THE IMPACT OF CLIMATE CHANGE ON THE PHILIPPINE FISHERIES: A MOVING DIRECTION TOWARDS FULL ACCESS TO OPEN MARKET AGENDA?

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Annalyn C. Daw-as, Eleanor D. Paca, and Gladys M. Navarro

For additional information, please contact:

Author’s name: Annalyn C. Daw-as
Designation: Saint Louis University Baguio City
Affiliation: Saint Louis University, A. Bonifacio St., Baguio City
Address: +6374- 4448246 loc 333
Tel. no.
E-mail

Co-author’s name: Eleanor D. Paca and Gladys M. Navarro
Designation: Associate Professor and Professor
Affiliation: Saint Louis University Baguio City
Address: Saint Louis University, A. Bonifacio St., Baguio City
Tel. no.: +6374- 4448246 loc 333
E-mail: eleanorpaca@yahoo.com, gladmanav@yahoo.com
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Annalyn C. Daw-as, Eleanor D. Paca¹, and Gladys M. Navarro²

ABSTRACT

This paper aims to determine the influence of climate change on the total fish catch in the Philippines and to develop a “sustainable fisheries output model” that captures the effect of climate change. The climate determinants include temperature, rainfall, humidity, and sea level pressure. The paper adopts Schaefer model as a starting point for understanding the behavior of fisheries growth in the Philippines. Model predictions indicate that the variable can positively and negatively affect the fisheries output. The paper concludes that the climate must be a basis on fisheries development in the Philippines. Managed fisheries sector must consider the climate determinants that affect its productivity. Open market participation of the fisheries sector must be supported by government-led management on climate change.

KEYWORDS AND PHRASES: climate change, fish catch, sustainable fisheries output model

1. Introduction

Philippine water is plentiful with many varieties of fish and plays a significant role in the lives and livelihoods of Filipinos. It is an important natural resource being a source of food and contributes to the country’s export. Fishing is a vital industry in the Philippines, it contributes to income, employment, foreign exchange earnings, nutrition (Trinidad et. al. 2002), and with an average annual fish catch that exceeds 2 million metric tons annually. As a developing country, the country places importance to food security, employment and food safety, a way to reduce poverty. The pollution of coastal and inland waters and depletion of fish populations through over fishing have reduced the fishing sector’s productivity in some areas of the Philippines.

Republic Act No. 8550, also known as Philippine Fisheries Code of 1998, integrates all laws on fisheries and aquatic resources of the country. This code promotes sustainable development of Philippine fisheries based on ecological limits and gives better option to the use of municipal waters by small fisher folk. In this code it shifted the open access policy of government in fisheries to a limited access. This code also assigned Bureau of Fisheries and Aquatic Resources (BFAR) under the Department of Agriculture (DA) as a national government agency responsible for the development, conservation, management, protection and utilization of fisheries resources.

Philippine fisheries are divided into aquaculture, municipal and commercial. A municipal fishery refers to fishing activities for the vessels of three gross tonnages and below. It is regulated by the local government. In addition, a 15-km area of waters has been classified as municipal waters, falling under the jurisdiction of local municipal and city governments. The primary species included in the municipal catch are small sardines, mackerels, anchovies, round herring, fusiliers, milkfish, marlin, swordfish, sailfish, barracuda and shrimps.

¹ & ² Advisers
Commercial or deep sea fishing operates outside the municipal fishing boundaries using passive or active gears with a defined gross tonnage of fishing vessels (ADB-RETA 5945). It’s not allowed to fish within 15 kilometers from the shoreline unless special ordinances approving this activity are approved by the municipal or city councils. It is regulated by the Bureau of Fisheries and Aquatic Resources of the Department of Agriculture (DA-BFAR). The commercial fishers are usually based near large population centers where they land the bulk of their catch. They move over a wide area in search for fish. The common fish catch are Rounds cad and Indian sardines.

The aquaculture sector includes fishery operations involving all forms of raising and culturing fish and other fishery species in fresh, brackish and marine water areas. The main harvests are seaweed, milkfish, tilapia, and shrimps or prawns.

