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# Possible Effects of El Niño on Some Philippine Marine Fisheries Resources

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**El Niño is the warm phase of extreme climatic phenomenon observed in the equatorial Pacific. Over the past decades, frequent El Niño events have been observed and pose great threat to biodiversity. Reporting mostly the effects from 1982-1983 and 1997-1998 events, El Niño affected factors involved in ocean- atmospheric interactions such as sea surface temperature, salinity, nutrient availability, precipitation rate, ocean currents, and tropical typhoons. The changes in these factors influenced marine organisms leading to an increased phytoplankton biomass and widespread coral bleaching, and possibly resulting to fish kills, occurrence of seaweed diseases and threats to marine mammals. It affected pelagic fishes leading to migration or change in catch production. The data in this paper raise concerns on the predicted impact of El Niño on food security. Considering our susceptibility, key researchable areas must be implemented to support management strategies that will mitigate the possible effects of El Niño in the country.**

Keywords: El Niño, fisheries, Pacific Ocean

## INTRODUCTION

The Philippines has been assessed as one of the most vulnerable countries to the impacts of extreme weather brought by climate change (Harmeling, 2010; Santos et al., 2011). The direct effects of climate change occur through alteration in the behaviour, morphology, and physiology of individual organisms which cumulatively leads to ecosystem regime shifts (Food and Agriculture Organization 2000; Brierly & Kingsford 2009; Portner & Peck 2010; Doney et al. 2012). Climate change is projected to impact the marine sector and this scenario poses great pressure to the livelihood and food security among Filipinos especially those who live in coastal areas where fishing is the primary source of livelihood.

Fisheries is one of the drivers of Philippine economy being an archipelagic country that has more water than land (Yap 1999). To emphasize its importance, as of 2013, the country ranked as the seventh largest producer of fish, 11th largest producer in terms of aquaculture, and third largest producer of seaweeds among the top producers in the world (Food and Agriculture Organization, 2013a, 2013b). Its contribution to the Philippine economy amounted to some P 190 Billion pesos and employed more than 1.6 million fishing operators nationwide (Bureau of Fisheries and Aquatic Resources, 2012). It supplies different commodity species such as tuna, small pelagics, tilapia, milkfish, shrimp/prawn, crabs, cephalopods, shellfishes, and seaweeds.

The Philippines, which lies in the Indo-West Pacific, has been described as one of the world's epicenters of marine biodiversity (Carpenter & Springer, 2005) indicating that the country is blessed with highly productive marine

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waters from which the fisheries sector greatly benefits. However, this rich marine biodiversity is also under threat due to rapid degradation of marine habitat and coastal waters (Myers et al. 2000; Roberts et al. 2002). Another cause of biodiversity loss is climate change, that affects the biology and movement of many organisms.

Over the past decades, one of the observed changes in climate was the frequent and extreme episodes of El Niño Southern Oscillation (ENSO),which has two phases: the occurrence of warmer (El Niño) and cooler (La Niña) climatic patterns with El Niño being the more extreme phase (Gitay et al. 2002; Meuser et al. 2013) . Studies on climate modeling show that the occurrence of ENSO events is predicted to increase in the future due to greenhouse warming (Timmermann et al. 1999; Cai et al, 2014). To date, many El Niño events have been measured and classified as weak, moderate, or strong (Table 1). Since 1950, the two strongest El Niño events occurred in 1982/1883 and 1997/1998, with the latter considered as the strongest El Niño in history (McPhaden 1999; Garcia et al. 2004; Meuser et al. 2013). This phenomenon has lasting effects on global biodiversity particularly since El Niño happens in the biodiversity hotspots of the world including the Philippines (Figure 1) (Holmgren, et al. 2006; Meuser et al. 2013). Such extreme climatic changes may result to alteration of marine biodiversity patterns in a hotspot like in Australia where there was a change in community structure after a high-magnitude warming event (Wernberg et al. 2012). However, it is still important to note that increased El Niño events is just one of the many threats to biodiversity. This event together with anthropogenic activities such as deforestation, illegal trade, and overfishing contribute to biodiversity loss such as in the Philippines.

