

Examiner's commentary

The candidate travelled to participate on research activities with an environmental organization and the field work was done together with other scientists with a clear “hands on” approach from the student. In the description of the methodology the involvement and engagement of the candidate during the collection of data in the field is evident. The candidate applies the systems approach to study the relationship among different species, and the sources used in the essay are appropriate and academically reliable. The data collected allowed relevant analysis and discussion of the research to be carried out. The conclusions to individual questions of the analysis are effectively supported by the evidence. However, the evaluation of the research is limited. One of the strengths of this essay is the exploration of an environmental topic of interest to the candidate integrating theoretical context with field work.

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The Effects of Overfishing on the
African Penguin Population in South Africa

Research Question: To what extent is overfishing the main cause for
the decline of the African Penguin population in South Africa (March-August 2018)

International Baccalaureate Extended Essay

Area of Study: Environmental Systems and Societies

May 2019

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Introduction:

The African Penguin (previously known as the ‘Jackass Penguin’) is the only penguin species found on the African continent. It is commonly found along the coast of South Africa and across Robben Island. Since the 1900’s, the African Penguins population has been in decline. This is because of how they were treated during the 20th century; explorers would steal their eggs to use as food and hunt them for sport. Over this time, the African Penguin population had decreased from over 2 million to less than 40,000 total members of the species alive today (Koenig 1). This makes their population less than 10% of what it was previously, and why the African Penguin species is classified as endangered.

To better understand what is causing the decline of the African Penguin population, I travelled to Robben Island, which is off the coast of Cape Town, South Africa. Robben Island is home to a protected African Penguin colony. The colony itself is off-limits to everyone except researchers and assistants collecting data on the penguins of the colony. The research on the penguins is conducted to monitor and discover trends in the Robben Island penguin colony, which is what I did with the Earthwatch organization. Over the course of 2 weeks, I stayed on the island to perform data collection, with one example being chick condition monitoring. By measuring the chicks head length and total weight, it can be predicted quite accurately if the chick will survive into adulthood. This is a method that has been tested and shown to be effective. It also determines the quality of the fish in the water. Chicks are predicted to not survive to adulthood if their head measurement and weight fall below a certain trend line on the chick condition graph, and this will happen if they aren’t getting fed quality fish or enough fish in general. Therefore, overfishing in the waters could potentially have a negative effect on the African Penguin population, which is why I’m researching the question “To what extent is

overfishing the main cause for the decline of the African Penguin population on Robben Island, South Africa in 2018 between March and August?”

Background:

The wildlife of Robben Island has had a tough history since as long as humans have been visiting it. Many species have been eradicated from the island entirely, such as the Ostrich, Cattle Egret, and the Bontebok (Crawford 11), and many others are endangered, such as the African Black Oystercatcher, and of course the African Penguin (Crawford 7). The main cause for the decline of the African Penguin in the start of the 20th century can be attributed to over-exploitation of the birds' eggs for consumption, along with harvesting their guano for fertilizer, which degraded their habitats over time (Crawford 7). This caused the population of the African Penguins to drop from about 2 million to less than 40,000, which is less than 10% of what it was originally (Koenig 1).

During the summer of 2018, I travelled to Robben Island to help the researchers in the Earthwatch Organization with the data collection of the African Penguin colony there. Experiencing the wildlife on Robben Island first-hand was fascinating. Studying the penguins and interacting with them let me see for myself how important these animals are and how they're in danger of being lost forever.

Today, the African Penguins face different problems that threaten their survival. One is predation by Cape Fur Seals. Cape Fur Seals have been recently observed hunting and killing African Penguins and other sea birds just to eat the fish out of their stomach (Nasutus). This is a growing problem as this behavior isn't normal for Cape Fur Seals. Some of the mother seals are seen teaching their male pups to hunt the penguins only for their stomach contents due to the

