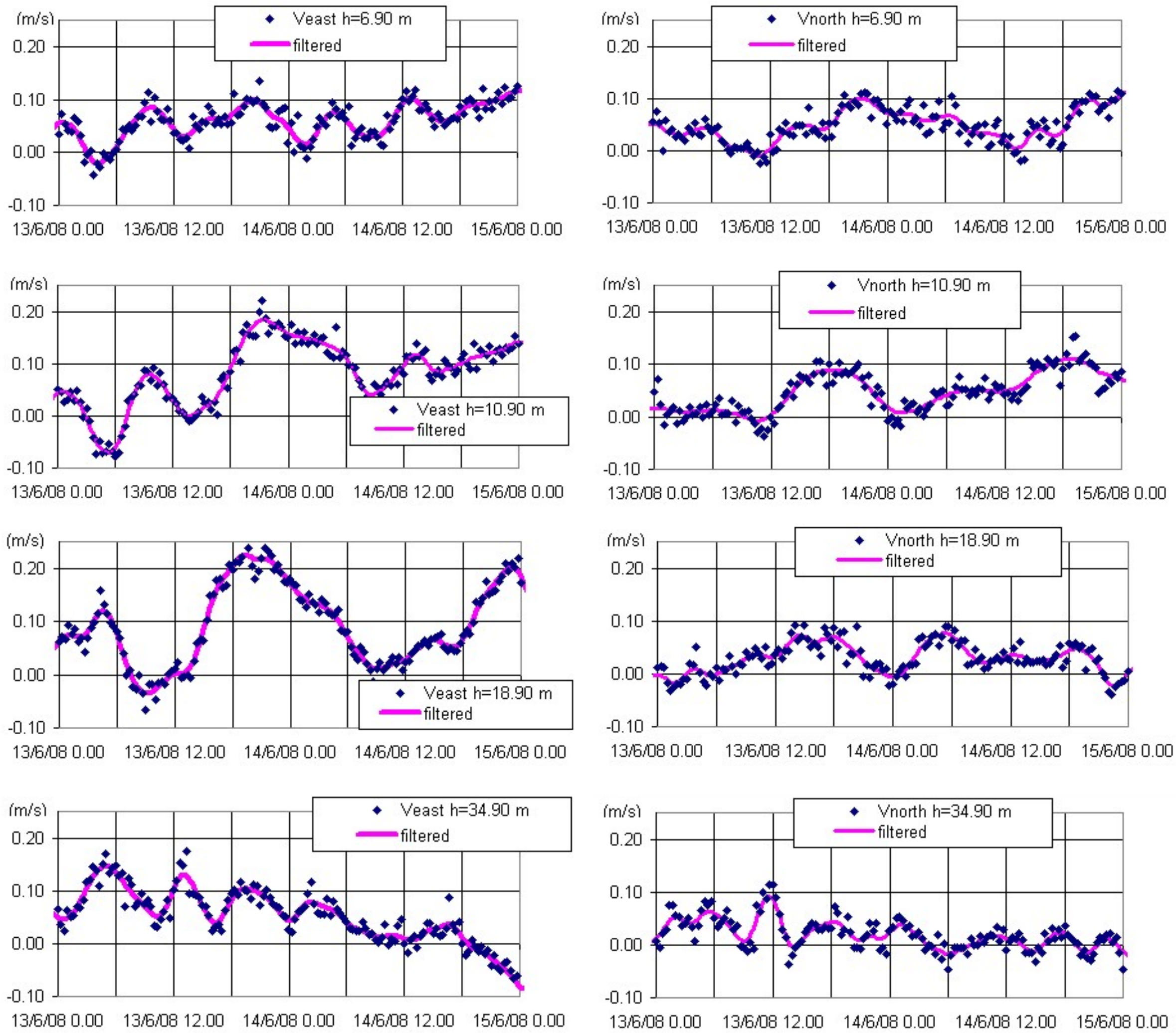

Figure 5. Veast and Vnorth velocities recorded by ADP SonTek (10 cells) at the depth h from the surface.

Analysing these signals it is possible to observe:

1. velocities show a cyclic behaviour due to the tide influence;
2. during these two days the two velocity component, Veast and Vnorth, are mostly positive. A prevalent current towards north-east directions seems to characterise this area.

The evidence of this prevailing current superimposed to the tidal cycle, can be argued from the vector representation of the filtered velocities (fig. 6). The two instruments (Aquadop Nortek and ADP Sontek) positioned at different depths h from the surface, show for three consecutive days the same direction of the velocity vectors.

