Global Climate Change and Intensification of Coastal Ocean Upwelling

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Abstract: ***A mechanism exists whereby global greenhouse warming could, by intensifying the alongshore wind stress on the ocean surface, lead to acceleration of coastal upwelling. Evidence from several different regions suggests that the major coastal upwelling systems of the world have been growing in upwelling intensity as greenhouse gases have accumulated in the earth's atmosphere. Thus the cool foggy summer conditions that typify the coastlands of northern California and other similar upwelling regions might, under global warming, become even more pronounced. Effects of enhanced upwelling on the marine ecosystem are uncertain but potentially dramatic.***

Keywords: Climate, Coastal Ocean Upwelling, temperature, current, environment

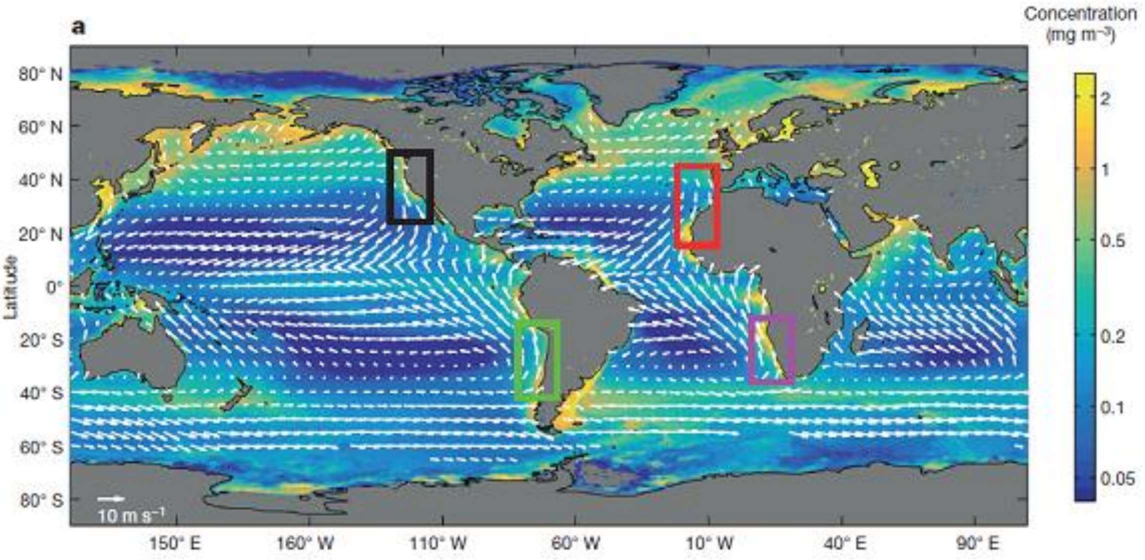
1. Introduction

According to an article in the journal Nature published, it can be said that the phenomenon of Upwelling in the ocean, with increasing global temperatures, followed by greenhouse gases, by the end of this century, especially in the higher latitudes will increase significantly, and this causes significant changes in biodiversity the water will be free. Cold waters rise toward the surface, bringing nutrients. Due to global warming that caused by greenhouse gases, waters affected by the heat and a colder layer is placed below the upper layer. If it continues, largely will be lead to increased lack of oxygen or hypoxic conditions and with excessive rise in upwelling, significant threat in terms of ecologically and economically will follow. Only about 2 percent of the area of the world's oceans, the regions of coastal upwelling contributes to more than 20 percent of global fishery catches which represents the economic and social impact caused by the disruption of the system.

In this study, we have tried to report the cause climate change, its consequences and effects on upwelling system, changes and anticipated changes in the system along with examples of different areas. The consequences of increased upwelling are increase of oxygen consumption most of the oxygen capacity of the ecosystem and thus create hypoxic conditions for organisms in these areas. Well as increase the amount of wind is due to increased the difference between seas and land temperature and dryness is its subsequent which will be followed by subsequent impacts. Some times and some areas are more prone to react to the effects of climate change in fact there is more severe.

2. Mechanisms and consequences of the rise in temperature

Increase the amount the upwelling effects on marine systems is unclear, but it seems the effect is very impressive. Figure 1 shows the main areas of the upwelling system in world.



