1.1. The Rhodes Gyre

The Rhodes Gyre (Fig. 1) rotates anti-clockwise forming a distinct vertical cylinder of eastern Mediterranean water to the south of the island of Rhodes. It is likely that this cyclonic gyre results from wind-driven basin circulation, and the interaction of the main currents with land masses and seafloor morphology (i.e. Rhodes Trench). This cyclonic rotation causes deep water, rich in nutrients, to rise from the bottom to the surface and in consequence the Gyre is much more fertile than the rest of the eastern Mediterranean, which is known as one of the most oligotrophic (nutrient-poor) aquatic environments in the world because of its extremely low primary production (Gaines et al., 2006).

Napolitano et al. (2000) have studied the biological production characteristics of the Rhodes Gyre through a one-dimensional, coupled physical–biological model using single aggregated compartments of phytoplankton, zooplankton, detritus, as well as ammonium and nitrate forms of inorganic nitrogen. It interacts with the physical model through vertical eddy diffusivity. The model simulations demonstrate the importance of physical oceanographic characteristics affecting yearly planktonic structures, and shows that annual primary production in the Rhodes basin is comparable with the north-western Mediterranean. The Rhodes basin reveals a strong bloom in early spring, typically in March, a weaker bloom in early winter, typically in January, and a subsurface production below the seasonal thermocline during the summer.

The strong and permanent effect of the Rhodes Gyre on offshore primary production in the Rhodes basin is also linked to the area’s particular geomorphology, which is characterized by a deep trough bordering Rhodes Island to the west, Finike seamounts (Anaximander) to the east and Finike basin to the south-east, and by the effect of the in-flow of water masses trough the Karpotous Straits as well as the presence of several submarine canyons.

Even if the processes of deep-water fertilization in this area are poorly investigated up to now, submarine canyons may have a role by enhancing the flux of nutrients from the land, as in other Mediterranean areas. Moreover, recent evidence has indicated that the current oligotrophic nature of the eastern Mediterranean may shift to a more productive system due to increased anthropogenic
The south-western Anatolian continental slope delineates the north-eastern margin of the Rhodes Basin; here the slope face is dissected by numerous submarine canyons (Hall et al., 2009). Around the Island of Rhodes, the continental shelf on the western side appears to be generally smooth, while on the eastern side it is steeper and cut by a number of submarine canyons; here, depths of over 350 meters are encountered less than one mile seaward of the 200-meter contour.

Most of the submarine canyons are located on the north-eastern platform portion where the continental slope is inclined from 8° to 15°. A major canyon, Nereus canyon, extends to the north-east from the northern tip of the island, and two more canyons, Brigitte and Trianta, as well as several small V-shaped sea valleys, are located in Trianta Bay on the north-western side of the Island. Goedicke (1977) identified at least ten main submarine canyons between Rhodes and Lindos, and a number of slope gullies, which seem to be associated with the on-shore topography. Within Kallithea Bay, two canyons incise the shelf; in Atlântou Bay, two canyons exist in association with the mouths of the Psalidos and Pera rivers; offshore from Tsampika, the head of the major canyon was likely to have been connected with the ancient Lutani river-mouth, which was in the past to the south of Cape Vahyah, and has now shifted to its northern side; between Tsampika and Cape Archángelos, two smaller canyon heads lie near the mouth of two intermittent rivers; in Malóna Bay and Vlichá Bay, another two canyons and one main canyon offshore from Lindos (Cape Sumiani and Cape Foca) have no connection with present-day river valleys. All these factors lead to the conclusion that the northernmost canyon off the east side of Rhodes Island originated due to subaerial erosion, while the southern ones are of tectonic origin.

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Finally, the cyclonic Rhodes Gyre is confined by three anticyclonic gyres; lerapetra to the south-west, Mersa-Matruh to the south and the West Cyprus Gyre to the east, thus forming a large oceanic triad system which enhances reproductive habitat suitability for small pelagic species thanks to co-occurring mechanisms: nutrient enrichment, concentration of larval food distributions, and local retention of eggs and larvae (Agostini and Bakun, 2002).

1.2 Effect of south-western Anatolia submarine canyons on biodiversity

A very narrow shelf characterizes the south-western Anatolian coast and several canyons connect the abyssal floor of the Rhodes and Finike basins with the upper shelf. Notably, these canyons and submarine landslides are active channels which have been interpreted as having been triggered by on-going faulting and which attest to substantial present-day direct clastic sedimentation from Turkey and the Island of Rhodes into the above-mentioned basins (Ocakoglu, 2011).

