The 2nd International Conference on Biological Engineering and Medical Science
DOI: 10.54254/2753-8818/4/20220603

The Conservation of Endemic Species--Take Galapagos Penguins as an Example

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Abstract. Endemic species refers to the species that are distributes only in a certain region of the world. Galapagos penguins, well-known as one of the smallest penguins in size, can be used as a typical example of endemic species. Since the extinction of endemic species in one place may lead to the extinction of the whole population of the species, endemic species may need some special attentions from the public. Unfortunately, Galapagos penguins, as a kind of endemic species, after being severely affected by ENSO event and human activities such as bycatch, is at the brink of extinction at the moment. Given that climate change is making ENSO even more frequently in the future, it is highly possible that without further intervention, the species of Galapagos penguins will be lost forever.

Keywords: Galapagos penguins, conservation, climate change, ENSO

1. Introduction

Galapagos penguin is a kind of endemic species on Galapagos Islands, also known for its incredibly small size as a penguin. Due to the fact that they only distribute in one single region, a slight decrease in the population may eventually leads to the extinction of the whole species. Therefore, the conservation of endemic species, such as Galapagos penguins may have more special significance. Unfortunately, Galapagos penguins have been included into the list of endangered species since 2000, urging more attention to the conservation of the species [1].

2. The cause of the endemism

To begin with, the endemism of the Galapagos penguins is likely to be caused by the geographical isolation of Galapagos Islands for the continents. Considering this natural characteristic of the islands, it is highly possible that when the ancestors of Galapagos penguins entered the islands, they were not able to move back to the continent, hence they stayed on the island, and it was the evolution which finally completed the process of speciation. Moreover, one of the key factors that helped to ensure the survival of their ancestors was the wide variety of habitat zones on the islands [2]. The diverse habitat zones definitely gave rise to local biodiversity, thus creating an ecosystem that is able to support the survival of a wide range of creatures, including Galapagos penguins.

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3. The cause of the vulnerability

Despite the fact that Galapagos Islands is an ideal habitat for Galapagos penguins for generations, some recent changes have created negative impact on the population. The main factors include climate change and human activities.

Both La Niña and El Niño events, which refer to change in climate patterns globally, can influence the population of Galapagos penguins greatly. La Niña, together with El Niño, were named after ENSO, which stands for El Niño-Southern Oscillation, and they are basically the opposite of each other: while La Niña will result in a decrease in the temperature of the eastern coast of Pacific where Galapagos Islands are located, increasing rainfall and temperature are presented on the eastern coast of Pacific, and both of them have an equally strong impact on the climate pattern of regions all over the world [3].

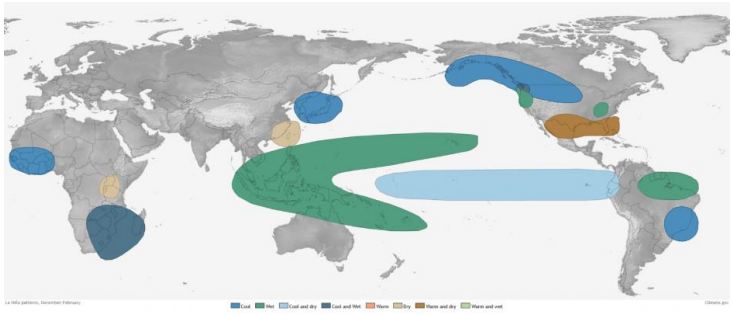

Figure 1. La Niña patterns from December to February [18].

At the most current level of understanding, the causes of ENSO can be generally related to the ocean current. When warm water is gradually built up at the eastern coast of Pacific, more specifically, along equator, El Niño is highly likely to take place. In this case, La Niña tend to take place as a result of the effect of hypercorrection, which means places which are abnormally cold and dry in El Niño years will usually become warm and wet [4]. Therefore, due to the great influence of both El Niñ as well as La Niña on the regions surrounding the Pacific Ocean, once these changes climate pattern take place, Galapagos islands could be highly under the threat.