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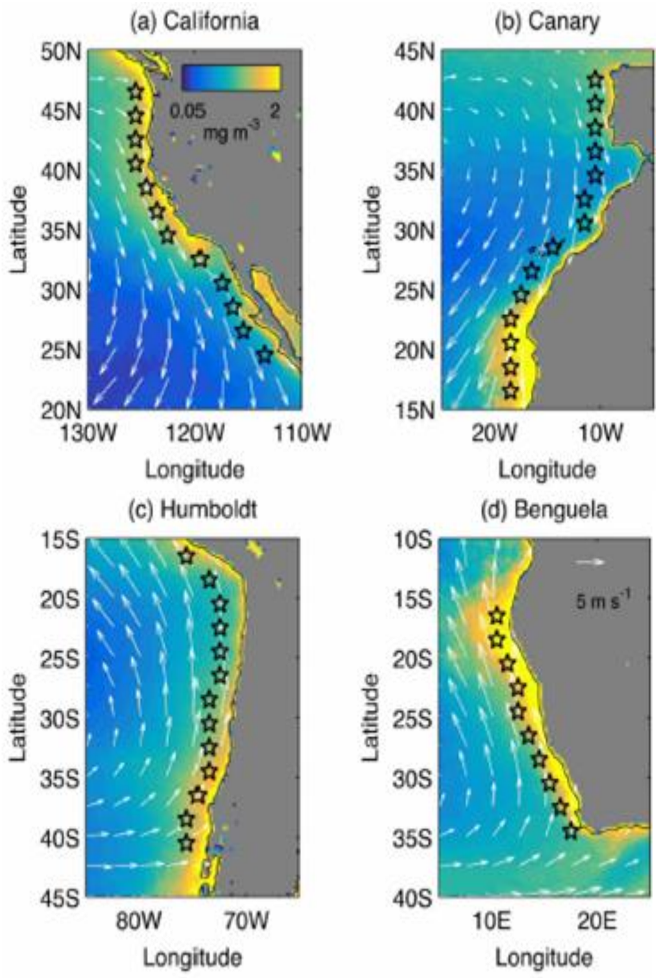

Figure 1: The main areas of upwelling systems, black squares, California, Red Square, Canary Islands, South America square green and purple squares Africa with magnification (image below) (Wang et al., 2015)

The coastal ocean off the westernunited States is a classic wind driven coastal upwelling system. During the warmer seasons of the year, strong northerly and northwesterly winds induce offshore transport of surface waters. Upwelling of cool, nutrient-enriched water from depth (Fig. 2) balances the resulting loss of surface water near the coast and infuses essential plant nutrients to the surface layers of the ocean (Ryther, 2009).

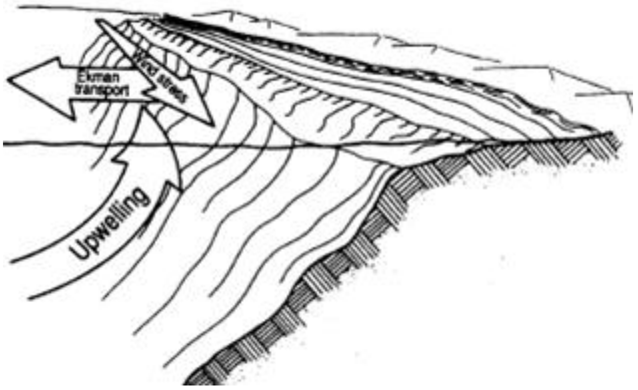

Figure 2: A conceptual diagram of the coastal upwelling process [modified from (6)]. The coast is represented in cutaway view and the ocean is to the left. Offshore transport in the surface Ekman layer driven by the alongshore stress of the wind on the sea surface is replaced by upwelling from depth.

Cooling and stabilizationof the onshore air flow by contact with the upwelled surface waters leads to the cool summer climate of the adjacent coastlands (Trewartha, 2008). Similar upwelling systems occur in the other major subtropical eastern ocean boundary regions; examples are the Canary current system off the Iberian Peninsula and northwestern Africa, the Benguela current system offsouthwestem Africa, and the Peru current system off westem South America. Upwelling in all of these regions tends to be highly seasonal in temperate latitudes, where it peaks in the spring-summer, but tends toward year-round continuity in the more tropical portions (Parrish, 2006). The vigorous alongshore wind that drives coastal upwelling in these systems is maintained in part by a strong atmospheric pressure gradient between a thermal low-pressure cell that develops over the heated land mass and the higher barometric pressure over the cooler ocean (Bakun, 2008). Because of the large-scale atmospheric subsidence occurring in the eastern limbs of the subtropical gyres, and also because of the stabilized, dehumidified onshore air flow, the areas of these coastlands inland of the direct influence of coastal stratus and fog are characterized during the upwelling seasons by dry Mediterranean-type (or desert) climates and clear atmospheric conditions (Trewartha, 2008). The clear conditions lead to strong daytime heating by short-wave solar radiation, particularly in interiorvalleys such as the Central Valley of California, and rapid nighttime, long-wave radiative cooling. Recent decades have seen a substantial build-up of CO2 and other greenhouse gases in the earth's atmosphere (Ramanathan, 1988). Resulting inhibition of nighttime cooling and enhancement of daytime heating should lead to intensification of the continental thermal lows adjacent to upwelling regions. This intensification would be reflected in increased onshore-offshore atmospheric pressure gradients, intensified alongshore winds, and accelerated coastal upwelling circulations (Fig. 2). As a positive feedback, the cooling of the ocean surface those results might locally intensify the low-altitude barometric highs at the oceanic sides of the onshore-offshore pressure gradients. No routine observations of actual rate of upwelling are available (Bakun, 2008 ;Mason, 1986). Wind observations reported by ships at sea tend to be irregularly distributed in time and space. In order to produce homogeneous time series, the upwelling index computations are based on analyzed fields wherein the geostrophic constraint is employed to incorporate data on both wind and barometric pressure, and information is spread in time and space to fill data voids and to detect erroneous reports (Holl and Mendenhall, 1972). The highest intensity core of the California Current upwelling system is situated in the Point Arena-Cape Mendocino region near 39°N (Parrish, 2006). The equatorward alongshore