**Table 1**. El Niño Years and Intensities (Source: Null, 2014).

| El Niño | | |
|---|---|---|
| **Weak** | **Moderate** | **Strong** |
| 1952-1953 | 1951-1952 | 1957-1958 |
| 1953-1954 | 1963-1964 | 1965-1966 |
| 1958-1959 | 1968-1969 | 1972-1973 |
| 1969-1970 | 1986-1987 | 1982-1983 |
| 1976-1977 | 1991-1992 | 1987-1988 |
| 1977-1978 | 1994-1995 | 1997-1998 |
| 2004-2005 | 2002-2003 | |
| 2006-2007 | 2009-2010 | |

Perhaps the most obvious effect of El Niño in the Philippines is the change in weather and climatic patterns brought by modifications in ocean-atmosphere interactions in the Western Pacific. Depending on the intensity, Delos Reyes & David (2006) reported that past El Niño events reduced the rainfall rate up to 50% resulting to drought. Moreover, strong El Niño prevented tropical cyclones while weak to moderate events had longer effects on the weather. Strong El Niño takes five to eight months to cover the country with drought and has strong but short effect while weak to moderate events only require one to four months and have milder but longer damage (Delos Reyes & David 2006).

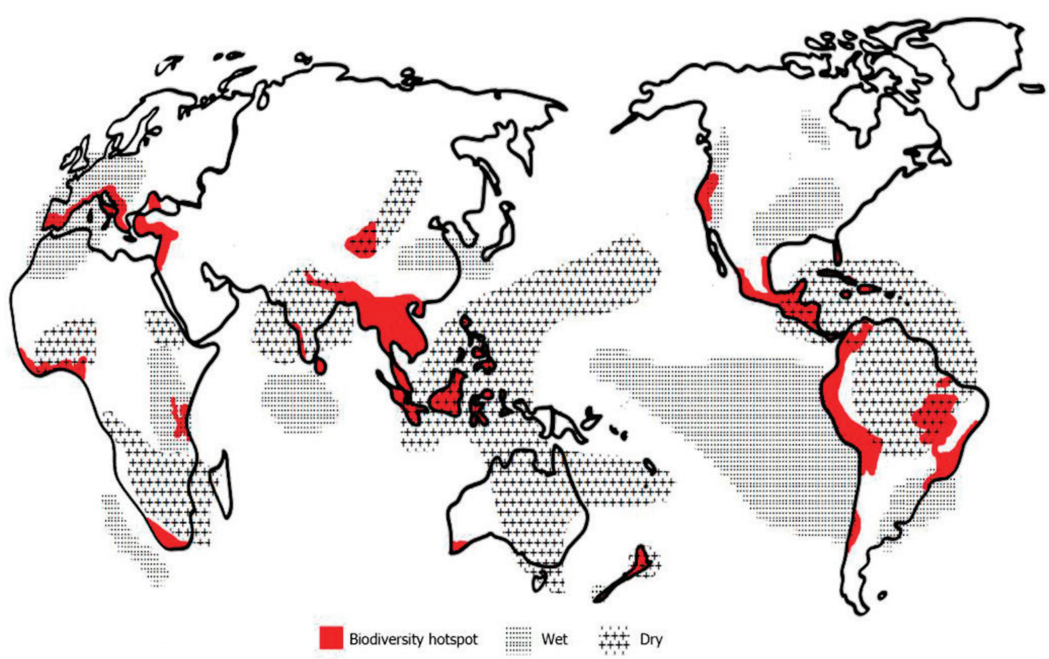


**Figure 1**. El Niño and Biodiversity. The most biodiverse areas (Myers et al., 2000) and areas affected during El Niño (Allan et al., 1996) in the world (Source: Meuser et al., 2013; Figure redrawn by Michael Mendiola).

This paper aims to review the possible effects of El Niño on marine fisheries resources in the Philippines as well as highlights key researchable areas that will enhance and support management strategies to mitigate its impacts.

**El Niño Phenomenon**

According to the National Oceanic and Atmospheric Administration (NOAA), El Niño refers to the three-month average positive sea surface temperature anomalies above the 0.5 °C threshold from the running means of multiple 30-year base periods in the Niño 3.4 region (5°N-5°S, 120°-170°W). It is the warm phase of El Niño Southern Oscillation (ENSO), which refers to the inter-annual climatic variability that causes changes in atmospheric and ocean conditions (Trenberth 1997; Lu et al. 1998). It brings heavy rainfall that causes flooding in the equatorial Eastern Pacific (EEP) and equatorial Central Pacific (ECP) regions while drought in the equatorial Western Pacific (EWP) region where the Philippines, Indonesia and Australia are located (Rasmusson & Wallace 1983).