Philippines is a member of developing member country (DMC) that is supported by the Asian Development Bank (ADB) that is a source of multilateral financing for fisheries. ADB funded the loan of the Fisheries Resources Management project in the country. The government is also engaging non-government and people’s organization on fisheries co-management.

In the light of global issue on climate change and securing food sustainability in the country, this paper aims to provide an assessment of the Philippine’s fishery sector and suggest a sustainable fisheries output model that captures the effect of climate change. It includes determinants of rainfall, temperature, and humidity that are theoretically justified. Specifically, this paper is aimed:

1. To determine the influence of climate change on output of an economy’s fisheries sector; and

2. To assess, from the empirical results of the model, if the country is open to full open market agenda on the fishing sector and its ability to compete in an open, globalized economy to achieve its development goals on food sustainability and security.

2. Background of the Study

In 2006, the Philippines is ranked as number eight among the top fish producing countries in the world with its total production of 4.41 million metric tons of fish, crustaceans, mollusks, and aquatic plants (including seaweeds). The production constitutes 2.8% of the total world production of 159.9 million metric tons (BFAR, 2007).

Philippine fisheries systems are facing a collapse generally due to overfishing. Total fish production of the country has been steady, around 2.7 million metric tons per year in the 1990s. The increase in total production is accounted for by the growth in aquaculture (Trinidad, et. al., 2002). According to World Bank, if there would be no change in fish consumption and no active human population management program, the domestic demand for fish will reach 3.2 billion kilograms by 2020, given the projected population growth rate of the country (Tacio, 2009).

Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (Arunlanathan, 2007). Philippine climate is generally tropical and maritime. It is characterized by relatively high temperature, high humidity and abundant rainfall (PAGASA). According to the Department of Science and Technology-Philippine Council for Aquatic and Marine Research and Development (DOST-PCAMRD), our country, particularly the fisheries sector is among Asian countries most vulnerable to climate change. Dr. Rafael D. Guerrero III, the
executive director of the Laguna-based Philippine Council for Aquatic and Marine Research and Development (PCAMRD) warns that with the global warming we may have problems in the next five to ten years unless we do something about it.

Figure 1 shows the trend in total quantity of fish production in commercial and municipal fishing for the year 1965-2003. During the early 1950s, municipal fisheries comprised the bulk of fisheries production, which was greater than the commercial sector (Trinidad, et. al., 2002). Fishery production in 1965 was 667,200 tons, five times greater after 38 years. Production hovered at 1.2 million tons for almost the entire decade of the 1970s. Then, the contribution of the municipal sector to total fishery production dropped drastically to a little over 30 percent of the total catch.

![Figure 1. Total Quantity of Fish Production (thousand metric tons) from 1965-2003](source: Philippine Statistical Yearbook)

In Figure 2, catch per unit effort, as measured in tons/hp for the total small pelagic fish catch from municipal fisheries in the Philippines, has declined intensely from 1948 to 1997. The total catch of small pelagic fish has also not increased much since 1975, even with huge increase in effort. This indicates that total fishing effort is much higher than can be
maintained for sustainable catches both in ecological and economic terms (Trinidad, et. al., 2002).

Figures 3, 4, and 5 illustrate the climate determinants (rainfall, temperature, and humidity) from 1965 to 2003. Rainfall is the most important climatic element in the Philippines and its distribution throughout the country arise from one region to another. It depends upon the direction of the moisture-bearing winds and the location of the mountain systems (PAGASA). There is also an increase of annual rainfall and number of rainy days (Anglo, 2006).

Based on observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level and confirmed by scientific studies, a warming of the climate system is now a foregone conclusion (PAGASA). The country has an increase of 1.4°C per century change in temperature (IPCC, 2007). Humidity denotes to the moisture content of the atmosphere. Due to high temperature and the surrounding bodies of water, the Philippines have a high relative humidity (PAGASA).
3. Review of Related Literature

