Busta #1

Domanda n. 1
Il/la candidato/a illustri quali sono le proprie esperienze, comprese eventuali pubblicazioni, attinenti alla tematica del bando.

The candidate explains his/her own experience, including any publications relevant to the topic of the call.

Domanda n. 2
Descrizione degli elementi necessari alla progettazione di un osservatorio oceanografico mirato allo studio di processi fisici e biogeochimici in aree convettive.

Description of the elements required for the design of an oceanographic observatory to study the physical and biogeochemical processes in convection areas.

Domanda n.3
Discussione sul tema scritto

Discussion of the essay

Busta #2

Domanda n. 1

Il/la candidato/a illustri quali sono le proprie esperienze, comprese eventuali pubblicazioni, attinenti alla tematica del bando.

The candidate explains his/her own experience, including any publications relevant to the topic of the call.

Domanda n. 2

Descrizione della struttura di un progetto di ricerca mirato ad effettuare il monitoraggio dell'ambiente marino (esempi a discrezione del candidato).

Description of the structure of a marine environmental monitoring research project (examples at the candidate's discretion).

Domanda n.3

Discussione sul tema scritto

Discussion of the essay

Busta #3

Domanda n. 1

Il/la candidato/a illustri quali sono le proprie esperienze, comprese eventuali pubblicazioni, attinenti alla tematica del bando.

The candidate explains his/her own experience, including any publications relevant to the topic of the call.

Domanda n. 2

Descrizione della strumentazione utilizzata nelle misure oceanografiche per aree costiere e mare aperto e breve discussione relativa al processing dei dati oceanografici acquisiti.

Description of the instruments used in oceanographic measurements in coastal areas and on the open sea, and brief discussion of the processing of the oceanographic data acquired.

Domanda n.3

Discussione sul tema scritto

Discussion of the essay

Busta # 4

Domanda n. 1

Il/la candidato/a illustri quali sono le proprie esperienze, comprese eventuali pubblicazioni, attinenti alla tematica del bando.

The candidate explains his/her own experience, including any publications relevant to the topic of the call.

Domanda n. 2

Metodi di analisi per lo studio e la descrizione di processi fisici e biogeochimici nel Mar Mediterraneo a diverse scale spaziali e temporali

Methods of analysis to study and description of physical and biogeochemical processes in the Mediterranean Sea at different spatial and temporal scales

Domanda n.3

Discussione sul tema scritto

Discussion of the essay

and that the thickness of the layer with the highest salinity also increased and reached the surface. Obviously, in this case, there was a large influx of more saline intermediate and surface water from the LB. Buljan explained that the ingressions were the result of an intensification of the cyclonic circulation in the IS, which was related to a certain degree to the pressure patterns over the Mediterranean Sea. The view of a stationary circulation in the Mediterranean Sea still held, but unlike the variations in the amount of water entering the AS, the variations in salinity were more difficult to explain. Buljan discussed three hypotheses: (i) variability of the AW flux through the Strait of Gibraltar; (ii) variability of the inflowing AW salinity; (iii) oscillation of the E-P factor (evaporation-precipitation) in the Mediterranean Sea. Buljan suggested that all these three sources of variability could contribute to the salinity oscillations in the Mediterranean Sea. However, due to the lack of continuous observations over longer time periods, Buljan was unable to provide conclusive answers to the question regarding decadal variability, which is the true scale of the Adriatic Ingression.

Interestingly, at the time of his work Buljan was waiting for the publication of data collected by the R/V Atlantis in 1948 during the Mediterranean expedition to confirm his expectation of an increase in salinity in accordance with the decadal fluctuation already assumed. From the Mediterranean Medatlas time series elaborated by Rixen et al. (2005) and presented by Gačić et al. (2013), we know that salinity did indeed increase in 1948 as Buljan expected in IS.

It was clear from Buljan's work that his attempts to correlate the variability of salinity in the Mediterranean Sea with the variability of salinity and flux of AW in the Strait of Gibraltar, the so-called Atlantic transgressions (Le Danois, 1934), were not satisfactory and retained their hypothetical character.

The other part of the story of salinity in the AS that needed to be explained was the regression, that is, the return of the AS to "normal" salinity conditions after the ingression event. Unlike the increase in salinity, Buljan did not assert an extra-Adriatic mechanism in this case. A gradual decrease in salinity in the AS was the result of the prevailing inflow of freshwater from northern rivers and its progressive advection and mixing to the south. In other words, after the influence of extra-Adriatic forcing, the increase in salinity weakened and finally stopped, then the dilution operated by rivers re-established the "normal" salinity conditions (Buljan, 1953).

Another aspect of the Adriatic Ingression mechanism concerns the nutrient dynamics. Buljan (1964) and Buljan and Zore-Armanda (1976) compared phosphate and total P concentrations in the intermediate layer of the AS and found higher phosphate levels in the SA than in the Jabuka Pit (Middle Adriatic). They argued that the IS was an important source of phosphorus compounds for the AS, especially at the time of ingressions.