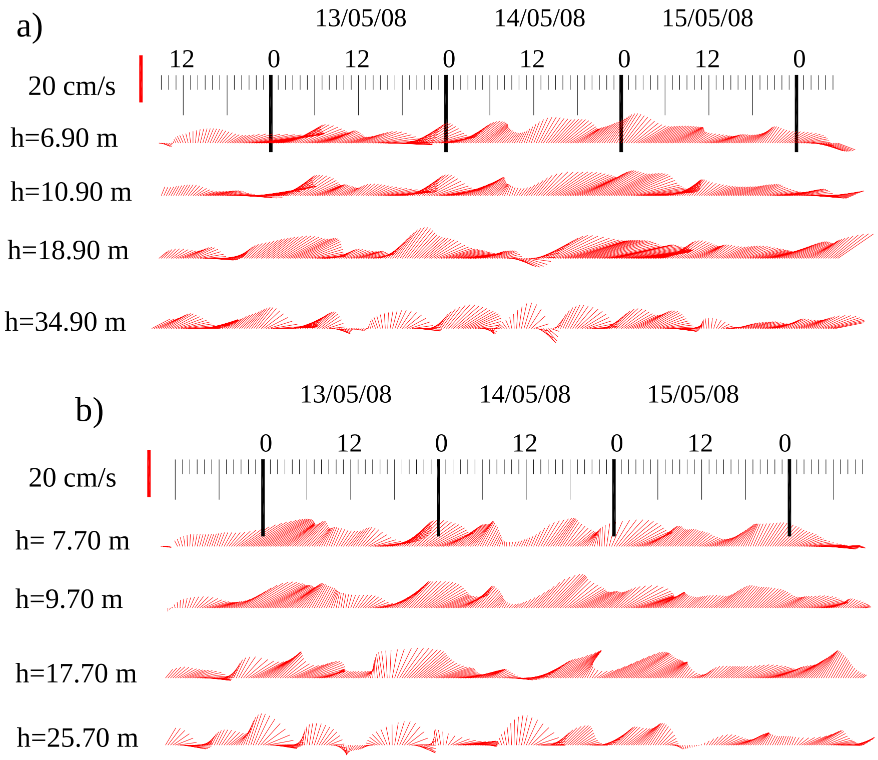

Figure 6. Prevailing current directed towards North-East direction. a) ADP SonTek 10 cells, b) Aquadop Nortek.

A different behaviour can be found during the 6th and the 7th of July. The two instruments recorded velocities in South-West direction (fig. 7).

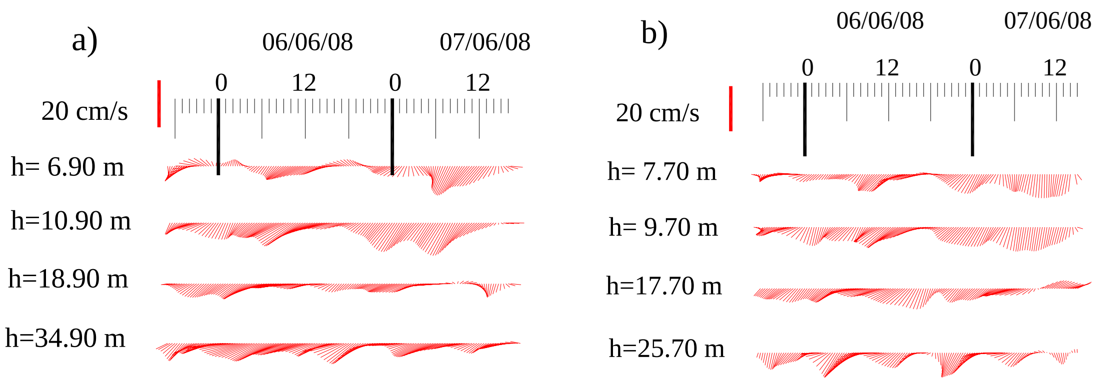

Figure 7. Prevailing current directed towards South-West- a) ADP SonTek 10 cells, b) Aquadop Nortek.

The analysis of the Figg. 6 and 7 highlights the presence of a persistent current from South-West to North-East direction that can invert in the opposite direction. The tide affects this current with accelerations or decelerations.
The presence of the tide effect on the velocities components can be argued also by the power spectra analysis of the (filtered) data (fig. 8). A peak at 22 hours period can be noted.