During normal conditions, a high atmospheric pressure exists in the EEP while a low atmospheric pressure exists in the EWP. The atmospheric gradient drives the easterly tradewinds westward pushing the warm surface water from the EEP and ECP towards the EWP (Figure 2a). The water stays confined causing higher water level and deeper thermocline in the EWP than in the ECP and EEP (Cane, 1983). At the same time, the low atmospheric pressure brings frequent tropical rainstorms in the EWP.

As part of the EWP, the Philippine waters, as part of the EWP, are tropical in character, relatively warm and saline (Barut et al. 1997). Sea surface temperatures are generally above 28˚C in summer and only a few degrees lower during the cold months. The thermocline depth is usually about 150 m and varies seasonally. Nutrient concentrations and biological productivity are highest over the shelves and decline rapidly with depth and distance from the coast. When El Niño occurs, the atmospheric pressure falls in the EEP and rises in the EWP. This causes the easterly tradewinds to relax and the pool of warm water that normally resides in the EWP to spread across the equatorial plate (Figure 2b). The warm surface water distributes from the EWP to the ECP and EEP causing a shift in sea surface temperature, sea level and thermocline in the latter regions. The sea surface temperature becomes warmer in the EEP while the waters in the EWP become cooler (Rasmusson & Wallace 1983). The sea level decreases and the thermocline elevates in the EWP than in the ECP and EEP. There is also a reversal in the occurrence of tropical cyclones having more frequent events in the EEP and ECP. The lower atmospheric pressure in the latter regions brings excessive rains while the higher atmospheric pressure in the EWP brings drought.

In the Philippines, monthly rainfall is reduced during an El Niño event, such that strong events suppress typhoons while weak to moderate ones shift the direction of typhoons towards the northeast (Delos Reyes & David 2006). Similarly, neighboring countries, such as Indonesia and Malaysia, experience the same trend where there is reduced rainfall during an El Niño year (Cheang 1993; Kirono et al. 1999).

Studies also show that the bifurcation of North Equatorial Current (NEC) is affected by El Niño events (Zenimoto et al. 2009). In the Philippines, NEC bifurcation during El Niño shifts northward and weakens the Kuroshio Current going north while strengthens the Mindanao Current going south (Qu & Lukas 2003; Kashino et al. 2009; Yang et al. 2013; Gordon et al. 2014). Both currents affect the ocean circulation and transport processes in the country and neighboring regions, which in turn affects some marine organisms.

Furthermore, since teleconnections distribute tropical climatic patterns towards the pole, El Niño affects climatic variability not only in the tropics but also in

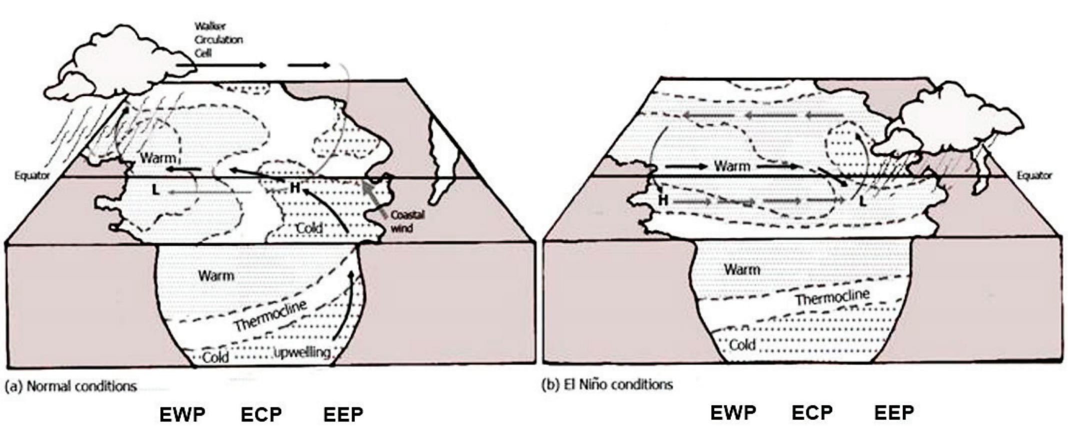


**Figure 2**. ENSO and normal events. a) normal b) El Niño. (Source: Trujillo & Thurman, 2001. Figure redrawn by Michael Mendiola).