In summary, according to the Adriatic Ingression theory, the decadal variability of salinity and nutrient content in the southern and Middle Adriatic was explained by the variability of the inflow of Ionian waters, with the more saline and nutrient-rich LIW being the main component. The cause of the Adriatic Ingression was associated with the meridional atmospheric pressure gradient over the AS.

3.4. The reversals of the Ionian circulation

Circulation in the upper layer of IS is subject to reversals on a decadal scale (Fig. 5).

Starting from the first observed reversal in 1997, Theocharis et al. (1999), Manca et al. (2003), and Borzelli et al. (2009) explained the change in circulation with the spreading of CDW (formerly CSOW) in the Ionian abyssal layer during the second phase of the EMT. During 1995–1997, CDW occupied mainly the eastern and northeastern flanks of the Ionian basin, resulting in a bottom pressure gradient toward the center of the basin. This gradient supported the anticyclonic circulation in the upper thermocline layer. After 1997, CDW increasingly mixed into the central abyssal part of the Ionian (Roether et al., 2007), leading to a reversal of the bottom pressure gradient, with the flank of the basin occupied by AdDW, which was less dense than the CDW. This led to a reversal of circulation in the upper layer as well, which changed from anticyclonic to cyclonic. Absolute Dynamic Topography (ADT) maps show the sudden change in sea surface structure (Fig. 5).

Reversals occurred again in 2006, 2011, and 2018, as indicated by the altimetry data recorded to date (Fig. 5), suggesting that this phenomenon generally occurred with a time scale of about five years and was not necessarily related to the EMT. The circulation pattern has been termed the NIG by Gačić et al. (2011).

The first consequence of the reversal of the Ionian circulation is the changing pathway of AW, which flows more easily northward into the Ionian interior during the anticyclonic phase, while during the cyclonic phase it is preferentially directed eastward toward LB (Fig. 6). The path of the LIW is also influenced by the Ionian circulation, but in the opposite way: when NIG is anticyclonic, the LIW moves eastward directly toward the SC; on the other hand, the cyclonic NIG favors the LIW path northward along the eastern boundary of the IS (Fig. 6).

The resulting salinity in the IS is affected by the circulation regime: lower salinity during the anticyclonic phase and higher salinity during the cyclonic phase.

Finally, the variability of salinity in the IS is the source of the salinity changes in AS.

3.5. The Adriatic-Ionian Bimodal Oscillating System

The first evidence of the specific behavior of the IS came from studies addressing the sea level trends in the Mediterranean from the altimetric data (Cazenave et al., 2001; Vigo et al., 2005). They noted the negative trend of sea level of about −10 mm/year in the IS between January 1993 and December 1999, in contrast to what was observed in the rest of the Mediterranean, without giving a clear explanation (see the revised trend 1993–1999 in Fig. 7, obtained from ADT data). The negative trend was observed because the sea level time series was relatively short with respect to the temporal variability associated with the decadal inversions of the NIG circulation.

In the first attempts to calculate the sea level trend in the Mediterranean, there was no knowledge of the pronounced decadal circulation variations in the IS, so no reliable explanation could be offered at that time. It was not until Gačić et al. (2010) that the phenomenon of cyclic NIG inversions found its full explanation in the form of the mechanism called the BiOS.

In conjunction with the anticyclonic/cyclonic circulation mode in the IS, less salty AW/saltier (LIW/LSW) is advected into the AS (Fig. 6). This water then participates in the winter convection, which is responsible for the variations in volume and density of the water formed. In the post-convection period, the AdDW spreads into the IS with a higher or lower density than the ambient Ionian deep water, changing the orientation of the horizontal pressure gradient. During the cyclonic mode of the NIG, the AdDW propagates with progressively higher density into the IS, mainly following its preferred path along the Italian continental slope and, in some cases, along the eastern continental slope (Malanotte-Rizzoli et al., 1997). This leads to a lowering of sea level along the AdDW path, creating the density gradient toward the coast and the resulting surface geostrophic flow toward the north (transition to anticyclonic mode). Therefore, the cyclonic circulation weakens, and after a certain time the anticyclonic flow takes its place. Conversely, during the anticyclonic phase of the NIG relatively fresh AW enters the AS, leading to a decrease in AdDW density. The latter penetrates into the IS along the western side, creating a condition where sea level is higher than in the center of the gyre, producing a sea surface pressure gradient responsible for the southward geostrophic flow that eventually overwhelms the northward branch of the Ionian anticyclone, again creating the cyclonic basin-wide gyre. In the layer above the AdDW vein, the northward geostrophic flow is generated by the surface layer pressure gradient in the opposite direction. As shown in laboratory experiments (Rubino