In fact, when the temperature on Galapagos islands, especially near the ocean surface, start to increase, the reproduction rate of Galapagos penguins will decrease. Galapagos penguins mostly distribute on the two west-most islands of Galapagos Islands, called Fernandina and Isabela islands, through which a current called Cromwell Current passes. The current nourishes the ocean ecosystem for Galapagos penguins, but at the same time, the dependent on Cromwell Current makes changes in sea surface temperature vital to the whole local ecosystem [5]. Apart from the effect of current on the Galapagos penguins, other aspects of weathers that shows abnormal features due to El Niño and La Niña can also account for the low reproduction rate of Galapagos penguins. For example, research have shown that the El Niño would also lead to a dramatic decrease in the intensity of southeast wind that passes through the habitats of Galapagos penguins. This will further result in weaker coastal upwelling in coastal area where Galapagos penguins reside. Coastal upwelling is the phenomenon where the strong wind from the ocean will bring the water at the sea surface to the bottom, and therefore bring water from the bottom to the surface, creating a kind of circulation at coastal area [6]. This is especially vital for the survival of animals such as Galapagos penguins because when coastal upwelling takes place, the nutrients from the ocean bottom will be brought to the surface of the sea where creatures such as Galapagos penguins inhabit, supporting the ecosystem at sea surface to a large extent. With decreasing frequency and intensity of coastal upwelling, the abundance of food supply for Galapagos penguins will show a declination definitely. In addition, during the as the sea surface temperature in the coastal area of Galapagos islands increased, Galapagos penguins have shown substantial loss of weight and also a great percentage of nesting failure (Figure 2). While failures in nesting usually refers to failures in breeding considering the important role of nests in the raising of chicks, the two discoveries mentioned above not only indicates the correlation between sea surface cooling and breeding success, but also the

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relationship between food supply and warm temperature. As shown by Figure 2, the breeding of Galapagos penguins continues to successfully carry on when the ocean surface temperature is warmer [7].

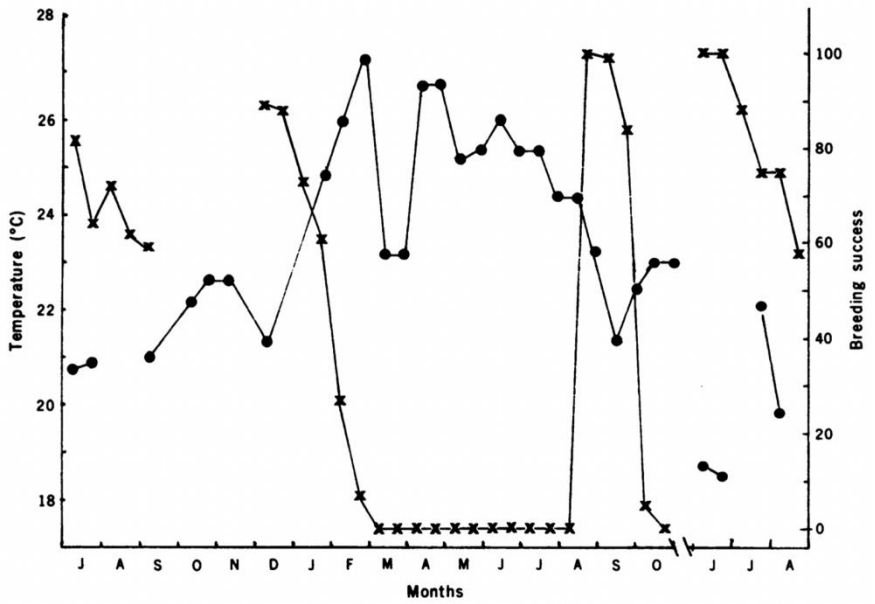

Figure 2. The changing of sea surface temperature on Fernandina Islands and the breeding success of Galapagos penguins in the region [7].