In the deepest part of the Levantine basin, the noticeable correlation of bentthic production with distance from land masses confirms that the lateral transport of organic matter through submarine canyons plays a major role. Moreover, the patchiness of macrofauna abundance indicates that the deep Levantine Sea is an event-driven system, in which terrestrial run-off affects the functioning of the community by spatial variability in food ingestion events (Türkay, 1996).
been reported at depths between 400 m and 4,264 m, including 20 species of decapod crustaceans such as the endemic geryonid crab (*Chaceon mediterraneus*); one species, *Levantocaris horningae*, was described as new to science and *Polycheles typhlops*, *Acanthephyra eximia*, *Aristeus antennatus*, *Calocaris macedreae*, *Parapeneus longirostris* and *Geryon longipes* were found to be dominant in the Cretan Sea and Rhodes basin; *Scopelocheirus hopei*, *Scopelocheirus polymedus*, *Orchomenella nana*, *Orchomene grimaldi*, *Epimeria cf. cornigera* were the most abundant amphipod species recorded by baited trap, and *Ileraustroe ilergetes*, *Pseudotiron bouvieri*, *Rhachotropis rostrata* and *Stegophaloides christianiensis* are amphipod species endemic to the Mediterranean; among cumaceans, *Procampylaspis bonnieri*, *Campylaspis glabra*, *Makrokylindrus longipes*, *Platysympus typicus* and *Procampylaspis armata* were the most frequently collected, while *Yoldia micrometrica*, *Kelliella abyssicola*, *Cardyomia costellata*, *Entalina tetragona*, *Benthomangelia macra*, *Benthonella tenella* and *Bathyarca pectunculoides* were the most common benthic molluscs identified at depths greater than 1,000 m.

The Rhodes basin can, in fact, be divided into two sub-basins: a deeper northern one, and a shallower southern one, separated by a broad, asymmetrical swell oriented east–west. The northern margin of the basin is interrupted by the large, north-east oriented Fethiye canyon, which extends into the Turkish shelf and Fethiye bay. Along the Fethiye canyon an important fault zone occurs, forming the north-eastern extension of the Pliny Trench (Ocakoglu, 2011), while the southern sub-basin lies in morphological continuity of the Strabo Trench (Woodside et al., 2000).

In general, the Mediterranean Turkish shelf and slope appear to be significantly dissected and transected by canyons and gullies (Ozel et al., 2007). Even if many of these canyons can be classified as blind canyons (confined to the slope) according to Harris and Whiteley (2011), some of them are the extension of canyons on land, such as Saklikent canyon, or correspond with river mouths (i.e. Dalaman and Esen Streams) (Fig. 2).

Between Kalkan and Finike, a number of shallow coastal canyons incise the upper shelf becoming deeper even very close to the shore: they play a role of stepping stones between the coast and the open sea (Fig. 3). Spawners and recruits of many fish species, which migrate from the Beymelek and Koycegiz lagoon system to off-shore habitats and vice-versa, use these coastal canyons. Coastal canyon communities generally consist of sponges (*Axinella verrucosa*, *A. polyoides*), some lobster species (*Scyllarus arctus* and *S. latus*), as well as stony corals such as *Caryophyllia* spp.

Evidence of macrofaunal abundance and the diverse conditions of marine invertebrates in the Eastern Mediterranean have been discussed by Danovaro et al. (2010): megabenthic species have been reported at depths between 400 m and 4,264 m, including 20 species of decapod crustaceans such as the endemic geryonid crab (*Chaceon mediterraneus*); one species, *Levantocaris horningae*, was described as new to science and *Polycheles typhlops*, *Acanthephyra eximia*, *Aristeus antennatus*, *Calocaris macedreae*, *Parapeneus longirostris* and *Geryon longipes* were found to be dominant in the Cretan Sea and Rhodes basin; *Scopelocheirus hopei*, *Scopelocheirus polymedus*, *Orchomenella nana*, *Orchomene grimaldi*, *Epimeria cf. cornigera* were the most abundant amphipod species recorded by baited trap, and *Ileraustroe ilergetes*, *Pseudotiron bouvieri*, *Rhachotropis rostrata* and *Stegophaloides christianiensis* are amphipod species endemic to the Mediterranean; among cumaceans, *Procampylaspis bonnieri*, *Campylaspis glabra*, *Makrokylindrus longipes*, *Platysympus typicus* and *Procampylaspis armata* were the most frequently collected, while *Yoldia micrometrica*, *Kelliella abyssicola*, *Cardyomia costellata*, *Entalina tetragona*, *Benthomangelia macra*, *Benthonella tenella* and *Bathyarca pectunculoides* were the most common benthic molluscs identified at depths greater than 1,000 m.
The Anatolia canyon (i.e. Fethiye canyon) extends down to the deep depression of the Island of Rhodes between Turkey and Greece, hosting deep-sea fish species including *Bathypterois dubius, Nezumia sclerorhynchus, Cataetyx laticeps, Chauliodus sloani, Coriphaenoides mediterraneus, Nettastoma melanurum* and *Lepadion lepidion* were the most abundant species. In the Rhodes Basin and at depths less than 2,300 m, the most abundant shark species were *Hexanchus griseus, Galeus melastomus, Centrophorus granulosus, Centroscymnus coelolepis, and Etmopterus spinax.*