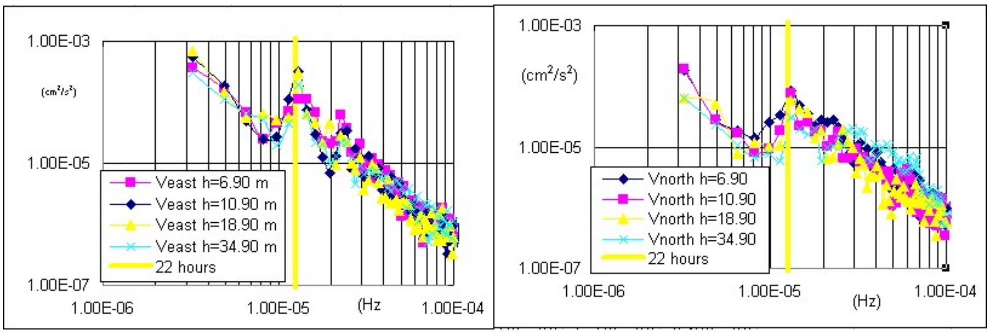

Figure 8. Power spectra of velocities components (ADP SonTek 10 cells).

A frequency analysis of the velocity directions has been also performed. The directions values have been subdivided in 24 sectors and the frequency of occurrence for each sector has been calculated (Fig. 9).
The prevailing direction South-West to North-East is present at each depth. This direction is almost parallel to the coastline. In particular the three instruments recorded dominant current in North-East direction (Fig. 9).
This behaviour is probably determined by the morphology of the area and the general circulation of the Castellammare gulf. The local circulation is strongly related to larger scale marine circulation.

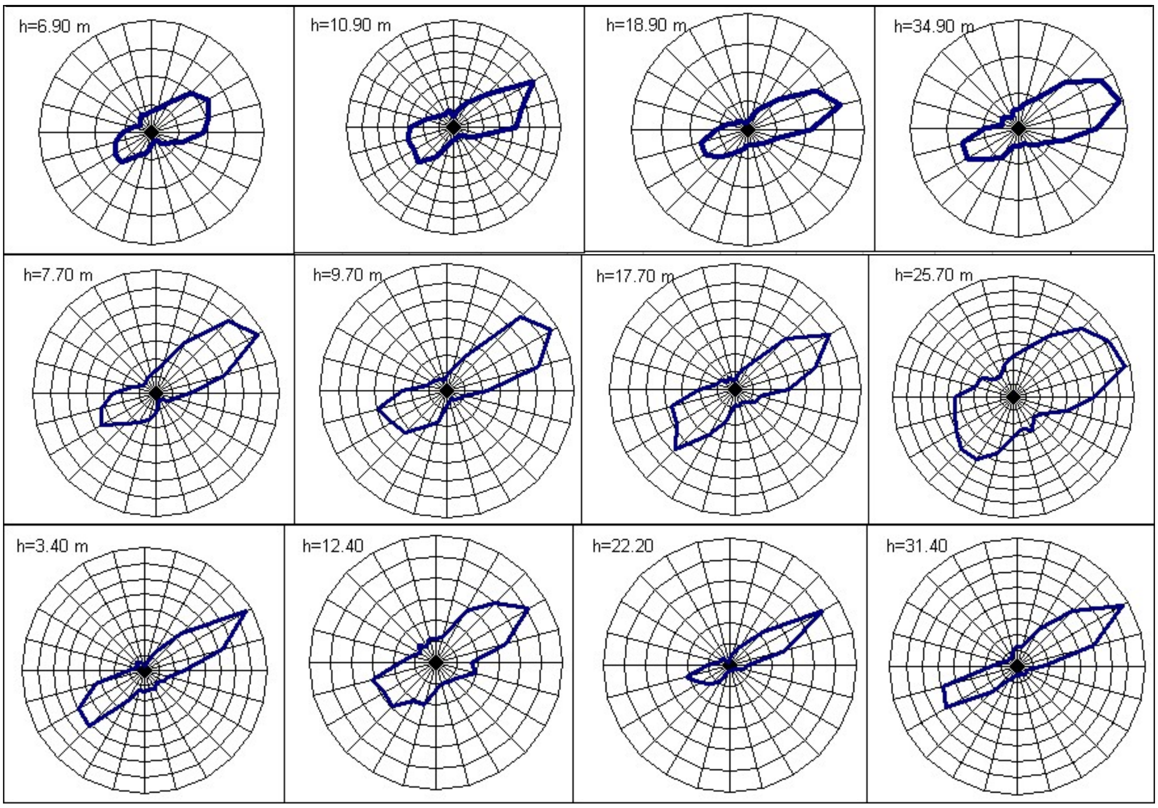

Figure 9. Frequency analysis of the velocity directions. a) ADP SonTek (10 cells), b) Aquadop Nortek (14 cells), c) ADP RDI.

CONCLUSIONS

The preliminary analysis of the collected data showed:

1. currents are parallel to the coastline of the study area;
2. the dominant direction is from South-East to North-West;
3. in some case an inversion occurs;
4. the tide influences the velocity field, accelerating and decelerating the above mentioned currents.

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