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Note on inertial oscillations in the North Adriatic

O inercijalnim oscilacijama u Sjevernom Jadranu

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INTRODUCTION

Inertial oscillations are unbalanced motions in the sea. They occur outside the coastal boundary layer during the geostrophic adjustment process. Inertial oscillations are observed in the ocean (Webster, 1968; Gonella, 1971) as well as in semi-closed seas and lakes (Blanton, 1975; Verber, 1966; Millot, and Crépon, 1981 etc.). Inertial oscillations are also generated in the upper water layers by temporal variations of the wind. The partitioning of the energy between geostrophic and inertial motions depends on winds duration (i.e. when the momentum is added impulsively, up to 75% of the energy goes into inertial motions). Inertial oscillations are almost exclusively confined to the internal modes of the stratifed ocean (Veronis, 1956). Millot and Crépon (1981) showed that most of the features of the observed inertial oscillations in the Gulf of Lions could be reproduced by a simple two-layer transient model.

There has been only one report of the existence of inertial oscillations in the Adriatic (Gačić, 1980), probably because most long-term current measurements have been associated with different pollution projects and made in the near-shore zone i.e. inside the coastal boundary layer where the signal at the inertial frequency is very weak.

Continuous current measurements since 1978 at the oil-drilling platform »Panon« in the North Adriatic have enabled us to observe inertial oscillations as an important feature of open Adriatic dynamics. In this paper we present the preliminary analysis of the time-series of mean hourly current vectors from August 10 through August 24 1979 when strong inertial oscillations took place. They were specially energetic during the onset of a strong E-wind event lasting from August 10 through August 12.

DATA ANALYSIS AND DISCUSSION

The platform »Panon« was situated in the North Adriatic as shown in Fig. 1. Currents were recorded at 15 minutes interval with »Alexeev« current meters at depths of 5, 25 and 50 meters. Winds were recorded continuously with the SIAP recorder. BT was lowered three times a day.

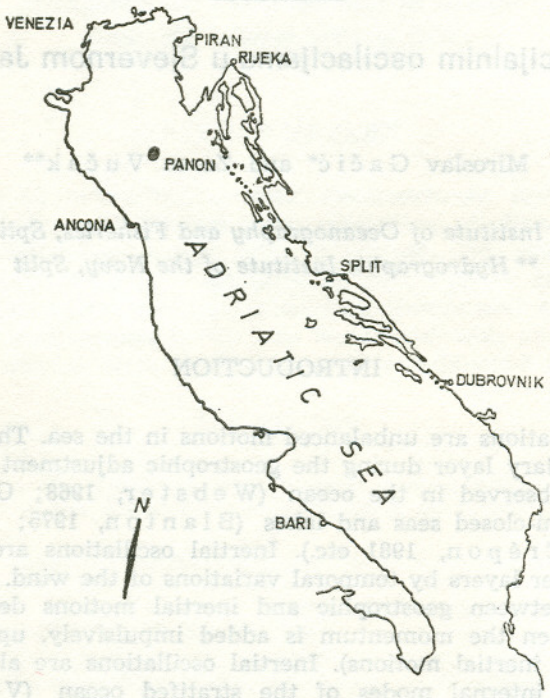

Fig. 1: Location of the oil-drilling platform »Panon«.

Current data were subjected to the rotary spectral analysis after G o n e l l a (1971). Spectral estimates were calculated for about 8 degrees of freedom using Blackman and Tukey method. In Fig. 2 the rotary spectra of the three current vector time-series are displayed. The most prominent peaks are centered at the local inertial frequency (0.0582 cph) in the clockwise part of the spectrum at all three depths.

Almost equal energy levels were present at that frequency at depths of 25 nad 50 meters. The inertial peak in the surface layer was almost an order of magnitude larger than the peaks at 25 and 50 meters depth. Tidal peaks were much lower than inertial. In all the spectra there was also high energy content near the zero-frequency because data were not detrended prior to spectral analysis.

Inspection of the hourly current vector time-series determined that an especially strong inertial signal was present during the onset of storm event from August 11 through August 12. As an illustration of this event the wind speed time-series for that period is presented (Fig. 3). The wind speed was rather unsteady while the wind direction was stable.

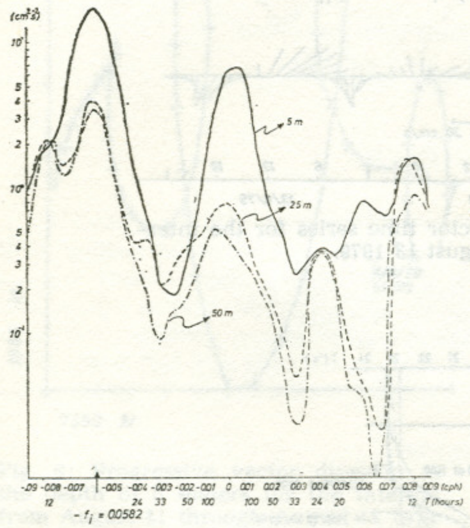

Fig. 2: Rotary current spectra for time-series from August 10 through August 24 1979.

