REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
02-16-2011

2. REPORT TYPE
Conference Proceeding

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Observations of Higher-Frequency Variability Through the Turkish Straits System

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
0601153N

6. AUTHOR(S)
Jeffrey W. Book, Ewa Jarosz and Sukru Besiktepe

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER
73-9441-09-5

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Research Laboratory
Oceanography Division
Stennis Space Center, MS 39529-5004

8. PERFORMING ORGANIZATION REPORT NUMBER
NRL/PP/7330--09-0098

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research
800 N. Quincy St.
Arlington, VA 22217-5660

10. SPONSOR/MONITOR'S ACRONYM(S)
ONR

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution is unlimited.

20110224051

13. SUPPLEMENTARY NOTES

14. ABSTRACT
From September 2008 through February 2009, Acoustic Doppler Current Profilers (ADCPs) measured flow in pairs at the four entrances and exits to the Turkish Strait System. Barotropic tide structures were observed for both diurnal and semidiurnal frequencies in the Aegean/Dardanelles entrance. At the Dardanelles/Sea of Marmara entrance some baroclinic structure was observed with diurnal tides having higher energy in the upper layer compared to the lower layer. Baroclinic structure in the semi-diurnal tides was observed at the Bosphorus/Sea of Marmara entrance and diurnal oscillations were weak. Both diurnal and semi-diurnal oscillations were weak at the Bosphorus/Black sea entrance as the temporal evolution of he flow was more concentrated at low frequencies in the form of a mid-water-column jet.

15. SUBJECT TERMS
Aegean Sea, Black Sea, bosphorus, dardanelles, tides

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
Unclassified	Unclassified	Unclassified	UL	1	Jeffrey Book
					19b. TELEPHONE NUMBER *(Include area code)* 228-688-5251

OBSERVATIONS OF HIGHER-FREQUENCY VARIABILITY THROUGH THE TURKISH STRAITS SYSTEM

Jeffrey W. Book [1]*, Ewa Jarosz [1] and Sükrü Besiktepe [2]
[1] U.S. Naval Research Laboratory, Stennis Space Center, MS, U.S.A. - book@nrlssc.navy.mil
[2] NATO Undersea Research Centre, La Spezia, Italy

Abstract

From September 2008 through February 2009, Acoustic Doppler Current Profilers (ADCPs) measured flow in pairs at the four entrances and exits to the Turkish Strait System. Barotropic tide structures were observed for both diurnal and semidiurnal frequencies in the Aegean/ Dardanelles entrance. At the Dardanelles/Sea of Marmara entrance some baroclinic structure was observed with diurnal tides having higher energy in the upper layer compared to the lower layer. Baroclinic structure in the semi-diurnal tides was observed at the Bosphorus/Sea of Marmara entrance and diurnal oscillations were weak. Both diurnal and semi-diurnal oscillations were weak at the Bosphorus/Black Sea entrance as the temporal evolution of the flow was more concentrated at low frequencies in the form of a mid-water-column jet.

Keywords: Aegean Sea, Black Sea, Bosphorus, Dardanelles, Tides

The U.S. Naval Research Laboratory in collaboration with NATO Undersea Research Centre and the Turkish Navy Office of Navigation, Hydrography and Oceanography, undertook a scientific research program, Exchange Processes in Ocean Straits (EPOS) that included an observational effort from September 2008 through February 2009 of maintaining pairs of bottom-mounted, upward-looking Acoustic Doppler Current Profilers near all entrances (exits) of the Turkish Strait System. Simultaneous current measurements allow connectivity ranging from high-frequency to seasonal processes to be investigated. One aspect of EPOS was to examine the frequency response of this system which includes very narrow passages and two vertical layers of opposed and energetic flow and exchange [1]. E.g., how do processes that are forced synoptically or faster propagate through the system and what is the baroclinic structure of their evolution?

To investigate this, rotary spectra were calculated from all the ADCP records separately for all depths. We used Welch's averaged periodogram method over block lengths of 43 days and 50% overlapping Hanning windows. No significant polarity differences were found between clockwise and counterclockwise spectra suggesting the absence of inertial activity at all four sections. There is a remarkable difference in the spectra results for each ADCP current section, particularly with regard to tidal oscillations. Diurnal and semidiurnal tides were clearly present at both ends of the Dardanelles Strait. The structures were primarily barotropic at the Aegean/Dardanelles entrance (Fig. 1, left). In contrast, at the Dardanelles/Sea of Marmara entrance the diurnal fluctuations in the lower layer entrance were notably weaker than fluctuations in the upper layer (Fig. 1, right). This suggests that the Dardanelles Strait geometry and/or its baroclinic structure has acted to extract some energy from the barotropic tide and convert it into baroclinic processes. Also, the differences between the diurnal and semidiurnal responses show a frequency dependence on this action.

At the Bosphorus/Sea of Marmara entrance the tidal frequency spectral peaks were different than those observed at the Dardanelles/Sea of Marmara entrance. Diurnal fluctuations were mostly absent and the semi-diurnal fluctuations had baroclinic structure, again with stronger spectral peaks in the upper than the lower layer (Fig. 2, left). This suggests that oscillations at diurnal and semi-diurnal frequency are not passing unaltered through the Sea of Marmara. The observed spectra at the Bosphorus/Black Sea entrance differed the most from the others as spectral energy was concentrated in the middle of the water column and at lower frequencies (Fig. 2, right). Flow was maximized in the upper portions of the lower layer in a jet-like structure as compared to maximums in the upper portions of the upper layer at other sections. Weak (primarily semidiurnal) tidal oscillations persisted in the upper layer and the flow maximum jet, but were virtually absent in the bottom of the water column. This suggests that the Bosphorus Strait geometry and/or its baroclinic structure also acts to alter or block higher frequency oscillations.

Analysis of these results has just begun and is ongoing. However, we can conclude that diurnal and higher frequency oscillations are an important component of the variability of the flow in parts of the Turkish Straits system, and that the Straits System acts to significantly affect the transmission of these frequencies.

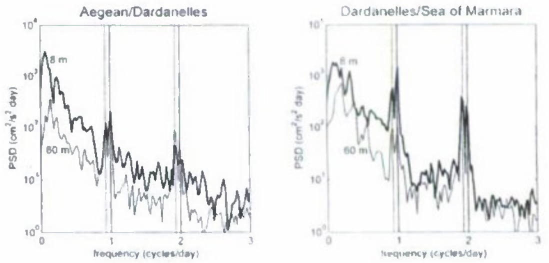

Fig. 1. Clockwise rotary spectra for representative moorings and depth levels in the Dardanelles Strait. The major tidal frequencies are marked by dotted lines.

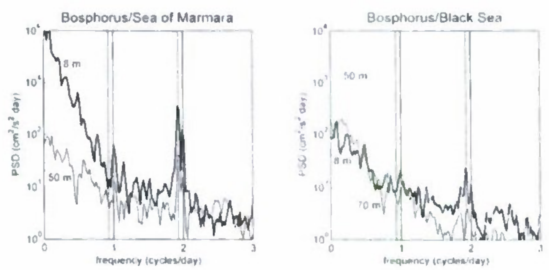

Fig. 2. As in Figure 1, but for the Bosphorus Strait.

Acknowledgments: This work was supported by the Office of Naval Research under Program Element 0601153N.

References

1 - Ünlüata Ü., Oguz T., Latif M.A. and Özsoy E., 1990. On the physical oceanography of the Turkish Straits. *In*: Pratt, L.J. (Ed.), The Physical Oceanography of Sea Straits. NATO ASI Ser. Kluwer Academic Publishing, Dordrecht, pp. 25–60.