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Water Column Study in the Monitoring Plan of the First Italian Offshore LNG Terminal

C Virno Lamberti*, P Tomassetti, S Ceracchi and M Gabellini

ISPRA, Institute for Environmental Protection and Research, Italy

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***Corresponding author:** C Virno Lamberti, Senior Researcher, ISPRA, Rome, Italy

Abstract

The first Italian offshore terminal for storing and regasifying liquefied natural gas, located in the North Adriatic Sea, started the operational activities in 2009. Institute for Environmental Protection and Research (ISPRA) elaborated and carried out the monitoring plan or the marine environment, in order to assess potential environmental impacts linked to the project. In this paper we present the monitoring activities conducted on the water column in order to study hydrodynamic and physical-chemical characterization in the offshore area close to the regasification terminal, to assess the hydrodynamism variation due to the terminal presence and the fate of the cold water's discharge linked to the process of vaporization. The terminal influences the evolution of marine currents in the immediate vicinity, causing a departure from the general flow and also the thermal features of the water column but from a distance of a few tens of meters from the terminal this effect disappears.

Keywords: Offshore structures; Hydrodynamics; Physical-chemical properties; LNG terminal

Introduction

Natural gas, produced by the anaerobic decomposition of organic material, is mainly used for generating electricity and for residential uses such as heating. Italy, not self-sufficient for natural gas extracted, imports natural gas from Russia for the most part, from the North Sea, Libya and Algeria. However, the growing demand for this energy source is a need to increase import routes so as to make supply more flexible and less dependent on providing singular foreign countries. In this context is the design of the offshore regasification terminal Liquefied Natural Gas (LNG) in the North Adriatic Sea, which opens a new connection with Persian Gulf and cover about 10% of the Italy's gas consumption.

The project started more than 10 years ago, consists of the construction and operation of an offshore terminal and connection's pipeline to the national distribution network. Retrieved from underground, natural gas is transported in liquid phase, involving a reduction in the volume of 600%. The liquefied gas is transported with LNG tankers (at atmospheric pressure and -162°C) from the Persian Gulf, the production site, to the regasification terminal, where it is unloaded, stored, regasified and then sent to the land via pipeline to be entered in the distribution network [1].

Terminal consists of reinforced concrete structure resting on the seabed (structure's type named GBS - Gravity Based Structure), at a depth of about 29 meters. Pipeline consists of an off-shore section, along approximately 15km (from the terminal to the coast), and an on-shore section, along approximately 25km. LNG vaporizers use sea water as a source of heat during the regasification process and then sea water is discharged into the sea (its temperature will be lower than receiving system). The sea water is discharged (maximum flow rate of 29000m^3/hr) in the South direction at -12m with a thermal delta of -4.6°C [2].

From September until November 2008 were conducted Terminal's installation activities and Terminal regasification operation started in 2009. This is the first offshore LNG terminal in Italy and the first in the world Gravity Based Structure for unloading, storing and regasifying LNG.

The Institute for Environmental Protection and Research, that acts under the vigilance and policy guidance of the Italian Ministry for the Environment and the Protection of Land and Sea, in 2005 designed the monitoring plan for the marine environment, identifying the main factors of pressure linked to the project [3]. Monitoring plan, based on an integrated approach considering the study of water column, sediments and biota, permits to identify spatial-temporal trends of the eventual alteration that could occur. The monitoring plan is devised as flexible tool allowing modifications when the activities are in progress, in relation with the acquired results.

In this paper we present some results of the study conducted on the water column for field current analysis and physical-chemical

characterization through the use of a multiparameter probe. The aim of the present study is to assess the hydrodynamism variation due to the presence of GBS and the fate of the cold water's discharge linked to the process of vaporization.

Materials and Methods

In September 2010, we carried out a survey in a marine area wide approximately 2 km X 3 km, around the GBS, located 12km from the nearest coast.