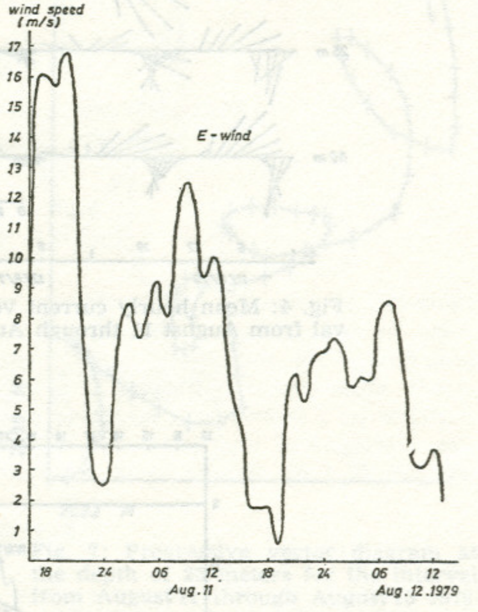

Fig. 3. Wind speed time-series for the interval with the strongest inertial oscillations.

We tried to observe the phase-lag between the surface and deeper layer currents. The time-series of hourly current data at three depths were plotted for the period when inertial oscillations were much stronger than any other motions i.e. from August 11 through August 13 (Fig. 4).

Fig. 4 shows that inertial oscillations at depths of 25 and 50 meters are in-phase. On the other hand the phase-lag between the surface inertial oscillations and inertial oscillations in deeper layers is approximately 180° which is in agreement with all the mentioned results. In another words, the observed inertial oscillations can also be reproduced by the two-layer model. Zero-crossing was between 5 and 25 meters probably in the thermocline, which, at this time of year, is very sharp separating the surface mixed layer from the cold bottom layer.

Five BT-profiles for the period of the onset of strong storm event are also presented in order to determine the thermocline depth (Fig. 5). The layer between 10 and 20 meters was the layer with the largest vertical temperature gradient and probably the layer where change of phase of inertial oscillations occured. Fig. 5 also shows the deepening of the surface mixed layer as a result of wind action.

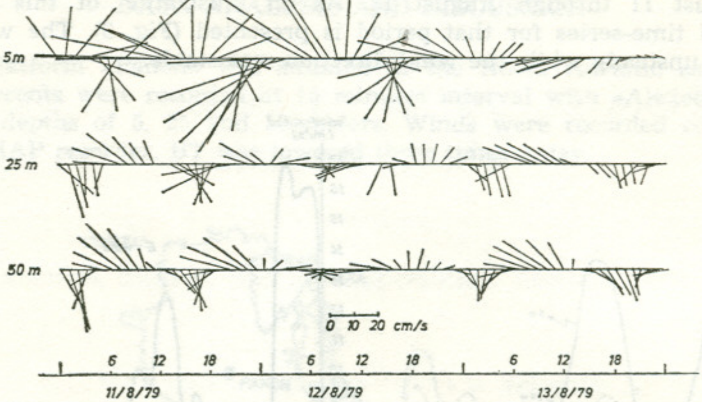

Fig. 4: Mean hourly current vector time series for the interval from August 11 through August 13 1979.

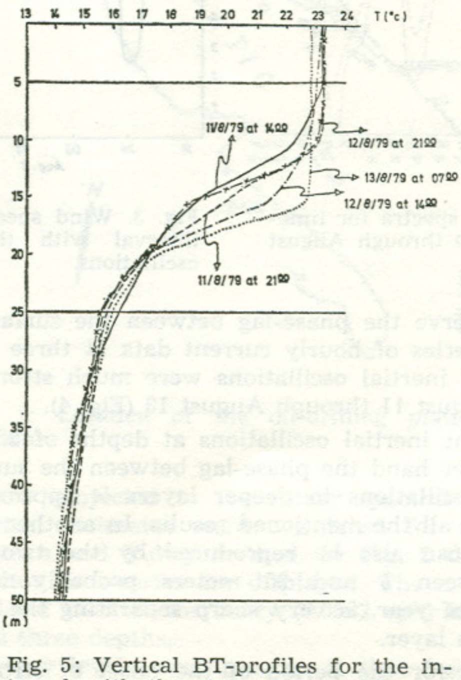

Fig. 5: Vertical BT-profiles for the interval with the strongest inertial oscillations. Current measurement depths are denoted by horizontal lines.