the sub-tropics and some mid-latitude regions (Allan et al. 1996; Kumar & Hoerling 1997; Gergis & Fowler, 2009). Thus, this phenomenon acts on a global scale with strong influences on the functioning of marine as well as terrestrial ecosystems (Ulloa et al. 2001; Holmgren et al. 2001). Particularly in marine ecosystems, El Niño affects individual organisms such as members of the phytoplankton community (Morales-Ramirez &Brugnoli-Olivera 2001; Iriarte & Gonzalez 2004), fishes (Cushing, 1981; Sharp & McLain 1993; Lehodey et al. 1997), corals (Glynn 1984; Brown & Suharsono 1990); and marine mammals (Benson et al. 2002; Crocker et al. 2006; Santos & Aquino 2012).

**Relation to Primary Productivity**

During non El Niño events, the shallow thermocline supports the natural upwelling in the EEP where nutrient-rich cool water rises towards the surface (Meuser et al. 2013). However, the upwelling is decreased during El Niño due to the eastward movement of warm surface water that leads to the depression of thermocline. The upwelling persists but the deeper thermocline brings nutrient-less warm water resulting to the low primary productivity in the EEP (Barber & Chavez 1983).

This is opposite in the EWP where the primary productivity increases as in the 1997/1998 El Niño (Murtugudde et al. 1999). The resulting shallow thermocline and the strong wind stress allowed water column mixing and brought the surface well-mixed layer below and deep nutrient-rich layer above that favoured primary production in the region (Vialard & Delecluse 1998; Lehodey 2001). In the Philippines, Cabrera et al. (2011) revealed that barrier layer is one mechanism that inhibits upwelling in the Bohol Sea during an El Niño event. They showed that barrier layer forms thinner during less precipitation, which results to weak water stratification. Stratification prevents water column mixing and its weakened condition during El Niño allows deep nutrient-rich water to rise necessary for the primary production (Cabrera et al. 2011).

Satellite images from SeaWiFS revealed that the primary production in EWP was high and coastal upwelling was enhanced during 1997/1998 El Niño compared to the 1998/1999 La Niña event that followed after (Figure 3). Lehodey (2001) also showed the same trend when El Niño resulted to an increase in water productivity during1982/1983 and 1997/1998using composite satellite images. Maclean (1989) was able to link dinoflagellate, *Pyrodinium bahamense var. compressum*, blooms to El Nino in Papua New Guinea, Borneo, and the Philippines from 1970 to 1988. Simultaneous to the 1982/1983 event, a red tide was recorded on 1983 in Samar, Philippines (Hallegraeff, 1989). These were followed by blooms on 1987 and 1991-1994 in Zambales, Philippines when mild El Nino years were recorded (Caturao 2001).

**Effects on Fisheries**

One of the environmental factors that generally affects the biology and migration of many fishes is temperature (Magnuson et al. 1979; Gulland 1980; Binder et al. 2011). Magnuson et al. (1979) coined the concept of thermal niche to refer the preferred temperature of fishes. Skipjack tunas (*Katsuwonus pelamis*), for example, are found mostly in the EWP because they prefer the warm pool of water normally residing in the region (Lehodey et al. 1997; Sugimoto et al. 2001). Mostly for pelagics, the geographical distribution of fishes is influenced by fluctuating temperature that even small changes may allow the fish stock to extend it distribution further towards