Wind stress during the spring-summer upwelling season, derived on the basis of the upwelling index methodology, has apparently intensified in the 30-year period 1945 to 1975 (Fig. 3A). Since 1975 the stress values have trended back toward the mean for the entire (-40-year) period. Actually, the period since 1975 has been one of anomalously warm conditions in the ocean off California (9); whether warm ocean conditions could have affected the onshoreoffshore pressure gradient by lessening the relative barometric high at the oceanic end of the gradient is unclear. In any case, substantial, natural interyear and interdecadal variability should be superimposed on any trends related to climatic warming. Certainly, the trend line fitted to the values in Fig. 3A indicates a trend toward substantially increased southward wind stress off the coast of northern California, even over the entire 1946 to 1988 periods. Because of the spatial spreading of information in the analysis procedures, the upwelling index series at different locations in the same region do not represent independent verifications of the trend. However, the index series do reflect significant spatial differences in the California current region (Bakun, 2008 ;Mason, 1986). All of the spring-summer series for this region (Table 1) show a trend toward increased intensity of upwelling-producing wind stress, except for the series located at 24°N and 27N. These two locations are off Baja California, where the waters of the Gulf of California rather than continental land surface occupy the interior and where therefore the proposed mechanism would be ineffective.

Table 1: Location calendar months incorporated in annual data, slope of the linear trend [significance: * = P < 0.05; ** = P < 0.01; (30)], and standard error of that slope, for averages of monthly alongshore wind stress series.

Latitude or area	Months	Slope (dyne cm^{-2} year^{-1})	Standard error
Upwelling index, northeastern Pacific			
48°N	4 to 9	0.0051**	0.0012
45°N	4 to 9	0.0011	0.0018
42°N	4 to 9	0.0033	0.0032
39°N	4 to 9	0.0206**	0.0044
36°N	4 to 9	0.0102*	0.0046
33°N	4 to 9	0.0136**	0.0050
30°N	4 to 9	0.0022	0.0030
27°N	4 to 9	−0.0041	0.0027
24°N	4 to 9	−0.0021	0.0021
Upwelling index, northeastern Atlantic			
43°N	4 to 9	0.0033**	0.0011
37°N	4 to 9	0.0051**	0.0018
28°N	1 to 12	0.0174**	0.0044
Ship reports, northeastern Atlantic (Fig. 4)			
Area A	4 to 9	0.0101**	0.0024
Area B	4 to 9	0.0048*	0.0022
Area C	4 to 9	0.0060**	0.0018
Area D	4 to 9	0.0064**	0.0016
Ship reports, southeastern Pacific			
Peru	4 to 9	0.0038**	0.0011
Peru	10 to 3	0.0035**	0.0012

Offthe Iberian Peninsula in the northeastern Atlantic Ocean, a 35-year trend toward increased wind stress during the spring to summer upwelling season (Fig. 3B and Table 1) has been reported (Wooster et al, 2002). Farther south in the Canary current region (southem Morocco; 28°N), annual mean values of upwelling are available for the period 1946 to 1981 (Belveze and Erzini, 1900). In this area, coastal upwelling, while peaking in the summer, tends to persist throughout the year (Wooster et al, 2002). Therefore, the use of the mean values, although not ideal, appears acceptable. Again, the general increasing trend is pronounced (Fig. 3C and Table 1). The upwelling system off Peru presents an extreme tropical case; coastal upwelling continues throughout the year and is actually somewhat more intense in austral winter than in summer (Parrish, 2006). Because of the low latitude location and correspondingly weakened geostrophic constraint, upwelling index computations are not appropriate. Here, wind stress estimates based on individual wind reports from ships at sea have been averaged by month over an area of coastal ocean between 4.5°S and 14.5°S latitudes (Bakun, 2008; Pauly et al., 2009). The long-term increasing trend in equatorward alongshore wind stress is not only clearly evident during the spring to summer half of the year (Fig. 3D), but also during fall to winter (Fig. 3E).