Many empirical researches were conducted to study the effects of climate change on fish output. K. M. Brander (2007) found strong interactions between the effects of fishing and the effects of climate because fishing reduces the age, size, and geographic diversity of populations and the biodiversity of marine ecosystems, making both more sensitive to additional stresses such as climate change. The frequency and intensity of extreme climate events is likely to have a major impact on future fisheries production in both inland and marine systems. Reducing fishing mortality in the majority of fisheries, which are currently fully exploited or overexploited, is the principal feasible means of reducing the impacts of climate change. It also shows that climate change has both direct and indirect impacts on fish stocks that are exploited commercially. Direct effects act on physiology and behavior and alter growth, development, reproductive capacity, mortality, and distribution. Indirect effects alter the productivity, structure, and composition of the ecosystems on which fish depend for food and shelter. The effects of increasing temperature on marine and freshwater ecosystems are already evident. Further changes in distribution and productivity are expected due to continuing warming and freshening of the arctic. Some of the changes are expected to have positive consequences for fish production, but in other cases reproductive capacity is reduced and stocks become vulnerable to levels of fishing that had previously been sustainable.

According to Food and Agriculture Organization of the United Nations, the impact on fisheries of changes in the structure and biological productivity of ecosystems will vary between fisheries and will depend of the specific environmental changes that occur and the particular biological characteristics of each species. In the oceans, where species can easily move, climate change will also result in modifications of the area of distribution of resources which will most likely move towards the North or South Pole. Consequences for the fishing industry could be significant.

Another study of Everett, et. al. (1995) says that climate change impacts are likely to make worst, most emphasized on marine fish stocks, particularly fishing pressure, diminishing wetlands and nursery areas, pollution, and UV-B radiation. In the oceans, climate change is expected to result in increases in sea surface temperature, global sea level rise, decreases in sea-ice cover and changes in salinity, wave conditions, and ocean circulation. On land, climate change will affect the availability of water, river flow regimes
(particularly in flood plains), size of lakes, etc., and the needs of water for other activities competing with fisheries. These changes in turn will have an impact on the biological productivity of aquatic ecosystems and on fisheries.

In the report by United Nation Environment Programme (UNEP) titled “In Dead Water”, climate change might slow down the global flow of ocean currents, which flush and clean the continental shelves and are critical to maintaining water quality, nutrient cycling and the life-cycle patterns of fish and other marine life in more than 75% of the world’s fishing grounds. Its change could adversely impact the fish production globally (Das, 2008). Sea level rise is a direct and major consequence of climate change. Higher water levels would provide outburst flows with higher lease to build upon and higher water levels would decrease natural and artificial drainage that would lead to pollution of water bodies (Billah, 2008).

Climate change can affect the temperature of inland lakes, the health of reefs and how nutrients circulate in the oceans (Portillo, 2009). It may have a wide range of possible effects on ocean currents and processes that can affect fish resources (Everett, 1996)

Bryne, et. al. (2003) examine relationships between a number of environmental variables and the daily sea trout smolt output in the Ireland. Temperature, photoperiod, absolute water level and change in water level are identified as having an important role in smolt migration.

Sharma, et. al. (2009) quantify and integrate the effects of climate change and the establishment of an invasive species on native lake trout Salvelinus namaycush populations.

Buisson, et. al. (undated) investigate the potential impacts of climate change on stream fish assemblages in terms of species and biological trait diversity, composition and similarity. It demonstrated that climate change could lead to contrasted impacts on fish assemblage structure and diversity depending on the position along the upstream-downstream gradient.

Allison, et. al. (2008) analysis suggests that they are likely to lead to either increased economic hardship or missed opportunities for development in countries that depend upon fisheries but lack the capacity to adapt. The precise impacts and direction of climate-driven change for particular fish stocks and fisheries are uncertain.

Arulanathan (2007) said that the impact of temperature rise on fish populations is undetermined because of lack of long- term research monitoring on the subject. But with coastal fishery resources under pressure because of overfishing, climate changes will likely worsen the situation to the stage of no recovery. The fisheries most sensitive to climate change are among those most affected by human interventions – such as those in dams, wetlands, coastal areas, manipulated habitats and areas affected by population growth.