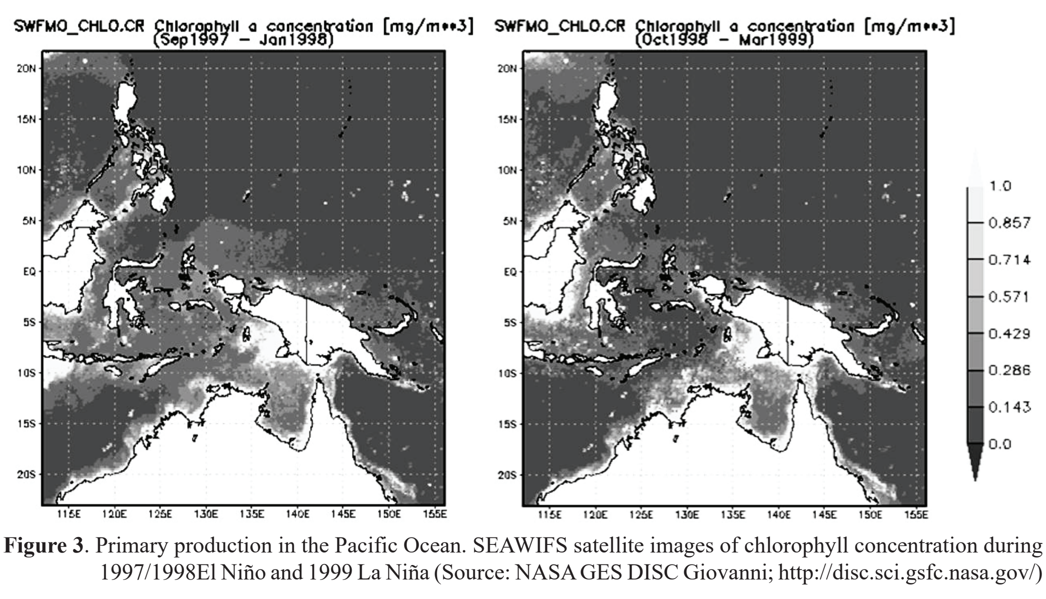


**Figure 3**. Primary production in the Pacific Ocean. SEAWIFS satellite images of chlorophyll concentration during 1997/1998El Niño and 1999 La Niña (Source: NASA GES DISC Giovanni; http://disc.sci.gsfc.nasa.gov/)

higher latitudes (Cushing & Dickson 1976; Portner & Peck 2010). So far, studies on the effects of El Niño on fishes focus mainly on small and large pelagic fishes.

The spread of warm water towards EEP deepens the thermocline and results to reduced productivity of upwelling. During 1972/1973 El Niño, one of the results was the devastation of anchovy fishery in Peru, one of the largest fishery in the world, due to reduction of nutrients (Cushing 1981; Bakun & Broad 2003). The distribution, spawning, and recruitment of northern anchovy off California was also negatively affected during the 1982/1983 El Niño event (Fiedler et al. 1986). This event also suppressed the upwelling in the ECP that resulted to a decrease in yellowfin tuna (*Thunnus albacares*) catches (Miller 2007). In 1997, the stocks of small pelagic fishes decreased again in the EEP particularly on the anchovy fishery (FAO 2000).

In the EWP, the spread of warm pool of water extends the distribution of tuna species. Lehodey et al. (1997) observed an eastward movement of the tagged skipjack tunas released in the EWP to the ECP during the 1991-1992 El Niño. Although the migration of skipjack tunas were mainly driven by temperature, the inhibition of equatorial upwelling concurrent with the spread of warm pool of EWP also drove these species as the water displaced eastward (Lehodey et al. 1997; Lehodey 2001). Bigeye tuna (*Thunnus obesus*) also extended to the east during El Niño years (Yukinawa, et al., 1988). In the Philippines, tuna catch drastically decreased up to 58% particularly in regions 2 and 9 with region 2 being unable to recover after the 1997 event (Vera & Hipolito 2006). Prolonged and recurring El Niño increases the effort of finding suitable fishing grounds and leads to decreased tuna harvest being landed in the Philippines. This happened to Taiwan mackerel purse seine fishery which experienced a sharp decrease in harvest by 47.75% during the 1997/1998 El Niño and had estimated loss of US $6.22 million by 1998 (Sun et al. 2006).

However, temperature alone cannot explain the abundance and distribution of fishes but also involves their feeding habitat. As discussed above, primary productivity in the Philippines is increased during El Niño years in some parts of the country. Villanoy et al. (2011) noted that sardine fishery in Zamboanga Peninsula had the highest landed catch during some El Niño years (2003, 2005, 2007) as compared during some non- El Niño years. El Niño enhanced the upwelling that is beneficial to pelagic plankton-feeding species such as sardines and supported the municipal fishery of Zamboanga.