The points on the graph refer to the mean sea surface temperature measured at a depth of 0.4 m down the ocean surface on a boat 100 m from the shore of Fernandina Islands, the westmost islands Galapagos islands. The crosses (x) on the graph refers to the breeding success indicating by nesting success of Galapagos penguins. La Niña years where the ocean temperature tends to decrease instead of increase shall also make huge differences on Galapagos penguins due to the fact that changes in climate patterns at this great scale will always result in changes in local plantations and the whole ecosystem, influencing the life of animals through different means but similar degree. Therefore, both El Niño and La Niña will not provide ideal living condition for Galapagos penguins. The most famous event mentioned previously, in which more than half of the Galapagos penguins on the islands were wiped out, was the El Niño in 1982[5]. El Niño, as introduced previously, is a periodic climate pattern that naturally occur globally every few years. When El Niño arrived, the rainfall, temperature, along with aspects of the weather, will be influenced greatly. The sea surface temperature across the Galapagos Islands therefore raised inevitably to an abnormal degree [8]. This drastic change resulted in an unprecedented low reproduction rate among the population of Galapagos penguins from 1982-1983 [8]. The low reproduction rate, together with the percentage of penguins died of starvation, caused the mortality of Galapagos penguins after the El Niño reached approximately 77% of the total population, and since the reproduction rate of Galapagos penguins also remained low after the El Niño event due to factors include but not limited to the loss of food sources, the recovering of the population was quite slow as well. In an estimation of the Galapagos penguins' population in 2004, the number of birds in the group was said to be only about 50% of the population prior to the El Niño event from 1982-1983 [9]. Indeed, no successful reproduction has been observed in the year 1982 (Figure 3).

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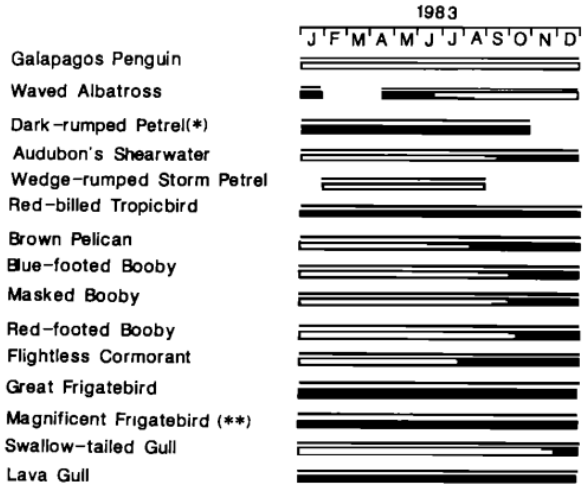

Figure 3. The breeding period and activities of sea birds on Galapagos Islands during 1982-1983 [8].

A solid bar in the figure represents normal breeding activities, while an open bar refers to the situation where there is no successful reproduction observed taking place. Unfortunately, this severe influence of climate change on Galapagos penguins even shows a tendency to become stronger in the future. While El Niño events that took place in the past decades generally show a decreasing manner, the frequency of extreme ones increased dramatically, and this increase in the frequency is highly possible to rise in the future as a result of global warming. According to its definition, extreme El Niño event differs from moderate El Niño event because it happens as a result of the massive reorganization of atmospheric convection, thus extreme El Niño event will always be accompanied with huge rainfall increase and drastic change in sea surface temperature, creating pressure on the local ecosystem. As shown in the Figures below, researchers have made series of predictions about the number of extreme El Niño events that is possible to take place in the future based on the data collected from recent El Niño events. While the number of extreme El Niño events in total happened between 1891 and 1990 was 101, this number is predicted to be doubled to 212 between 1991-2090 [10]. That also indicates that the potential impact of climate patterns, such as ENSO, would even have larger impact on the population of creatures such as Galapagos penguins. Given that ENSO itself has already brought tremendous change to the population, climate change could magnify the degree of significance, leading to some even more dramatic consequences. The impact of climate change brought by global warming on the ecosystem definitely deserves the more attention from the public.

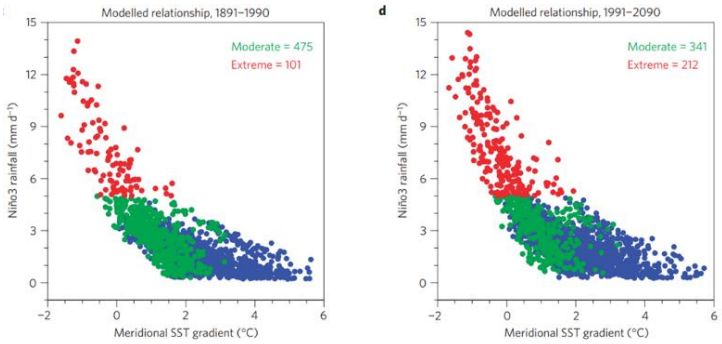

Figure 4. Evolution and nonlinear characteristics of modeled extreme El Niño events during the period from 1891 to 1990 and from 1991 to 2090, as well as changes in occurrences under the condition of global warming [10].