In recent studies, twenty-three fish species were collected or photographed in the Levant Sea at depths greater than in the Western Mediterranean, some nearly doubling the depth record of the species (Danovaro et al., 2010).

Larger-scale upwelling and downwelling structures of cyclones and anticyclones, dominating circulation in the central area of the Rhodes basin and Anaximenes Mountain (Fig. 4), affect the zooplankton community (Denda and Christiansen, 2011). Zooplankton standing stocks, at a generally low level due to the oligotrophic character of the eastern Mediterranean, were found to be higher in the Rhodes Basin than on the seamount, probably also influencing the distribution of top pelagic predators.

Cetaceans have also been observed around the Anatolian canyons. Mostly *Stenella coeruleoalba, Delphinus delphis, Ziphius cavirostris* and *Grampus griseus* have been reported. The sperm whale is strictly teuthophagus and 14 cephalopod species were found between Rhodes and Fethiye deep zone (Öztürk et al., 2007). This deep-sea upwelling canyon zone provides feeding grounds for whales and dolphins, mostly for sperm whales (Fig. 5). In 2010, 34 sperm whale sightings were reported in the upwelling canyon zone between Rhodes and Fethiye. Moreover, the submarine canyons from Finike to the south-eastern Anatolia region are spawning grounds for several migratory fish species, such as scombrids and bluefin tuna (*Thunnus thynnus*). Beaches in this area are nestling grounds for sea turtles, *Chelonia mydas* and *Caretta caretta* have also been observed offshore between Rhodes-Finike and were most probably feeding (Öztürk, 2009).

### 2. Protection proposals for the Eastern Mediterranean Sea

Four areas have been suggested for High Sea Marine Protected Areas (HSMPAs) in the Eastern Mediterranean Sea by Öztürk (2009) (Fig. 6). One of them (M1) falls between Rhodes and Finike where, as shown above, the most distinctive features are submarine canyons and the Anaximander Mountains (Öztürk et al., 2010), which are characterized by unique habitats also created by mud volcanoes and methane cold seep habitats, inhabited by communities quite different from those in all other known cold seeps (Medioni, 2003). This fragile ecosystem is under threat primarily from bottom trawling, which should be banned or controlled. Here, swordfish (*Xiphias gladius*) nets also cause severe cetacean by-catch.

Another proposed spot is a channel between Turkey and the island of Cyprus (M2). Routes of highly migratory, large and small pelagic fish also cross this area. Furthermore, it is a spawning ground for bullet tuna (*Auxis rochei*), Atlantic skipjack (*Euthynnus alleteratus*) and bluefin tuna (Karakulak et al., 2004). There are also nestling beaches of endangered marine turtles. In addition, (Gücü and Öztürk, 2010) reported that this area could be a north levant marine peace park.

![Conceptual model of water mass circulation effect on zooplankton in the Rhodes Basin and Anaximenes Mountain region.](image)

**Fig. 4:**

AMC, Asia Minor Current; MMJ, Mid-Mediterranean Jet. Figure not to scale, modified from Denda and Christiansen (2011).
The complexity of the high sea legal regulatory regime enforced in the international waters of the Aegean and eastern Mediterranean Sea has recently caused several management problems in the region, in particular with regard to illegal, unreported and unregulated fisheries (Öztürk and Baseren, 2008). There is no appropriate management tool for sustainable fisheries of large, highly migratory pelagic species in this area. Although regional organizations such as GFCM and ICCAT, responsible for fisheries management, exist, an assessment study (Tudela, 2003) showed a steep decline of bluefin tuna spawning stocks since 1993.