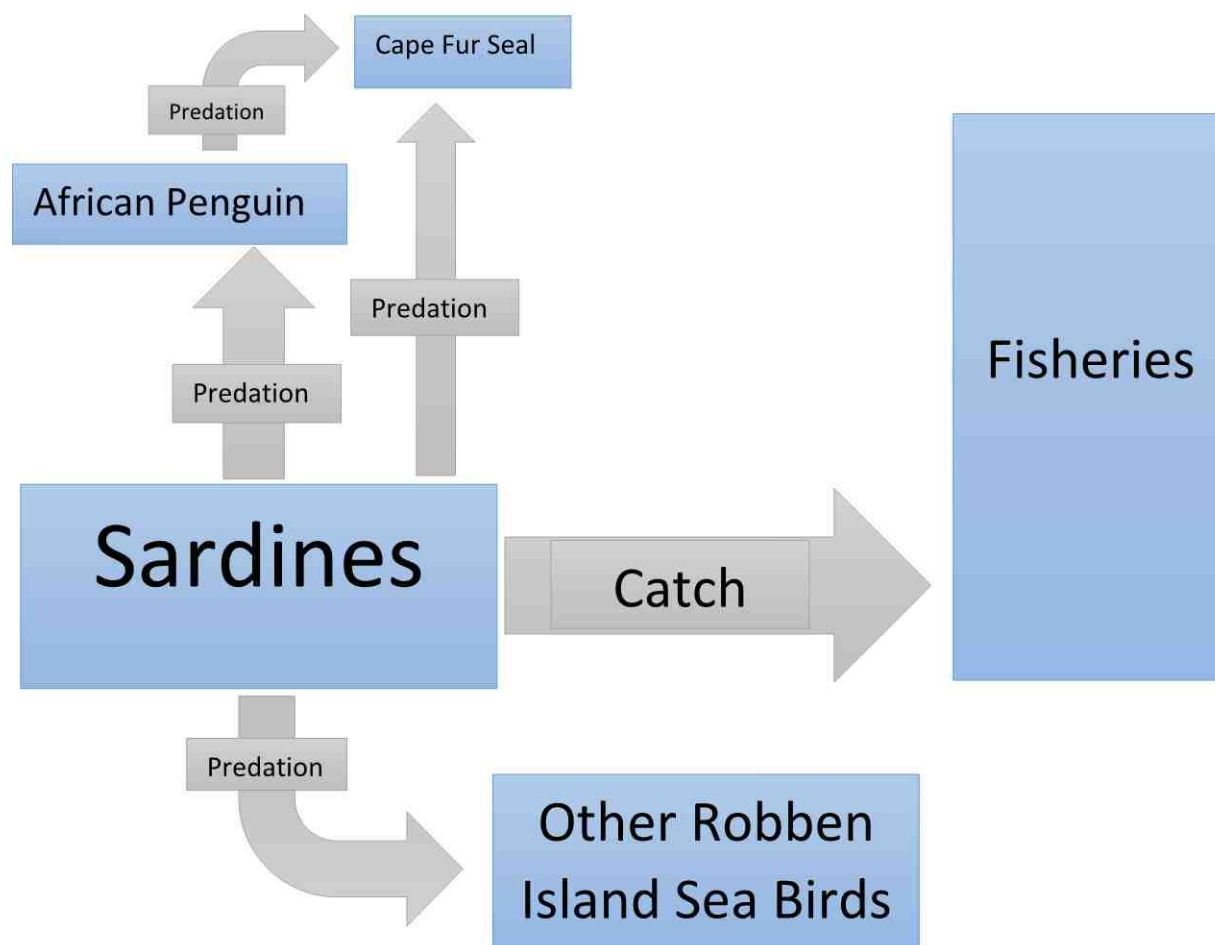
seals not having enough to eat themselves from fisheries overfishing (Nasutus). This unusual behavior is threatening the African coastal ecosystem as many bird species are facing a new threat they haven't had to before, and the seals are the reason many African sea bird species are facing endangerment. The seals that are seen exhibiting this behavior are being hunted in an attempt to end this unusual behavior and protect the seabird life of South Africa.

Another factor contributing to the decline of the African Penguin population today is overfishing due to fisheries. The overfishing makes it harder for penguins to find quality fish to feed themselves and their chicks. This is the topic that will be further explored in this extended essay. When the penguins can't find enough fish to eat, they may stay out in the ocean longer which takes more energy, or they may not be able to feed their chicks/themselves. This can lead to increased starvation or death in the population. The Earthwatch Organization uses the data they find to argue against the fisheries and try to stop them from overfishing in the waters where the penguins hunt their food, but the fisheries don't always cooperate, unfortunately.