The chemical-physical data of the water column were collected by mean of a CTD multi-probe profiler SBE-25 measuring the following chemical-physical parameters: temperature (°C), salinity (PSU), pH (unit), dissolved oxygen (ml/l). In order to characterize the areas influenced by the terminal and to collect data in a control area, 13 stations were fixed at different distances from the terminal, from 10 to 2000m (Figure 1): one transect was fixed just in front of the water outfall, located in the south part of the terminal at -12 m water depth, with stations at 10, 20, 50, 100, 500, 1000 and 2000m from it. At each station the multi-probe was deployed into the water from the surface to the bottom at a speed of 1m/s and set to collect data every 0.5s. The recorded data were performed by specific software [4] whose allow to have graphical representation of them.

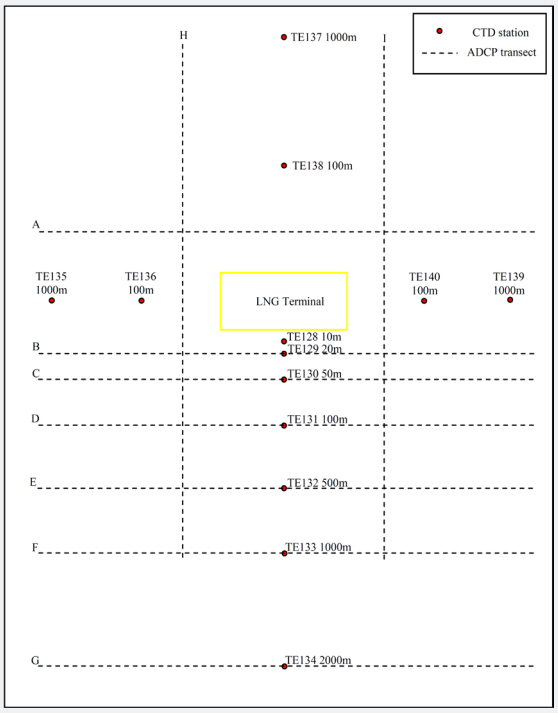

Figure 1: Location of CTD stations and current transects.

The current data have been acquired by mean of the ADCP (Acoustic Doppler Current Profiler) RD Instruments Sentinel 600kHz mounted on the side of the vessel. The ADCP was equipped with bottom tracking system in order to eliminate the speed, the pitch and the roll of the boat. The ADCP was set to collect data continuously and in 1m water column cells. This system was interfaced with D-GPS navigation system. The data was performed with specific software Winadcp (RD Instruments). During the campaign the current profiles over 9 transect were analyzed, 6 of them located in the south area at different distances from Terminal (B,C,D,E,F,G), one on the north area (A) and two perpendicular to them (H,I) (Figure 1).

Results

The results of the chemical-physical features of the water column close to the terminal showed limited effects of the cooling water outfall. The station fixed on 10m, 20m and 50m from the outfall showed limited temperature decrease at the surface until 10m depth, due to cold water coming from the outfall, located at -12m water depth, and arriving to the surface layer by the air bubbles transportations connected with the water discharge. However, this influence doesn't affect the wide of thermocline. In Figure 2 is represented the CTD profile on the station 128 at 10m from the terminal.

The comparison with the station 131, fixed along the same transect, but located 100m from the water outfall did not show differences between the trend profiles recorded at the 10m station with the exception of the temperature differences, of about 1°C, found in the surface layer (Figure 3).

The Figure 4 displays velocity and direction of sea current along the transect B located at 20m just in front of the water

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outfall in the south part of the terminal. The sea current shows a clear signal of perturbation induced by the cooling flow from the terminal: in the south area of the terminal is present a sea current with single direction south (180°) and high velocity (2-3m/s); at its sides, East and West, the sea current shows direction towards the discharge due to water attraction of the outfall flow, such as Venturi's effect (Figure 4), resulting in a deviation of the sea currents westward to the east of the terminal and eastward to the west with lower speeds. At 50 m from the outfall this effect disappears. The black areas visible in Figure 4 immediately at the sides of the outfall, are the current meter reading errors due to the extreme turbulence of the water and the existence of significant air bubbles which do not permit optimum operation of the doppler effect.