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Apart from climate change, human activities can also have influence on the population Galapagos penguins in negative way. As a kind of sea birds that live especially close to fishery, bycatching has influenced Galapagos penguins' population for centuries. Bycatch is defined as the unwanted and unexpected capture during fishery. When fishermen accidentally capture creatures with gender, sizes, or species they do not want, or creatures they are not allowed to keep, the creature will usually be discarded back into the sea. However, even not on purpose, many fish, mammals, and birds, such as Galapagos penguins or their desirable preys, become injured or even killed during this process. Therefore, Galapagos penguins are negatively influenced both directly and indirectly by bycatching. Even though these kind of independent accident sounds quite random and minor in regard to the whole population of a species, bycatching is actually becoming an important factor in the discussion of the vulnerability of Galapagos penguins over time. In research that focused on the effect of bycatch on some specific kinds of penguins worldwide, gillnet was discovered to be the most influential fishing method that influenced penguins on Galapagos Islands the most, and it can be clearly seen from the Figure below that the total number of penguins being harmed by bycatch on Galapagos Islands cannot be underestimated even within a global span [11].

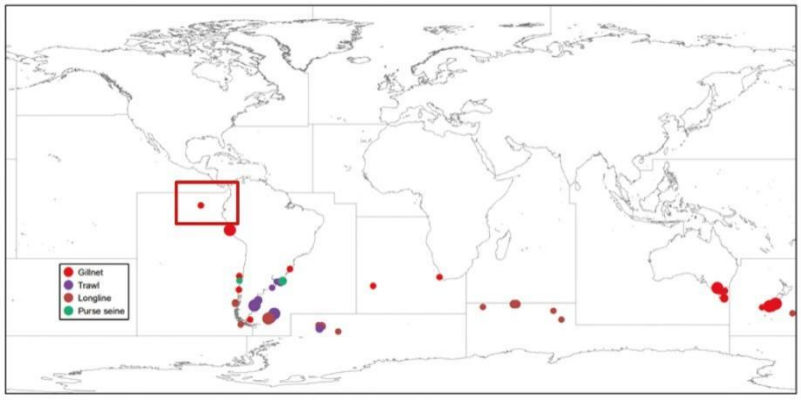

Figure 5. Penguin bycatch records, categorized by the tools used to bycatch, including gillnets, trawls, longlines and purse seine fisheries [11].

The position of the points in Figure 2 represents the location where the records were obtained. The size of each point represents the total number of penguins being harmed by specific kind of fishing method according to the records. The Galapagos Islands was marked with red in the Figure.

The conservation of Galapagos penguins has its own significance. Galapagos penguins actually play a quite important role in the ecosystem, by playing both as prey and as predators, helping to control the population of some animals while also providing food source for other animals. Some animals that prey on them include Galapagos Rice Rats, some specific kinds of snakes, hawks, crabs such as Sally Lightfoot Crabs, and owls as well as cats including domestic or feral cats; in addition, they are also consumed by sharks in water as well. At the same time, Galapagos penguins also help to control the number of animals like anchovies, red mullet, and sardines [12]. Indeed, Galapagos penguins are the major predators for small fishes and mollusks. Given that Galapagos Islands is a relatively isolated and therefore small ecosystem, the survival of Galapagos penguins seems important to maintain the balance of the environment. The loss of Galapagos penguins is highly possible to result in the loss of even more species, damaging the local biodiversity greatly.