Although high productivity means greater food source in relation to the amount of phytoplankton present, this could also lead to the occurrence of blooms for some algal species. Algal blooms not only affect shellfishes but may also trigger fish kills due to oxygen depletion. This poses threat to mariculture such as farms of milkfish, the main aquaculture product of the country. On January to February 2002, a massive fish kill of milkfish happened in Bolinao, Pangasinan simultaneous with the occurrence of dinoflagellate *Prorocentrum minimum* bloom (Azanza et al. 2005). Aquaculture areas like Bolinao are usually eutrophic, such that even in the absence of El Niño the water is already prone to algal blooms. Still, oceanographic conditions during El Niño create favorable conditions for algal growth and further contribute to the conditions set up by eutrophic waters. Yin et al. (1999) revealed that El Niño was responsible for the occurrence of several red tides in Hong Kong from 1997 to 1998, which resulted to an estimated loss of US $32 million from fish kills. The conditions brought by El Niño helped in the outbreak of red tides along the eutrophic coast of China (Yin et al. 1999). Moreover, reduced rainfall and drought caused by El Niño do not help to replenish the aquaculture areas with cleaner waters, thus, may further contribute to eutrophication. Martins et al. (2001) pointed out that the input of freshwater in a eutrophic water is a major factor that controls the incidence of algal blooms. Therefore, El Niño may further contribute to the induction algal bloom in many aquaculture farms of the country.

El Niño also seems to affect the transport of larvae and juveniles. The partitioning of NEC into Kuroshio and Mindanao currents also influences the oceanographic processes and determines the north-south fish differences and larval dispersal off coast the country (Alino & Gomez 1993; Qiu & Chen 2012). One example is the Japanese eel (*Anguilla japonica*), that is transported through the NEC in the northern part of the EWP and is, thus, one of the commodities found in Northern Luzon. Kim et al. (2007) showed through their larval transport model that eel larvae were transported more to the Mindanao current than the supposed route Kuroshio Current during El Niño years. There is no data on the eel catch in Luzon, however, time series catch in Taiwan showed that El Niño coincides to the years of low eel production (Han et al. 2009).

Reduced precipitation during El Niño causes relatively higher salinity and drought in the EWP. Euryhaline species such as most species of Tilapia (*Oreochromis* spp.) may not be affected by the phenomenon but other species strongly dependent on salinity may have negative effects to increased salinity. Portunid crabs (*Scylla serrata*) are known to be influenced by salinity changes and prefer lower salinity (Williams & Hill 1982; Bonine et al. 2008). Meynecke et al. (2012) reported that portunid crab production is higher during La Nina when rainfall rate is higher. Drought, on the other hand, limits the environment of many aquaculture farms shortening the culture periods of prawn (*Macrobrachium rosenbergii*) and tiger shrimp (*Penaeus monodon*) (Ahmed 2013).

**Effects on Coral Reefs and Associated Species**

Corals have relatively fixed thermal limits and only capable of tolerating a narrow range of temperature, thus, making them the first to be severely damaged from fluctuating water temperatures (Coles et al. 1976). They are central to reef ecosystems: support and protect all sorts of organisms in the reef, contribute to primary production, play a major role in nutrient cycling and reef growth (Hoegh-Guldberg 2004; Wild et al. 2004). Corals reefs are the most diverse marine environment and without these species, a great portion of the sea bed is basically empty. Therefore, destruction of these organisms reduces the diverse assemblages of marine organisms and disrupts interconnected relationships in the ecosystem (Meuser et al. 2013).

The increased sea surface temperatures brought about by extreme events such as El Niño have pronounced effects on the corals (Reaser et al. 2000). In the EEP, El Niño causes widespread and moderate to severe episodes of coral bleaching due to warm water intrusion (Glynn, 1984; Glynn & D'Croz 1990; Stone et al. 1999). Moderate bleaching reduces the survival of corals, while severe bleaching ultimately follows coral death (Doney et al. 2012). The corals in the EEP are profoundly affected by El Niño since they are directly submerged to anomalous warm water from the EWP. In the EWP, while sea surface temperature becomes cooler, lower sea level leaves corals from low tides and can cause mortality due to exposure to the air and high irradiance (Glynn 1996; Anthony & Kerswell 2007).