For protection of the Mediterranean marine environment, there are several international and inter-governmental organizations such as ACCOBAMS, ICCAT, GFCM, IUCN, RAC/SPA, and others which have implemented proposals for high sea marine protected areas overlapping or consistent with the three areas proposed for the Levantine basins. Greenpeace has already suggested some proposals and RAC/SPA/UNEP/MAP has produced a high sea SPA proposal. All these international initiatives are important to urge decision-makers and politicians that decisions need to be taken regarding the marine environment. Establishing the HSMPA will be an important step towards implementing the ecosystem approach towards management of the eastern Mediterranean Sea. This proposal may be beneficial and provide better management methods for sustainable fisheries as well coastal states, if they so desire. Designation of HSMPAs in the proposed areas will help to protect vulnerable habitats and threatened species, protect breeding populations which can provide recruiting stocks, restore over-exploited zones, increase fisheries productivity in the long term, reduce by-catch of seabirds, cetaceans and sea turtles, and reduce overfishing of highly migratory fish.

Scovazzi (2002) stated that the Mediterranean Sea should be considered a primary heritage of concern to bordering States. This message indicated that more responsibility should be adopted by each State to protect and cooperate for the protection of the Mediterranean Sea.

The third suggested area lies between Turkey, Syria, Lebanon and Cyprus (M3), where virgin stocks of deep sea shrimps such as P. longirostris, Plesionika martia, Aristaeomorpha foliacea and A. antennatus still exist. Furthermore, this is an area which is on the migration routes of bluefin tuna, tuna-like species, between Iskenderun and Cyprus from north to south. Common dolphins, which are rare in the eastern Mediterranean Sea, were also sighted in this area. These pristine habitats should be protected from international fishing fleets, IUU fisheries and ship-origin pollution. The area identified as A5 in Fig. 6 corresponds to the Rhodes basin, whose features have been discussed and summarized in the previous chapters.
Designation of HSMPAs is also one of the objectives of the Convention on Biological Diversity and the associated Jakarta Mandate. Furthermore, the IUCN Amman Resolution on High-Seas MPAs adopted in October 2000 called for national governments, NGO's and international agencies to improve integration of established multilateral agencies and existing legal mechanisms in order to identify areas of the high-seas suitable for collaborative management action, and to reach agreement by consensus on regimes for their conservation and management. Thus, collaborative management action in the Aegean Sea between Turkey and Greece could develop joint management processes. Acer (2006) suggested that a joint maritime regime and cooperation between Turkey and Greece need to be comprehensive, while Oral (2009) stated that the peaceful delimitation and establishment of uncontested maritime zones is a prerequisite to ensuring the future sustainability of the marine environment in the Aegean Sea. Equitable and reasonable solutions are needed to solve maritime disputes with the guidance of customary international law, which may then help to improve the recovery of the Aegean marine environment. In the eastern Mediterranean Sea, an area shown in Fig. 6 as M3, there may be a chance for peace and cooperation between Turkey, Syria, Lebanon and the Northern and Southern Republics of Cyprus.

There are several examples in the world ocean of particularly sensitive sea areas (PSSA), which are designated by the International Maritime Organization (IMO). The aim of the PSSA is to protect vulnerable habitats in marine areas, yet there is only one PSSA area in the Mediterranean Sea: the Strait of Bonifacio between France and Italy.

An HSMPA could substitute for this as an alternative protection instrument. Therefore, special long-term research programmes and special funds are needed for conservation of marine biological diversity resources beyond marine and coastal protected areas, with a view to establishing protected area networks. These proposals would also help to create a forum for discussion and exchange of information among scientists, marine conservationists, fisherman and decision-makers in the Mediterranean region.

Nevertheless, it is clear that there are increasing risks to biodiversity in areas beyond national jurisdiction in the eastern Mediterranean Sea, in benthic features such as seamount communities, cold seeps, hydrothermal vents and other specific habitats. For pelagic habitats, upwelling areas and gyres, such as that of Rhodes, also play important roles in fuelling ecosystems in the entire Levantine area.

Finally, there is an immediate need for taking concerted action in order to conserve high seas benthic and pelagic boundaries in the eastern Mediterranean Sea. Even these boundaries are uncertain due to a lack of detailed scientific information and simply poor knowledge.
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