RECENT PROGRESS ON THE BLACK SEA CIRCULATION AND ECOSYSTEM DYNAMICS

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Abstract

Its highly energetic mesoscale-dominated circulation and complex shelf-deep basin interactions, together with an array of natural and human impacts on a continuously changing perturbed ecosystem and biogeochemical structures, make the Black Sea a unique example. Some observational and modeling efforts that have been performed within the framework of several international programs explored, quantified, and predicted circulation, ecosystem and biogeochemical variability from the overall basin scale to coastal/shelf domains, and over time scales extending from weeks to decades.

Keywords : Black Sea, Circulation, Paleoceanography.

The Black Sea, once relatively an unexplored and isolated site of global oceans, has been a major focus of international and regional efforts since the early 1990s. Following the collapse of the former Soviet Union, Prof. Ünlüata was the leading person who initiated and promoted these collaborative efforts by bringing key scientists from the region as well as the international oceanographic community. Prof. Unluata's scientific vision and personality have been a key factor for successfull implementation of the HydroBlack, ComsBlack and NATO-SfS and NATO-SfP programs during the 1990s. Even though he moved to IOC during the late 1990s, his interest on the promotion of Black Sea oceanography continued till the last moment. The EU-funded projects, which are emerging during the present decade, are surely based on the earlier achievements made on his leadership.

Here, an overview of the progress achieved so far and the current state-of-the-art on the Black Sea oceanography is presented in terms of its circulation and ecosystem dynamics using a set of observational findings and modeling products.

The hydrographic, and remotely-sensed altimeter and ocean color observations as well as the modeling studies, reveal a complex, eddy-dominated circulation system with different types of structural organizations within the interior cyclonic cell, the Rim Current flowing along the abruptly varying continental slope and margin topography around the basin, and a series of anticyclonic eddies in the onshore side of the Rim Current [1, 2]. The interior circulation comprises several sub-basin scale gyres, each of them involving a series of cyclonic eddies. They evolve continuously by interactions among each other, as well as with meanders, and filaments of the Rim Current. The Rim Current structure is accompanied by coastal trapped waves with an embedded train of eddies and meanders propogating cyclonically around the basin. Over the annual time scale, westward propogating Rossby waves further contribute complexity to the basinwide circulation system. The Rim Current jet has a speed of 50-100 cm/s within the upper layer, and about 10-20 cm/s within the 150-300 m depth range. The mesoscale features evolving along the periphery of the basin as part of the Rim Current dynamic structure apparently link coastal biogeochemical processes to those beyond the continental margin, and thus provide a mechanism for two-way transports between nearshore and offshore regions.

Among marginal sea ecosystems, the Black Sea is of special interest because of dramatic changes that took place in its ecological properties from the early 1970s to the 1990s under cumulative effects of excessive nutrient enrichment, strong cooling/warming, over-exploitation of pelagic fish stocks, and population outbreak of gelatinous carnivores [3]. The Black Sea ecosystem was reorganized during this transition phase in different forms of top-down controlled food web structure through successive regime-shifts of distinct ecological properties. The Secchi disk depth, oxic-anoxic interface zone, dissolved oxygen and hydrogen sulphide concentrations also exhibit abrupt transition between their alternate regimes, and indicate tight coupling between the lower trophic food web structure and the biogeochemical pump in terms of regime-shift events.

The first shift, in 1973-1974, marks a switch from large predatory fish to small planktivore fish-controlled system, which persisted until 1989 in the form of increasing small pelagic and phytoplankton biomass and decreasing zooplankton biomass. The increase in phytoplankton biomass is further supported by a bottom-up contribution due to the cumulative response to high anthropogenic nutrient load and the concurrent shift of the physical system to the "cold climate regime" following its ~20-year persistence in the "warm climate regime". The end of the 1980s signifies the depletion of small planktivores and the transition to a gelatinous carnivore-controlled system. By the end of the 1990s, small planktivore populations take over control of the system again. Concomitantly, their top-down pressure when combined with diminishing anthropogenic nutrient load and more limited nutrient supply into the surface waters due to stabilizing effects of relatively warm winter conditions switched the "high production" regime of phytoplankton to its backgroun "low production" regime.

The Black Sea regime-shifts appear to be sporadic events forced by strong transient decadal perturbations, and therefore differ from the multi-decadal scale cyclical events observed in pelagic ocean ecosystems under low-frequency climatic forcing. The Black Sea observations illustrate that eutrophication and extreme fishery exploitation can indeed induce hysteresis in large marine ecosystems, if they can exert sufficiently strong forcing onto the system. They further illustrate the link between the disruption of the top predators, proliferation of new predator stocks, and regime-shift events. Examples of these features have been reported for some aquatic ecosystems, but are extremely limited for large marine ecosystems.

References

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