Although the effects of El Niño are more pronounced in the EEP, coral bleaching in the EWP have also been attributed to El Niño events. In 1982/1983, coral bleaching coincided with El Niño and was reported in Costa Rica, Great Barrier Reef, Java Sea, Polynesia, Galapagos Islands, Pacific coast of Panama and Colombia, southwestern Indian Ocean, southern Japan, the Caribbean, Florida and Bahama Islands (Glynn 1984; Coffroth et al. 1990). In the Philippines, bleaching was recorded in Alcoy reef in 1981 and Hilatagan Island in 1982. In 1997/1998, coral bleaching and mortality were recorded in India, Sri Lanka, Maldives, Kenya, Tanzania, southern Japan and other Indo-Pacific countries (Wilkinson et al. 1999; Fitt et al. 2001). In the Philippines, coral mortality due to bleaching resulted to a 46% reduction in live coral cover of the country (Capili et al. 2005). Bleaching affects the structure and dynamics of coral reef ecosystems as bleached sites in the country showed lower recruitment of reef-associated fishes as compared to unbleached and recovered areas (Booth & Beretta 2002; Capili et al. 2005). Bleached site may recover, however, it takes a long time to restore the reef back to its former state. Brown and Suharsono (1990) observed that an extensive bleached site in Thousand islands, Indonesia was able to recover after five years although the coral cover was still half of its state before the bleaching event.

**Effects on Seaweeds**

Like corals, seaweeds are good indicators of the effects of El Niño because they are directly subjected to changes in the Pacific where many species are confined. Temperature and salinity are ecological factors that generally affect the physiology, reproduction, development and distribution of seaweeds (Breeman 1988; Breeman 1990; Steen 2004). Some seaweeds can tolerate wide ranges of temperature and salinity, while some cannot depending on the species.

In the EEP, the sea level rise during El Niño can result to upward shift in the distribution of seaweeds (Harley et al. 2012) while lower salinity can reduce their survival (Steen 2004). The 1997/1998 El Niño caused the disappearance of giant kelps in their northeast Pacific range (Edwards, 2004). Grove et al. (2002) also linked the same event to the low kelp density in Southern California due to prolonged warm water surface temperature and more frequent rainfall.

In the EWP, the decrease in sea level can expose and destroy the upper layers of intertidal seaweed communities and experience desiccation, high irradiance, and osmotic stress (Davidson & Pearson 1996; Ji & Tanaka 2002). Although there is a direct relationship between seaweed vertical distribution and their stress tolerances, the extreme conditions have obviously lethal effects on the upper benthic communities (Davidson & Pearson 1996). Water loss due to exposure from air and heat decreases seaweed photosynthetic and respiration rates (Ji & Tanaka 2002) while drought can further reduce these metabolic processes. They can shift their distribution downward, however, this depends on the presence of a suitable substrate.

El Niño events may affect the survival of seaweeds in many coastal farms, which puts risk on the position of the Philippines as one of the producers of aquatic plants. Trono and Valdestamon (1994) reported a disease called "ice-ice" in Eucheuma sp. and Kappaphycus sp. which occurs during dry months when exposed to heat and high salinity. These seaweeds produce a moist substance under stress that attracts bacteria and causes the whitening and hardening of branches. An outbreak of the disease can occur when seaweeds exceed their optimal temperature of 28-32 °C and salinity of 30-35 ppt. The cultured seaweeds located at shallower portion of the coastal areas can be most affected when extreme heat occur during an El Nino.

In addition, some species of Porphyra and Gracilaria may develop "suminori" (Kusuda et al. 1992) and "white tips" (Weinberger et al. 1994) diseases, respectively, when exposed to high temperature conditions. Suminori disease is manifested by plasmoptysis of the thallus (Takayuki et al., 2009) while white tips disease is manifested by the development of white necrotic tissues (Weinberger et al. 1994).

**Effects on Marine Mammals**

Marine mammals are observed in almost all ocean habitats (Forcada 2009). The availability of prey, often a result of physical oceanographic processes, is critical to the habitat preferences of marine mammals (Learmonth et al. 2006). Although marine mammals are found around the world, they are distributed variably in areas where their food is abundant (Learmonth et al. 2006). Oceanographic changes brought by El Niño can affect the distribution of cetaceans as they may need to travel farther to find suitable feeding grounds (Santos & Aquino 2012). The effects of El Nino on smaller marine organisms such as changes in distribution and habitat are likely to cause a cascade effect on marine mammals that are dependent on their prey location (Santos & Aquino 2012).