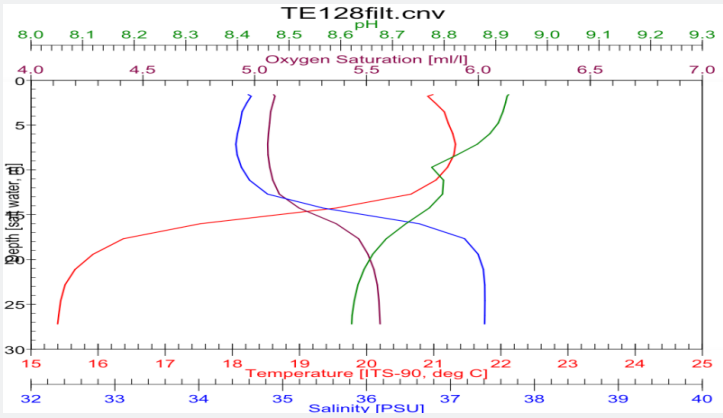

Figure 2: CTD results at 10 m from the outfall station.

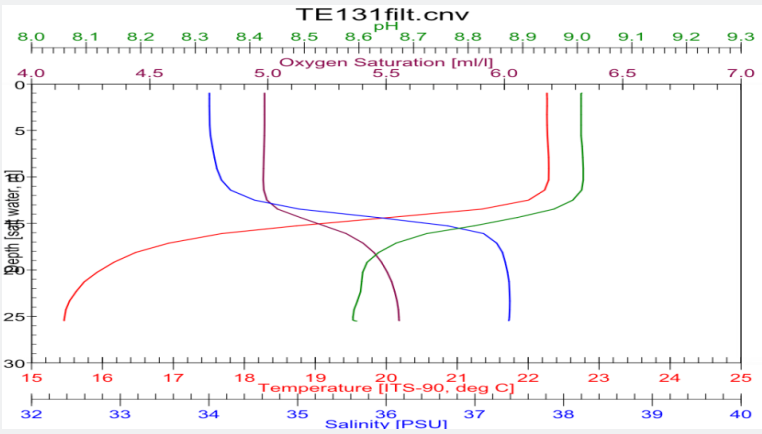

Figure 3: CTD results at 100 m from the outfall station.

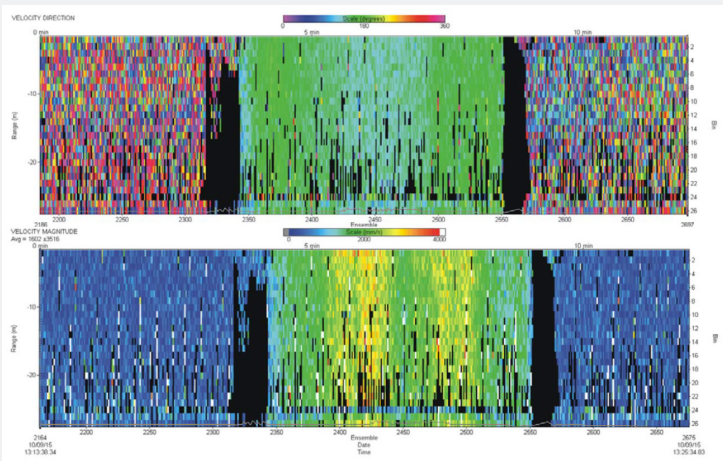

Figure 4: Direction and velocity of the sea currents along the transect located just in front of the water outfall.

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Discussion and Conclusion

The environmental monitoring activities are necessary to assess the main possible impacts associated with operation of the offshore LNG terminal, in particular in a very sensitive ecosystem [5,6] as the Northern Adriatic basin. Considering the important rate of cold water discharged into the sea during the regasification process, monitoring survey of the water column is recommended.

During the monitoring activities carried out close to the terminal, the physical-chemical features of water column did not show perturbation due to the cold-water discharge, with the exception of limited variation on temperature trend recorded in the station located at 10m from the outfall: this difference anyway is cut by half at 50m and disappeared at 100m from the outfall. Therefore, the minimal temperature variation is restricted in a very narrow area around the outfall.

The terminal influences the evolution of marine currents in the immediate vicinity of the discharge causing a departure from the general flow of marine currents but this effect disappears in the areas located at more of 50m from the outfall.

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