4. Conservation strategies

Thanks to the Ecuador government and attention from the international community, some conservation actions have already been taken to ensure the survival of Galapagos penguins. First, the supervision of the habitat using drone technology helps researcher to keep track of all the slight changes in the habitat. For example, drone technology can detect the change in the population of Galapagos penguins and ensures that action can be taken on time in response to those changes. Moreover, activities such as

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poaching can also be detected with drone technology as well, eliminating the reduction in the population by hunting to the smallest extent [13]. Second, there is a programmed called Plastic Pollution Free Galapagos that has already been carried out. This program simply focuses on mitigate plastic pollution through the means of education and scientific research [14]. Considering the huge impact of plastic pollution on the ocean as well as Galapagos penguins that live there, this program is more than needed in support of the conservation. Although there is plenty of existing conservation strategies, it can be seen that our recent approaches mainly focus on mitigation rather adaption. If problems like climate change and plastic pollution cannot be mitigated or solved, we still need to find our way out of it. Therefore, conservation strategies that focus more on adaptation can be the future focus of the conservation of species including Galapagos penguins. Possible future conservation strategies focus more on adaptation instead of mitigation could include the following:

4.1. Creating representations and better manage the protected areas network

Under the threat of climate change, the biggest challenge may be that the environment which used to be suitable for survival of some creatures are no more a good place to live because of the change of temperature, precipitation, etc. As a result, we are currently in a need to have protected area with distinct features. As we have protected areas with a wide variety of landforms, such as wetlands and coastal areas for example, with those protected areas, we are at least able to support ecosystem that particularly thrive only in those special environments. This is the way representation in protected area network can be created. In addition, replication of one protected area should also be created. Replication generally refers to the situation where we protect "multiple examples of each ecosystem types", so that we can have higher chance of keeping a copy of each type of ecosystems in the future [15].

4.2. Relocation of animals, or assisted migration

This method theoretically can only be used when the species is surely at the brink of extinction. This is not only due to the fact that once we decide to relocate the species, we usually tend to move the whole population of the species to serve our purpose of reviving the species, but also because of the danger this action will bring to the local ecosystem where the species is emigrated. An ethical question has been raised at this point. To move it or loss it? The influence of the relocation will bring on the local ecosystem is usually uncertain before the action has been taken. Are we going to save one species from extinction by putting other species at risk? This is a problem that should always be considered before the assisted migration takes place. Questions like when to move, where to move, how to move, how to release, whether temporary captivity is required are also something that researchers may want to think about [16]. These questions are especially important to endemic species such as Galapagos penguins, since they only distribute on Galapagos Islands, a relatively isolated environment from the rest of the world. The possible reaction between Galapagos penguins and other animals if the penguins are really relocated definitely needs deeper and more thorough considerations. Overall, even though assisted migration sounds like a very adventurous approach as one possible conservation strategy to protect Galapagos penguins, the chance of implementing this approach or at least taking it into our consideration remains very high, given that the world now is under a highly uncertain condition—in other words, under the condition of climate change.

4.3. Creating artificial nests

In addition, providing artificial nests for Galapagos penguins may also be something we want to consider. According to what have been introduced earlier, nest building is extremely important for the reproduction of Galapagos penguins. Their identity as opportunists ensures that they will only choose to reproduce when all the resources, include but not limited to nests and food, are all available to make sure the survival of their chicks. Therefore, providing man-made nest for the Galapagos penguins may also be a good place to start. With artificial nests provided, Galapagos penguins do not need to look for extra resources, and when as the expense of preparing for mating and reproduction is lowered, it is expected that there should be an increase in the production rate. Since Galapagos penguins normally

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resides in caves made of rocks with things to keep warmth like grass inside the caves. In this case, the nests prepared by human may not cause unnecessary influence on the environment given that the nesting sites of Galapagos penguins are naturally quite isolated and do not require many materials. Indeed, this approach has already been put in action, and evidence have shown that some penguins in the wild have started to use those artificial nests already [17]. Our future steps are to extend on this existing approach to see if this approach suits the local environment and gradually generalize the method to a wider population of Galapagos penguins.

5. Conclusion

At the very last, if we eventually find that we have nothing to do with the situation, chances are, animals such as Galapagos penguins can evolve and adapt the environment with new conditions after climate change. At the time we start to consider things like this, other related questions naturally pop in. Can we consider climate change as a sort of natural selection to some extent? What if climate change is inevitable process of which all creatures that cannot adapt to the rapid changes will be wiped out and eventually give the earth a chance to recover from the over-whelming number of creatures that it can support no more? This is not being pessimistic; instead, we are being objective. Tons of unsolvable questions are waiting to be discussed in a possible future, the future where climate change cannot be mitigated, or even adapted.

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