4. Theoretical Framework

The Schaefer surplus production (1954) model is a simple, useful and convenient method for assessing fish stocks (Wang, 2003). Based on the economic paper of Esmaeili entitled “Impact of Climate Change in Commercial Stocks in Iran,” it shows the Schaefer model general form as follows:

\[ y_{(i)} = \beta_1 f_{(i)} + \beta_2 f_{(i)}^2 \]  

(1)
Where \( y(t) \) is the fish catch in year \( t \), \( f(t) \) is the fishing effort in year \( t \), and \( \beta_1, \beta_2 \) are coefficients. Including the climate determinants (rainfall, temperature, humidity, sea level pressure) to the Schaefer model, the above equation would be:

\[
y(t) = \beta_1 f(t) + \beta_2 f^2(t) + \beta_3 f(t) R(t) + \beta_4 f(t) T(t) + \beta_5 f(t) H(t)
\]

(2)

Where \( R(t), T(t), H(t) \) are rainfall (mm), temperature (°C), and humidity (%). The maximum sustainable yield (MSY) and fishing effort associated with it (\( f_{MSY} \)) can be estimated from the first order condition \( \left( dy(t) / df(t) = 0 \right) \).

\[
\frac{\partial y(t)}{\partial f(t)} = \beta_1 + 2\beta_2 f(t) + \beta_3 R(t) + \beta_4 T(t) + \beta_5 H(t) + \beta_6 SP(t) = 0
\]

(3)

The expression for \( f_{MSY} \) for the above can therefore be written as:

\[
f_{MSY} = \frac{-(\beta_1 + \beta_3 R(t) + \beta_4 T(t) + \beta_5 H(t) + \beta_6 SP(t))}{2\beta_2}
\]

(4)

The MSY can be calculated by substitution of \( f_{MSY} \) into equation (2).

One limitation of the study is the scarcity of data. There is no computation for the maximum sustainable yield because the number of boats data is not obtained in the study that did not allow for the determination of the fishing effort.

The specification of the production function that is used in the study is expressed as follows:

\[
Q(t) = \beta_1 f(t) F(t) + \beta_2 f(t) R(t) + \beta_3 f(t) T(t) + \beta_4 f(t) H(t) + \mu_i
\]

(5)

This paper relies heavily on the Schaefer model, with little modification that is focused on climate change determinants that will cause the fish output to shift. Table 1 provides the theoretical predictions of the model, with total fish catch as the dependent variable.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catch Effort</td>
<td>+,-</td>
</tr>
<tr>
<td>Rainfall (mm)</td>
<td>+,-</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>+,-</td>
</tr>
<tr>
<td>Humidity (%)</td>
<td>+,-</td>
</tr>
</tbody>
</table>

Dependent variable is the total quantity of fish production in thousand metric tons.
5. Methodology

5.1 Data

Yearly data on total quantity of fish production and the historical climate data of the Philippines are obtained from the Annual Statistical Yearbook of National Statistic Coordination Board. The data is for the period 1965 to 2003.

5.2 Empirical Model

In estimating the impact of climate change determinants on quantity of fish production, the econometric equation is expressed as:

\[ Q = \beta_1 F + \beta_2 R + \beta_3 T + \beta_4 H + \mu_i \]  

where \( Q \) is the dependent variable representing the total quantity in thousand metric tons of fish production; \( F \) is the fishing catch per effort measured in terms of the metric tons per horsepower (mt/hp); \( R \) is average rainfall measured in terms of millimeter (mm); \( T \) is the average mean temperature that is in degree Celsius (°C); and \( H \) is the average relative humidity (in percent).

6. Empirical Results

6.1 Descriptive Statistic

Table 2 presents the computed mean, minimum, maximum, and range of each variable. The dependent variable is total quantity of fish production. The results show that the variables chosen in this study are in normal distribution.

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Quantity of Fish</td>
<td></td>
<td>1587.494</td>
<td>892.4</td>
<td>2164.7</td>
<td>1272.3</td>
</tr>
<tr>
<td>Production (thousand metric tons)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishing Effort (mt/hp)</td>
<td>34</td>
<td>-25.27</td>
<td>-140.34</td>
<td>2.9</td>
<td>143.24</td>
</tr>
<tr>
<td>Rainfall(mm)</td>
<td>34</td>
<td>2430.374</td>
<td>1833.7</td>
<td>3201.1</td>
<td>1367.4</td>
</tr>
<tr>
<td>Temperature(°C)</td>
<td>34</td>
<td>27.11765</td>
<td>26.5</td>
<td>28</td>
<td>1.5</td>
</tr>
<tr>
<td>Humidity (%)</td>
<td>34</td>
<td>81.64706</td>
<td>80</td>
<td>84</td>
<td>4</td>
</tr>
</tbody>
</table>
6.2 Empirical Results