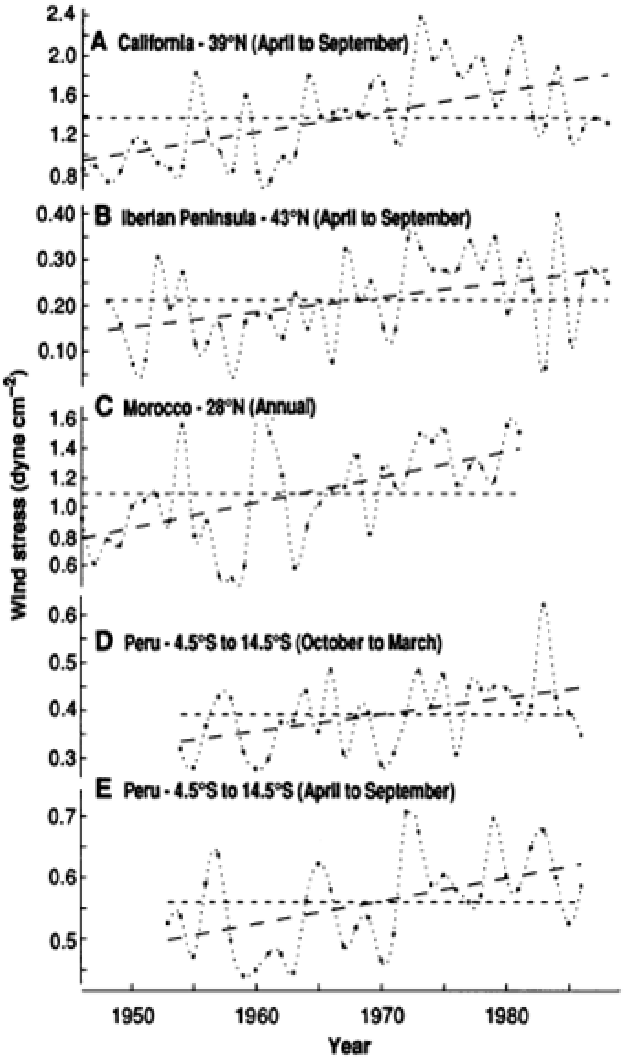

Figure 3: Within-year averages of monthly estimates of alongshore wind stress off (A) California, (B) the Iberian Peninsula, (C) Morocco, and (D and E) Peru (in D, each mean value for October to March is assigned to the year in which the January to March portion falls). Short dashes indicate the long-term mean of each series. Longer dashes indicate the linear trend fitted by the method of least squares.

In a study to establish the relationship between ocean temperature and wind intensity as well as upwelling area in the region of moroccan in the Canary Islands was carried out (Santos et al., 2012). Several studies carried out during the last years highlight a considerable global warming over the last century (see, for example, Casey and Cornillon., 2001 and the references therein). This warming is especially intense for the Atlantic Ocean, which contributes most to the increase in the heat content. More recently, some authors (Santos et al., 2012) have described the existence of different warming rates at oceanic and coastal locations in areas where coastal upwelling plays a key role.

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The Canary Upwelling Ecosystem (CUE) is one of the four major eastern boundary upwelling systems in the world ocean. The aim of the present study is to describe the regional differences in the warming rates between coastal and oceanic locations for the same latitude in the Moroccan sub-region of the CUE from 1982 to 2010. The effect of local forcings like wind and air temperature and remote forcings like atmospheric circulation patterns will be analyzed. The areaextendingfrom22 1N to331N andfrom6 1W to221W (Fig. 4) was selectedfrom1982to2010. As is clear colder temperatures in the coastal areas are cooler than ocean areas and this is due to the presence of cold upwelling. In the studies showed that the increase in global warming, the temperature difference between the coast and the ocean increased and this followed by more intense winds in this region that this phenomenon is parallel to increasing the upwelling phenomenon in these areas (Relvas et al., 2009; Sharp and Csirke, 1983) Some studies have also found that the wind has increased due to the increased upwelling phenomenon in geographical location 22-33N °, and has concluded that there is a direct correlation between the two (Patti et al., 2010; Pardo et al., 2011).

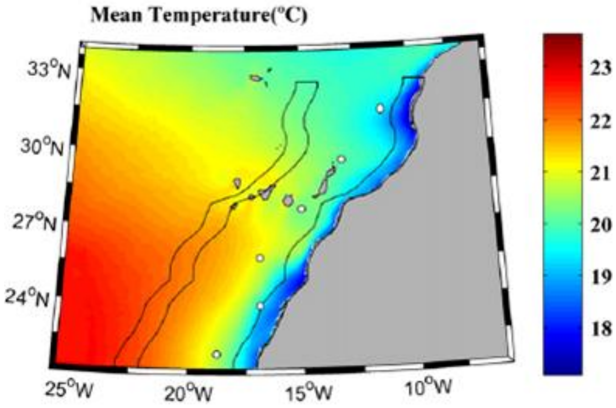

Figure 4: Mean SST(1C) averaged from 1982 to 2010.Polygons represent coastal and ocean location along the area under study. White points represent the control points where Ekman transport was calculated.

Also, as the impact of rising ocean temperatures and water relationship by increasing food rich In the marine areas that is caused by upwelling, and also its outcome. In this part, In the Iran is examples in this regard. In this section, are paid to examples in Iran.