When the MV Apollo Sea sank near Cape Town in 1994, oil was released into the surrounding waters, which effected the local wildlife. Seabirds, like the penguins, got the oil in their feathers which gave them an increased risk of ingesting the toxic oil when preening themselves (Crawford 7), and also made it harder for them to retain body heat. In extreme cases, this caused penguins to die of hypothermia (Crawford 7). Other forms of pollution, such as plastic waste in the ocean, can get lodged in penguins throats and kill them. Additionally, the toxic plastic can kill the penguins upon consumption. The oil and plastics also kill the penguins' food source, which is yet another negative impact from these sources, as it further limits the available food supply for the African Penguins and other seabird species.

A recurring problem on Robben Island is the Fallow Deer becoming overpopulated. When this happens, they eat a vast majority of the low leaves on the bushes, and the government has to issue a cull on the fallow deer to reduce their numbers and prevent this, as they have no natural predators on the island. These bushes are where the penguins sometimes make their nests, and when the deer eat these leaves, it leaves those penguins exposed. It is unknown whether or not this has a negative impact on the penguins' survival chances currently, as the penguins of Robben Island are protected against hunting and they are without any land predators.

Below is a diagram detailing the relationship between the various species (and fisheries) on Robben Island.



One way to help raise the African Penguin population would be to prevent fishing directly around penguin islands and colonies (Braun). It's hard for researchers to point to a single cause for the African Penguin population decline, but the greatest assumption so far is that the penguins are struggling to find enough sardines and anchovies due to overfishing. This population decline hasn't stopped since the 20th century, and unless immediate action is taken by the South African government and conservationists, it is unclear whether it will ever stop until it is too late for the population to recover.

In South Africa, the bird flu is being transmitted among seabirds, and the African Penguins are the most effected. Birds that contract the bird flu have a very low chance of survival, as they have no previous exposure or defense to it. The dead bird carcasses also transmit the disease rapidly, so these penguins must be buried once dead to attempt to limit further infection. Any tools that came into contact with penguin nests were cleaned during the Earthwatch project, as to not further spread the bird flu to other parts of the island, and when taking chick measurements, all tools were cleaned before and after use when they came into contact with chicks.

Penguin chicks have different stages of adolescence. Earthwatch uses a categorization scale to differentiate between these different stages when keeping data. The scale ranges from P0 to P4. A chick that is P0 is one that has just hatched and its eyes aren't open yet. P1 means the chick is still small and fluffy, and its eyes are now open. When a chick is P2, it is big and fluffy, but has not begun molting yet. A chick that is P3 means it has begun molting its fluff and therefore patches of blue sleek feathers are showing. Also during this time, these chicks will begin to fight back harder when necessary. A chick that is P4 has molted all of its fluffy feathers and now has only blue shiny feathers. It may also be referred to as a 'juvenile'. At this stage, the

parents will stop feeding the penguin and also stop returning to the nest, so the P4's have to go out to sea and learn to hunt fish themselves once they get hungry enough. When measuring chicks for data collection, the minimum head size of a chick was 70mm. If a chick's head length measured less than this, then its measurements were scrapped because the chick was too small. This means that P0's would not be tested and P1's would very rarely be measured. Chick condition data was often collected on P2's, P3's, and P4's, as they would always meet this requirement.

Method of Investigation:

My investigation of the research question was held in the following ways:

1. Secondary data was collected from various books gathered from the Earthwatch researchers on Robben Island directly related to the research question, alongside credible websites on the Robben Island environment.
2. Data was collected directly from the African Penguin chicks on Robben Island by joining the research team and working with the chicks and tools to obtain the necessary data, along with other data to benefit the research team.
3. The chick condition data for the two months of March and August was analyzed in accordance with the research previously published in 2014 by Lubbe and his chick condition index outlined within his research paper. This analysis was performed to provide a credible answer to the research question and further understanding on the cause of the African Penguin population decline.

The research project was carried out to help investigate the quality of fish for the months of March and August in the waters surrounding Robben Island, South Africa, and therefore help determine whether overfishing was a main cause for the current population decline in that time frame. Information was also collected from credible websites and books on the subject.

Materials:

- Clean Towel
- Hanging Scale (kg)
- Calipers
- Apron
- Cleaning solution soaked towels
- 15 drawstring bags
- Knee pads (optional)
- Pen
- GPS with coordinates
- Paper with data table

Procedure for Data Collection:

1. On Robben Island, find a location in the African Penguin colony where the penguins and their chicks have not been disturbed by humans too much before proceeding further. Disturbing the penguins too much may cause too much stress on the penguins, so this must be avoided.