Table 3 presents the regression results of the relationship of the total quantity of fish production and the climate change determinants based on the model.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Regression Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-21074.61</td>
</tr>
<tr>
<td></td>
<td>(-3.736)***</td>
</tr>
<tr>
<td>Fishing Effort (mt/hp)</td>
<td>-3.19</td>
</tr>
<tr>
<td></td>
<td>(-3.235)***</td>
</tr>
<tr>
<td>Rainfall (mm)</td>
<td>97.01</td>
</tr>
<tr>
<td></td>
<td>(-3.81503)***</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>579.07</td>
</tr>
<tr>
<td></td>
<td>(4.305)***</td>
</tr>
<tr>
<td>Humidity (%)</td>
<td>-0.4285</td>
</tr>
<tr>
<td></td>
<td>(2.277)***</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>72.13</td>
</tr>
<tr>
<td>Significance F</td>
<td>1.03E-07</td>
</tr>
</tbody>
</table>

Note: numbers in parenthesis are the t-ratios associated with the parameter estimates
***Significant at 0.01

In regression, linear model is used in this study. The result shows that the coefficient of determination is 72% which means that the fishing effort, rainfall, temperature, and humidity explain 72% of the variation in the total quantity of fish production in the Philippines. The constant (intercept value) is -21074.61, which means that assuming the value of fishing effort and climate determinants is zero simultaneously and it logically tells that the total quantity of fish production would also be equal to zero.

The significance \( F \) is equal 1.03E-07, which means that total quantity of fish production is significantly different over the 34 years observation brought about the fishing effort, rainfall, temperature, and humidity. This result initially validates theoretical predictions that total fish production in the country specifically in commercial fishery and municipal fishery is significantly different over the past 34 years as to the chosen climate change determinants and fishing effort.

The regression results further validates theoretical predictions given the values of the beta coefficients. In particular, the econometric model chosen allowed for the estimation of the beta coefficients of fish production with respect to the determinants of climate change and fishing effort.

\( \beta_1 \) is estimated at -3.19, i.e., the estimated value of total quantity of fish production with respect to fishing effort is 3.19 and fishing effort negatively affects total fish catch production. This means that a 1 mt/hp increase in the fishing effort, the estimated decrease of the total quantity of fishery production is by 3.19 thousand metric tons. \( \beta_2 \) is valued at 97.01, indicating an estimated value of total quantity of fish production with respect to temperature is 97.01. This means that a 1 mm increase in the rainfall, the total quantity of fishery production is estimated to increase by 97.01 thousand metric tons. The estimated \( \beta_3 \) coefficient is 579.07, indicating the value of total quantity of fish production with respect to temperature. This means that a 1°C increase in the temperature is estimated to increase the total quantity of fishery production by 579.07 metric tons. \( \beta_4 \) coefficient is estimated at -0.43 or the estimated value of total quantity of fish production with respect to humidity is 0.43.
This means that a 1% increase in the humidity is estimated to decrease the total quantity of fishery production by 4.3 hundred metric tons.

Given the above coefficient estimates, empirical results reveal that total quantity of fish production is very elastic with respect to the climate change determinants. The results of the model indicate that there has been an overfishing in the country. It also indicates that climate changes proved to be very volatile leading to very high responsiveness of total fish production. Over the past 34 years, the data also reveal that there had been drastic changes in the climate change determinants.

7. Conclusion

Fishing is a vital industry in the Philippines. It contributes to income, employment, foreign exchange earnings, and nutrition. On one hand, the pollution of coastal and inland waters and depletion of fish populations through over-fishing have reduced the fishing sector’s productivity in some areas of the Philippines.

Philippine total fish production has been steady, and the increase in total production is accounted for by the growth only in aquaculture. World Bank concluded that if human population is not managed and no change in fish consumption is experienced, demand for fish consumption will reach 3.2 million metric tons by 2020. Average fish production in 34 years is only about 1.99 million metric tons with a growth rate of 4.5%.