In the EEP, there was a displacement in the community structure when rarely found Risso's dolphins increased in number while naturally abundant short-finned pilot whales declined in Santa Catalina Island, California following the 1982/1983 El Niño(Shane 1995). Bottlenose dolphins, also extended their distribution range from southern to central California on 1983 (Well et al. 1990). Whitehead (1997) also reported that the fecundity and calf survival of sperm whales was reduced during and after an El Niño event.

The available studies on marine mammals in the Philippines were mostly focused on taxonomy, distribution and fishery (Dollar 1994; Dollar et al. 1994; Santos & Aquino 2012). Drought and increased salinity may become a threat to their survival such as Irrawaddy dolphins (Orcaella brevirostris) that lives in coastal waters and estuaries (Alava et al. 2012). Nevertheless, it appears that the feeding and migration of marine mammals in Philippine waters would not be significantly affected because their oceanic preys dwell in the deeper water layer except for some species that have limitations in their range in distribution such as Humpbacked Whales (Megaptera novaeangliae) only known to occur in Northern Philippines (Santos & Aquino 2012). An enhanced water column mixing during El Nino causes only a change in the vertical distribution of preys but not displacement to distant areas. For example, spinner dolphins are shown to feed on mcytophids and other components of the deep scattering layer, an area not affected by the movement of sea surface water towards the EEP (Pauly et al. 1995).

**Key Researchable Areas**

Based on this review, it is clear that there is a dearth of information regarding the specific effects of El Nino on marine resources in the country. Such information is critical in developing the right management interventions to mitigate the impacts of El Nino.

As an output of a nationwide consultation in 2015, the Bureau of Agricultural Research has come up with the Climate Change Research, Development and Extension Agenda Program for 2016-2022 (BAR 2016). Five (5) broad researchable areas have been identified by stakeholders for the attainment of a climate-resilient capture fisheries in the country namely:

1. Spatial distribution and migration patterns of fish and socio-economic implications of changes in resources availability;
2. Development of early warning systems inclusive of marine biodiversity and habitat;
3. Improvement of post-harvest technologies and food safety of major food fish species;
4. Recommendations for enhancing resiliency of fisheries infrastructures; and
5. Vulnerability assessment studies of coastal areas.

The Plan includes a detailed matrix in a value chain format (from production, post-harvest and processing to policy) the specific problems that climate change may bring to the country, the specific researchable area pertaining to the said problem, expected outputs, possible implementing agencies and timelines.

## SUMMARY AND CONCLUSION

El Niño is one of the apparent changes in climate and has been occurring more frequently in the past years. Certainly, changes in ocean and atmospheric patterns brought by this phenomenon have a significant impact on organisms that live particularly in the marine environment across the equatorial Pacific. Most marine organisms are crucial for the subsistence of fisheries sector, yet the most vulnerable to such extreme climatic variability. Although the conditions may be beneficial in some organisms, the overall effects of El Niño marine resources and consequently to fisheries sector appear to be negative. Table 2 summarizes the effect of El Niño on some important commodity species and other marine organisms and its implications on fisheries. The effects may vary from good to severe cases depending on species involved although it shows that more organisms are at disadvantage.

**Table 2**. Summary of the effects of El Niño on selected marine organisms and its corresponding impact on fisheries.

| Resources | Effect on species | Impact |
|---|---|---|
| Primary productivity (Phytoplankton) | Increased biomass | Productive waters; Enhanced coastal upwelling; Red tides |
| Fishery resources (pelagic fishes; invertebrates) | Displace distribution; Change in larval transport and recruitment; Sensitivity to salinity changes | Reduced fisheries1; Fish kills; Limitations on aquaculture |
| Corals | Bleaching to mortality | Reduction of coral cover; Low recruitment of fishes |
| Seaweeds | Desiccation; Displace vertical distribution; Occurrence of seaweed diseases; | Reduced seaweed production |
| Marine mammals | Displace distribution | |

[1]With exceptions on small pelagics such as sardines

This study presents an opportunity to assess the potential effects of El Niño on some of our marine fisheries resources and predicted scenarios provide information to mitigate the consequences of incoming ENSO events and reduce the loss of biodiversity and negative impacts on marine fisheries. Moreover, based on this review, one can draw that there is an urgent need to implement existing climate change-related research, development, and extensions plans in the country to better understand and mitigate the effect of incoming El Niño events in the country.

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