2. Lay down a towel and place all listed materials around towel to prepare for measuring the chicks. Make sure all tools are clean before using them around chicks such as the calipers and apron. These two materials need to be cleaned after all chicks in one nest are measured.
3. Find a nest with penguin chicks and make note of the GPS value on the data table. Only the last three digits of the South and East reading need to be recorded. A nest with chicks will usually have 1 or 2 chicks. If there is more than 2 chicks in a nest, then the chicks are creching. These chicks can still be tested, but it may be harder to retrieve them from the nest as they will likely run away rather than stay in the nest.
4. Reach into the penguin nest and grab the chicks by the flipper. Turn the penguins head towards you and now grab both flippers while pulling the chick out of the nest towards you. The flippers are strong and can handle a lot of force, so there is little risk of breaking the flipper. (Note: If the adult penguin is in the nest, it will need to be pushed aside in order to grab the chicks. The adult penguin can and will crush a finger in its beak, but pushing it aside with a stick is enough to keep it away).
5. Hold the penguin chick with one hand on its back and one hand under its belly with feet supported to best prevent the chick from breaking free or fighting back, and point the back end away from your body. Bring the chick back to the towel in this manner and put on the apron to prevent getting guano on you.
6. Hold the chick securely, as it will try to break free and run back to its nest. It may help to have one person hold the chick while another performs the measurements with the calipers. When chick has calmed down, feel for the back of the chick's head where there is a crest. Place one end of the calipers on that crest and the other end to the tip of the

chick's beak. Keep calipers tight, but not so tight that the chicks head is being squeezed, and record the measurement. Do this twice and take the average of the two measurements (Note: If the measurements average to below 70mm length, then return the chick to the nest and scrap the collected data for that chick) Also, determine if the chick is P1, P2, P3, or P4 and record on the data table.

7. Open a drawstring bag and place the chick inside, feet first if possible. Hang bag from the hanging scale and wait for the chick to stop struggling inside the bag to take reading. Record the weight (kg) of the chick before removing it from the bag to return it to its nest. The same drawstring bag can be used for chicks in the same nest, but a new bag must be used for different nests, to prevent the spread of the bird flu as best as possible
8. Repeat steps 4-7 for any other chicks in the same nest.
9. Clean all instruments that came into contact with the chick. This would include the calipers and the apron, along with any hands that came into contact with the chick. The bag used for weighing the chick can be put aside for cleaning later. New bags must be used when measuring chicks from different nests.
10. Locate a new penguin nest with chicks and repeat steps 3-9 until about 15 to 20 chicks in total have been tested. The towel and materials can be moved if necessary to get closer to the next nest.
11. Once all chicks have been measured, make sure to thoroughly clean all equipment used with the towels soaked in cleaning solution.

Raw Data:

Data table for chicks measured in March 2018:

Chick size	Head1 (mm)	Head2 (mm)	Weight (Kg)	Head Average (mm)	Weight Average (gm)
P2	88.5	87.9	1.37	88.2	1370
P2	85.4	84.5	1.24	84.95	1240
P2	87.2	86.8	1.14	87	1140
P3	92.4	91.5	1.55	91.95	1550
P3	98.8	98.8	2.36	98.8	2360
P3	105.2	105.3	2.36	105.25	2360
P2	81.4	80.5	1.01	80.95	1010
P2	82	82	0.94	82	940
P4	111.1	111.2	2.57	111.15	2570
P4	117.5	115.8	2.81	116.65	2810
P3	115	116.2	2.24	115.6	2240
P3	95.9	96.2	1.99	96.05	1990
P3	102.6	103	2.18	102.8	2180
P3	114.1	115	2.26	114.55	2260
P3	110	110.8	2.73	110.4	2730
P2	84.2	82.6	1.17	83.4	1170
P2	85.9	84.9	1.62	85.4	1620
P2	96	96	1.76	96	1760
P2	97.3	97.4	1.64	97.35	1640
P2	88.1	87.4	1.37	87.75	1370
P3	95	95.5	1.88	95.25	1880
P1	70.5	71.2	0.74	70.85	740
P2	86.5	87.2	1.36	86.85	1360
P3	105.8	104.7	2.1	105.25	2100
P3	104.2	103.4	2.18	103.8	2180
P3	104.4	103.9	2.31	104.15	2310
P2	80.6	79.4	1.06	80	1060