The sudden appearance of blue green algae is considered as the bloom plankton and this bloom usually is created after using significant amounts of inorganic fertilizers like urea and superphosphate also, after the application of some herbicides such as sodium arsenic of this bloom caused. During the warm and rainy seasons, the number of golden brown algae, diatoms, green and blue and green increase so that water in pools, lake and reservoir will be dark. In some cases, yellow green foam floating on the water surface may be developed on the water surface, which is called the algae bloom. The flourishing plankton lead to release large amounts of carbon dioxide and oxygen deficiency caused during the night. It was reported that at a concentration of 20 to 30 parts per million of carbon dioxide due to the high mortality of fish, hence the unexpected combination must be eradicated. According to researchers at the National Center for Oceanography, phytoplankton Cochlodinium has a nerve poison (neurotoxin), which does not affect humans. The phytoplankton is harmful algae (HAB) because due to the high concentration cause high consumption of dissolved oxygen in the water and resulting in the death of fish. High concentrations of this phytoplankton, also effects on growth and survival of some zooplankton, shell larval. Red tide unlike the common name is called for any discoloration in the sea. So that the algal blooms in marine ecosystems is one of the most common occurrences marine ecosystems. Due to this, growth of one aquatic species increases and on the other hand, other aquatic life is faced with the threat of destruction. First bloom has reported in ancient Egypt. First red tide has reported in 1983-2005 in the Persian Gulf and Caspian Sea that caused the death of many fish. The occurrence of red tide in the world, and then in the Persian Gulf in recent years and is growing and scientific evidence indicating that subject. Also in the waters of Kuwait, bloom of some harmful species algae in the Persian Gulf have reported but to investigate the effect needs further study. Increasing environmental stress and increased farming on the coast of the main causes harmful algae blooms. Occurrence harmful algae blooms, often have been reported as a result of increasing environmental stresses, including excess nutrients, and increased pollution in coastal areas of culture and education. Increase in nutrients in wastewaters, wastes fish farms, as well as climate change and the warming of the seas, is one of the main causes of this phenomenon. In the Persian Gulf due to the lower depth and penetration of light into the water, the risk of algal blooms is more. Global climate change and increasing global temperature can cause spread red tide phenomenon. Some NASA and India scientists found that increase water chlorophyll have direct relation with frequencies of marine earthquakes. Accordingly following earthquake, ground layers is friction with each other and produces heat. Increase in water temperature could lead to chlorophyll «a» and algae provide. As mentioned above, the upwelling phenomenon caused by the nutrients deposited in sea floor is dispersed in water and cause excessive growth of phytoplankton (Nazari, 2010). Figure 5 shows the areas that have great potential for the occurrence of red tide caused by the upwelling in the Persian Gulf. As well, the impact and spread of this algae species have been identified in the world.

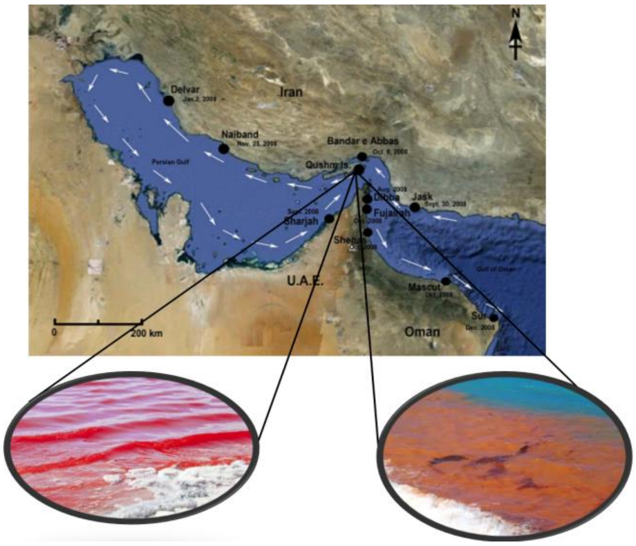

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Figure 5: A: direction of red tide in the Persian Gulf (Qeshm); B: image of microscopic algae Cochlodinium polykricoides; C: consequences of red tide in the Persian Gulf, including the death of fish, coral reefs and other marine animals; D: the global spread red tide algal species involved in the Persian Gulf.

The procedures used to derive the various time series from the available data bases have been consistently applied over the entire record. The analyzed data fields forming the data base for the upwelling index computations (Bakun, 2008) have been routinely produced throughout the record period in support of weather forecasting activities. Because of the extended period of assembly of these data, one wonders if artificial in homogencities could have crept in to produce the indicated trend (such as the transition from subjective hand analysis to objective computer analysis, altered data distributions due to changes in shipping routes, or establishment of new coastal reporting stations in data-poor areas). Because the analysis procedures act to spread available information in time and space, one cannot look to upwelling index series computed at nearby locations for independent corroborations. The area off Spain and Portugal is much higher in maritime data density than the other major eastern ocean upwelling regions, including California (Parrish, 2006). Here, four strictly independent (sharing no data) series of monthly means of wind stress estimates have been constructed from ship reports available in each of four adjacent 50 latitude by 50 longitude quadrangles (Fig. 6). Although details of the shorter scale interyear variability appear somewhat different among the four series, they all corroborate (Fig. 7 and Table 1).

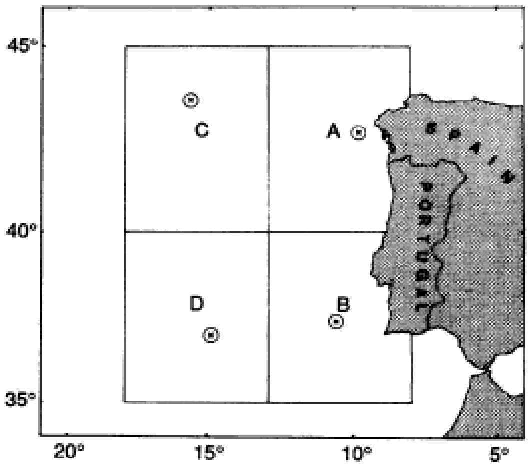

Figure 6: Four 50 by 50 quadrangles (areas labeled A, B, C, and D) offthe Iberian Peninsula in which sea surface wind stress estimates based on maritime wind reports were summarized to produce monthly time series shown in Fig. 7. The mean latitude and longitude of the reports available in each of the areas over the period 1948 to 1979 is marked by an "x" surrounded by a small circle.