Several studies reveal considerable impacts of climate change to fish production. The fisheries most sensitive to climate change are among those most affected by human interventions – such as those in dams, wetlands, coastal areas, manipulated habitats and areas affected by population growth. Similarly, climate change could lead to contrasted impacts on fish assemblage structure and diversity. Another study further suggests that climate changes are likely to lead to either increased economic hardship or missed opportunities for development in countries that depend upon fisheries but lack the capacity to adapt.

This paper contributes to an assessment of Philippine fishery output due to fishing effort and climate changes occurring from 1970 to 2003. The result of the study shows that there is a drastic change in the climate determinants. Rainfall, temperature, and humidity have a random pattern and it shows that there is a sharp decrease and sharp increase on the variable.

Over the 34 years observation, a summary on the descriptive statistics, the range value of fishing effort shows that if there will be an increase of 143.24 metric tons per horsepower, there would be an average of 1.2 million change on the production of fish. Likewise, 1367.4 millimeter changes in rainfall would lead an average of 2.9 million changes on the production of fish. And a 1.5°C changes in temperature would lead to an average of 2.9 million changes on the production of fish. If the humidity would change by 4%, there would be an average of 2.9 million change on production of fish. Therefore, a little change in the fishing effort and climate determinants would result to an enormous change in the total quantity of fish production. The results of the model indicate that climate changes proved to be very volatile leading to very high responsiveness of total fish production. Data also shows that there had been drastic changes in the climate change determinants.

The study uses the Schaefer model focusing on the effect of fishing effort and climate change shifters to total fish production of commercial and municipal fishing in the country. The paper examined the impact of fishing effort and climate change determinants in terms of rainfall, temperature, and humidity. Empirical results reveal that Philippine total fish catch is...
very elastic in terms of the chosen determinants, i.e., a 1% change in fishing effort, rainfall, temperature, and humidity can bring about a drastic change in total fish production in commercial and municipal fishing. This result significantly reveals that fishing production is very responsive to the effect of climate change.

8. Policy Implication

Given the empirical result of the study, the fishery sector, especially the commercial and municipal fishery, is not yet prepared for an open market economy model in the short run. For one, the Philippine economy as a whole chooses to be more pragmatic than proactive in responding to climate change. Plans and programs to mitigate the impact of climate change are undertaken as they may see fit rather than addressing the problem on a longer span of time. Programs are also sporadic rather than holistic. There is nary an effort on the part of the government to create a massive information and education campaign (IEC) particularly among subsistence fishers. The result of the study shows that fishing production is very volatile to variables of climate change. Given this fact, subsistence level fishermen are among the most vulnerable group who cannot immediately overcome the economic impact of climate change. In the absence of a strong fishery administration and local manufacturing industries, technological developments must come from abroad. But fishermen do not have the funds to improve fishing equipment, machinery, and gear. This makes the fishery sector unprepared for an immediate open market economy, implying a need for strong support.

Government involvement is still needed to promote sustainability and for food security. The government must need to create awareness on climate change. In attaining the sustainability we must consider the proposed solution of the Food and Agriculture Organization which includes the following:

1. active participation at global and regional level, to ongoing discussion and collaboration
2. allocating research funds to analyze local and regional potential changes in resource importance and composition and likely socio-economic impacts;
3. sharing information obtained with the sector on potential changes, their scale and possible effects on resources and fisheries;
4. developing effective national and international scale resource management regimes and associated monitoring systems to facilitate adaptation of exploitation regimes in a shifting environment;
5. strengthening regional fisheries management organization
6. Integrating fisheries management into coastal areas management to ensure that fisheries needs are taken up when dealing with protection of coastal areas from sea level rise, etc. For instance, to ensure that public works to protect coastal areas do not destroy nursery areas important to fisheries;
7. analyzing aquaculture sustainability in an eco regional context, forecasting changes in productivity or resistance and in required related changes in culture systems, cultured species or delocalization of productive systems. Particular attention should be given to coastal investments; and
8. government’s consideration of constructing and maintaining appropriate infrastructure for storm forecasting, signaling systems and safe refuges for dealing with possible rising sea level and increased storminess.
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