Progressive vector diagrams were plotted for the interval with the strongest inertial oscillations (Figs. 6, 7 and 8). In these figures the clockwise rotation of the current vector superimposed on the mean, relatively slow, motion is clear. The mean current in the surface layer was wind-ward (i.e. toward west), while in deeper layers it was rotated to the left with respect to the surface current.

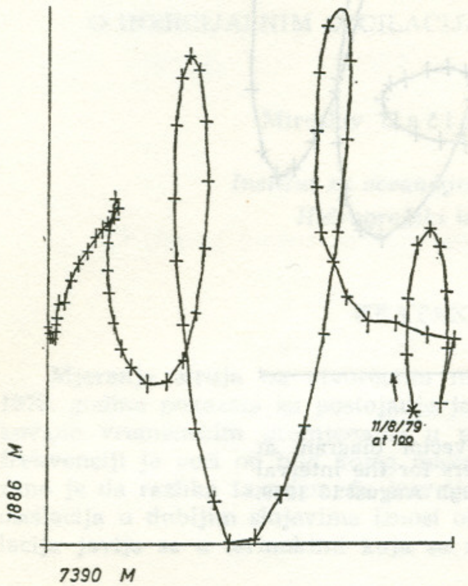

Fig. 6: Progressive vector diagram at the depth of 5 meters for the interval from August 11 through August 13 1979.

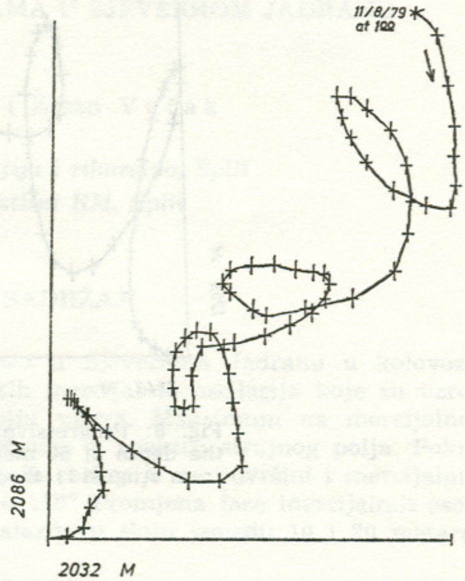

Fig. 7: Progressive vector diagram at the depth of 25 meters for the interval from August 11 through August 13 1979.

CONCLUSIONS

Preliminary informations on the characteristics of inertial oscillations in the North Adriatic have been presented.

The inertial peak at all three depths was the most prominent; energy at that frequency was much greater in the surface layer than in depeer layers.

Inertial oscillations, during the reported period have shown the prevalence of the vertical structure similar to that of the first internal mode with the zero-crossing somewhere between 5 and 25 meters.

This zero-crossing was probably in the thermocline situated at that time between 10 and 20 meters.

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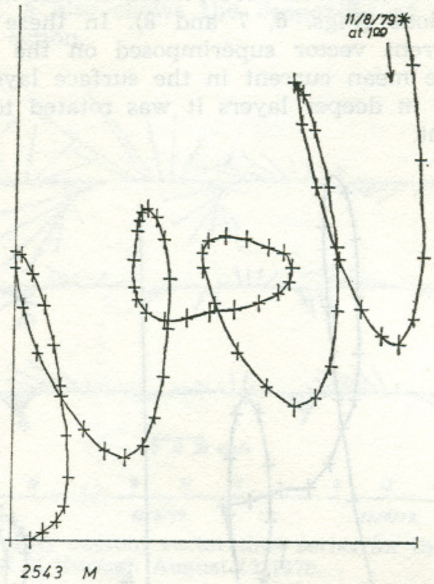

Fig. 8: Progressive vector diagram at the depth of 50 meters for the interval from August 11 through August 13 1979.

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O INERCIJALNIM OSCILACIJAMA U SJEVERNOM JADRANU

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KRATAK SADRŽAJ

Mjerenja struja na otvorenom moru u Sjevernom Jadranu u kolovozu 1979. godine pokazala su postojanje jakih inercijalnih oscilacija koje su uzrokovane vremenskim promjenama u polju vjetra. Maksimum na inercijalnoj frekvenciji je veći od bilo kojeg maksimuma u spektru strujnog polja. Pokazano je da razlika faza između inercijalnih oscilacija na površini i inercijalnih oscilacija u dubljim slojevima iznosi oko 180° Promjena faze inercijalnih oscilacija javlja se u termoklini koja se nalazila u sloju između 10 i 20 metara.

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