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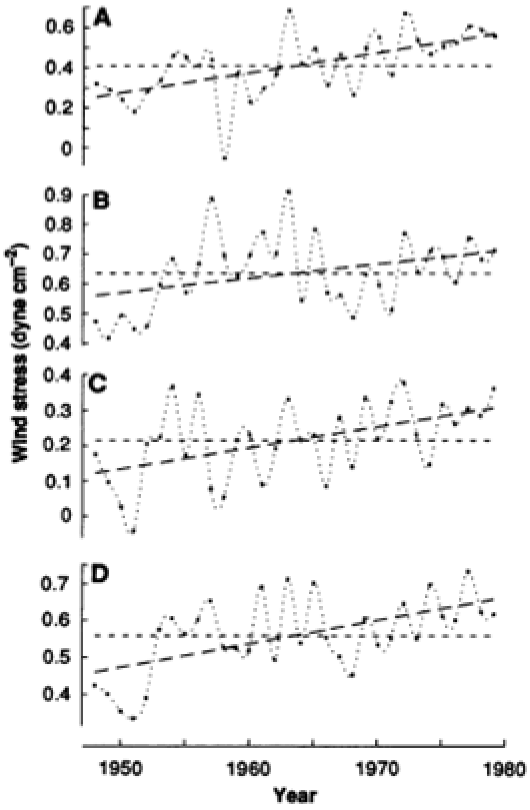


Figure 7: Six-month (April to September) averages of monthly estimates of alongshore wind stress produced from ship reports within the four areas (A, B, C, and D) shown in Fig. 6. Short dashes indicate the long-term mean of the series. Longer dashes indicate the linear trend fitted by the method of least squares

Thus data from widely separated areas around the world suggest that the equatorward alongshore wind stress that drives coastal upwelling has been increasing during the respective upwelling seasons of the past 40 years. In seasons when upwelling is weak or absent, no consistent pattern of increasing equatorward stress is apparent (for example, off California the slopes of the trend lines for the series of October to March means are weakly negative; off the Iberian Peninsula the fall-winter series exhibit a mixture of weakly positive and weakly negative trends). Thus the increasing trend in equatorward stress is observed only during the upwelling seasons. These are the only seasons during which thermal lows in surface atmospheric pressure develop over the adjacent land mass and therefore in which the hypothesized greenhouse mechanism could operate.

When the various series are differenced, effectively removing the linear trends, significant interregional correlation among the time series vanishes. Evidently, the only feature shared among regions is the longterm trend. Other known types of global teleconnections, such as El Nifno-Southern

Oscillation, are known to be evident in shorter period components of interannual variability. The substantial shorter period interannual variability evident in the time series (Fig. 3) is apparently not shared among regions to any significant degree. A greenhouse mechanism is consistent with the simple monotonically increasing trend that corresponds to the observed interregional pattern. Moreover, simulations of increased atmospheric CO2 with general circulation models suggest that southward wind stress will increase in the spring and summer off northern California (Torn, 2000).

Intensification of coastal upwelling along subtropical and tropical eastern ocean boundaries would have important consequences. Evidently, with increased global warming, the coastal surface waters in these regions could cool relative to the surfaces of either the continental land mass on one side or the ocean interior on the other. With greater temperature contrast at the land-sea boundary, summer sea breezes would tend to be enhanced. Cool, foggy, summer conditions at the coast could become even more pronounced and wind flow through passes in coastal mountain ranges toward the heated interior valleys could strengthen. The onshore air flow might become even more stable and less humid because of enhanced heat loss to the relatively cool ocean surface; thus the coastal zone inland of the fog zone might become even more arid during upwelling seasons.

Effects on the marine ecosystem are more difficult to gauge. Short-term climatic warmings, associated with intense El Nino episodes, have recently occurred in the Peru (Pauly et al, 2009) and California (Cury, 1989) systems. But the specific dynamics underlying El Nino (Picaut, 1985) are most likely not identical to those controlling effects of climate warming. Moreover the distribution of biological populations, as well as their abundance, appears often to be more related to the dynamic physical processes that control various patterns in the ecosystem (Legendre et al., 2006; Bakun, 2008) than to direct effects of temperature itself. For example, recent empirical results (Cury, 1989) indicate that reproductive success of pelagic fishes in upwelling regions depends on the winds being neither so weak that there is insufficient upwelling to enrich the trophic pyramid nor so strong that turbulent mixing of the water column prevents maintenance of fine-scale concentrations of minute food organisms essential to larval survival.

In projecting direct physiological effects of climatic warming on organisms, a first inclination might be to merely increment present characteristic isotherm patterns and to predict changes in biological distributions according to the resulting translocation of temperature ranges. Clearly, there are problems with such a procedure. Also, care must be taken in using evidence from past warm epochs, where various causal aspects of the warming have been somewhat different, to predict the effects of greenhouse warming on the ocean ecosystem. The dynamic ocean processes that determine the temperature distributions could be fundamentally altered.

In the absence of counteracting effects (Chavez, 2005), intensified upwelling would tend to enhance primary organic production in these systems. But whether this increased primary production would be channeled to trophic components that society particularly values is unclear. There has been little clear demonstration that increased primary production actually promotes reproductive success and population growth of commercial fishes (Bakun, 2008; Cury et al., 1989). For example, increased production might be channeled to the mesopelagic fish communities that are diffused over wide areas and thereby largely lost from the neritic ecosystem. In addition, increased organic production might cause large areas of these systems to become anoxic at depth (Jackson et al., 1989) and thereby promote sedimentation of unoxidized organic matter on the sea floor. In any case, if primary production increases, the rate at which carbon is sequestered beneath the ocean thermocline should likewise increase, and thus the rate of buildup of CO2 in the atmosphere should be reduced.

If greenhouse warming leads to less global temperature contrast between tropical and Polar Regions, ocean basin-scale atmospheric and ocean circulations might slow down. Remote Sensing of the Caspian Sea and Persian Gulf. Remote Sensing observation and information about an object without touching it is. Usually sensors located on the satellite platform that global coverage and have ability to review the site. Remote Sensing is a supplement to fixed calibration. Some of the applications of satellite of remote sensing can be as simple as tool to measuring the temperature of the sea surface. For this purpose, the radio reflected the ocean's surface by showing different colors on maps; appropriate satellite imagery will be achieved. Surface water temperature data record by 14 satellites.

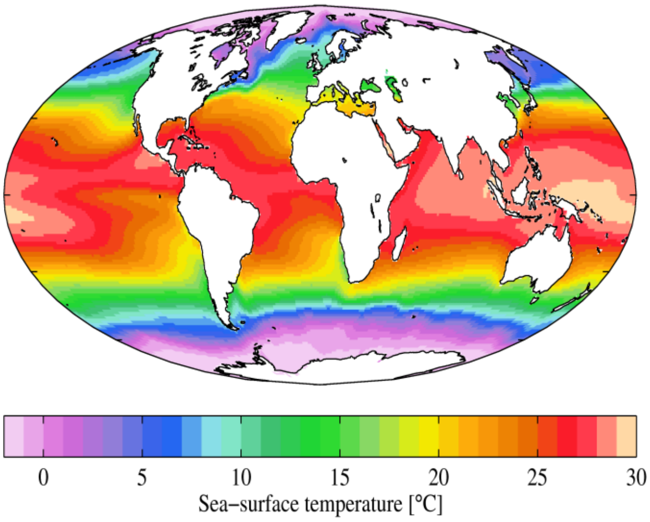


Figure 8: The global water surface temperature Remote sensing in the Caspian Sea

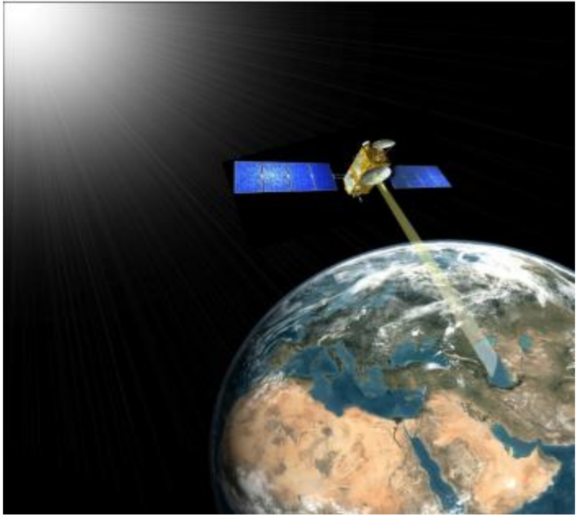


Figure 9: Schematic view of satellite capture imagery in the Caspian

Average temperature is 6-10 ° C in winter and 30 ° C in summer and middle part of the Caspian Sea is colder in other parts of the (Figure 10).

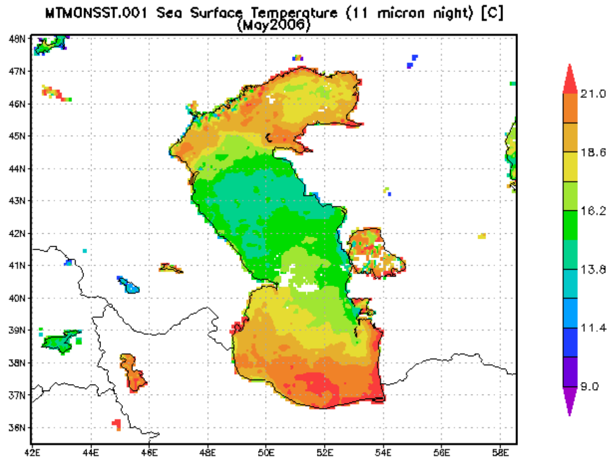
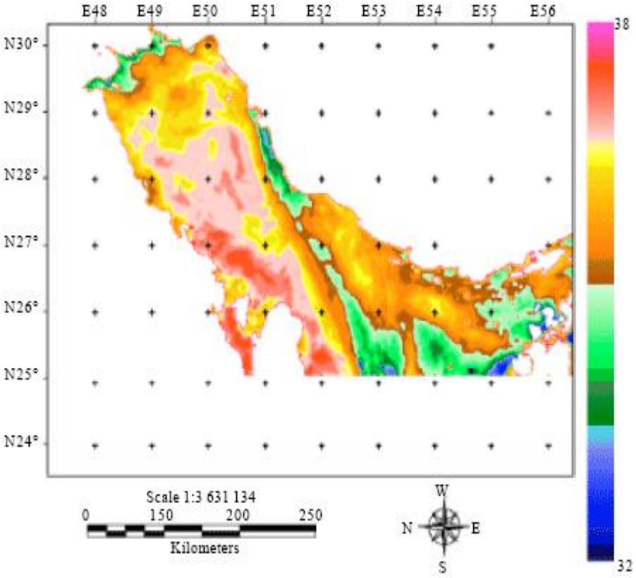


Figure 10: Satellite image of the status of the Caspian Sea surface temperatures in the spring

3. Remote sensing in the Persian Gulf

Figure 11 shows the temperature of the Persian Gulf in the summer. Due to its geographical location in the Persian Gulf, which is located in low latitude and high temperatures in the heating season, the temperature in the western part of the Persian Gulf is 32˚C and 38 ˚C in the eastern part of the Persian Gulf. The amount of temperatures in the eastern and western parts of the Persian Gulf is 15 ˚C and 28 ˚C respectively in the cold season (Figure 12).



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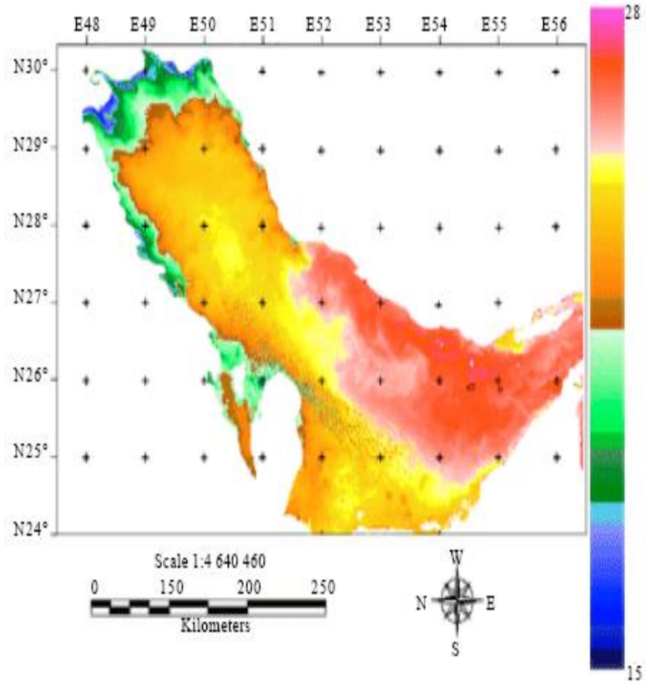

Figure 11 and 12: The surface temperature of the Persian Gulf in summer (above) and winter (bottom)

4. Conclusion

- However, in this study it was found that due to wind currents there was a close relationship between the marine and terrestrial environments. It was also found that there is trend towards intensification of rising ocean temperatures, which disrupt the oceanic phenomena such as upwelling as an integral part of the global climate changes. On the other hand, it was found that the increase in temperature causes warmer areas in the oceans and colder areas in upwelling costal that this increase will be in these areas and this increase wind intensity in these areas. Also, as mentioned above, the climate change could eventually lead to big changes in aquatic ecosystems is particularly upwelling areas. But nonetheless, we need further studies to predict the exact consequences of the resonance upwelling phenomenon in the ocean. About the reduction of red tide caused by upwelling in Persian Gulf and the Caspian Sea, these suggestions are available:
- Rapid response to reduce congestion by using local technologies (for example, precipitation with strong suctions are provided by centrifuge, etc.) can be helped to reduce their numbers and prevent reinfection. Moreover, deposited algae can be used for many pharmaceutical, food, health, etc. These algae generally are deposited as cysts and next year with favorable conditions will be bloomed again.
- Reduce homes and industry wastewater input into the sea is the most important short-term solution. New regulatory actions encouraging all those involved in coastal and marine to follow environmental laws and regulations, imposing heavy fines, the participation of organizations in cooperation with the monitors ongoing and research is one of the medium-term solutions.
- Also equip all industry with the latest findings of the environmental technology, according to the new regulatory. Equip organizations that responsible for dealing with pollution to the latest available technologies in the world, accurate and regular monitoring and creation information bases, including long-term solutions that should be seriously considered in order to deal with red tide.

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