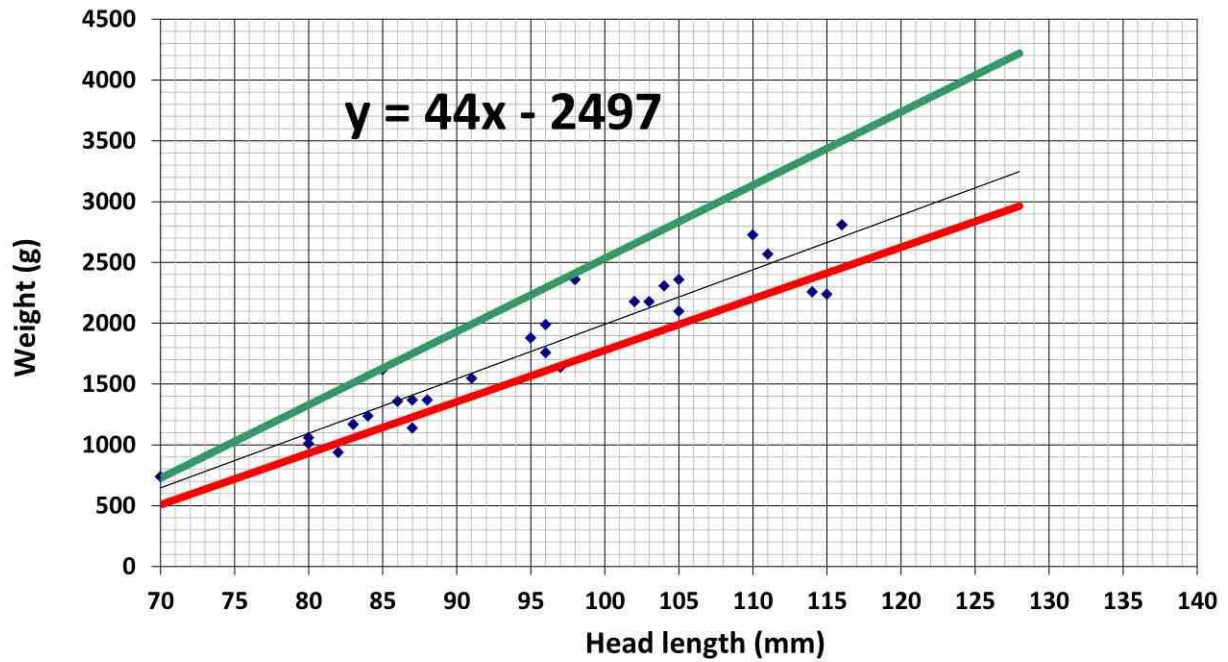
Data table for chicks measured in August 2018:

Chick size	Head1 (mm)	Head2 (mm)	Weight (Kg)	Head Average (mm)	Weight Average (gm)
P2	87	83	1.32	85	1320
P2	92.1	92	1.49	92.05	1490
P3	105.7	105.4	2.35	105.55	2350
P2	92.7	92	1.6	92.35	1600
P3	97	97	1.8	97	1800
P4	115.5	115.4	2.65	115.45	2650
P4	113.4	112.5	2.67	112.95	2670
P4	117.1	117.3	3.16	117.2	3160
P4	115.3	116.7	2.87	116	2870
P3	101.9	100.8	2.39	101.35	2390
P4	104.8	105.3	2.26	105.05	2260
P4	104.7	104.7	2.26	104.7	2260
P4	106.8	108.8	2.84	107.8	2840
P3	104.6	104.6	2.19	104.6	2190
P2	92.4	91.8	1.46	92.1	1460
P2	102.3	101.9	2.42	102.1	2420
P2	70.6	70.9	0.74	70.75	740
P2	74.1	73.4	0.8	73.75	800
P2	79.7	79.4	1.34	79.55	1340
P2	89.3	88.3	1.58	88.8	1580
P3	110	109.7	2.33	109.85	2330
P4	114.5	114.9	3.1	114.7	3100
P3	101.7	102.3	2.35	102	2350
P2	98.6	98.3	2.18	98.45	2180
P2	98.9	100	2.37	99.45	2370
P4	111.2	110.2	2.65	110.7	2650
P2	102.2	102.8	2.15	102.5	2150
P3	105.6	107.4	2.65	106.5	2650
P2	94.4	93.6	1.5	94	1500
P2	92.5	92.7	1.69	92.6	1690

Investigation:

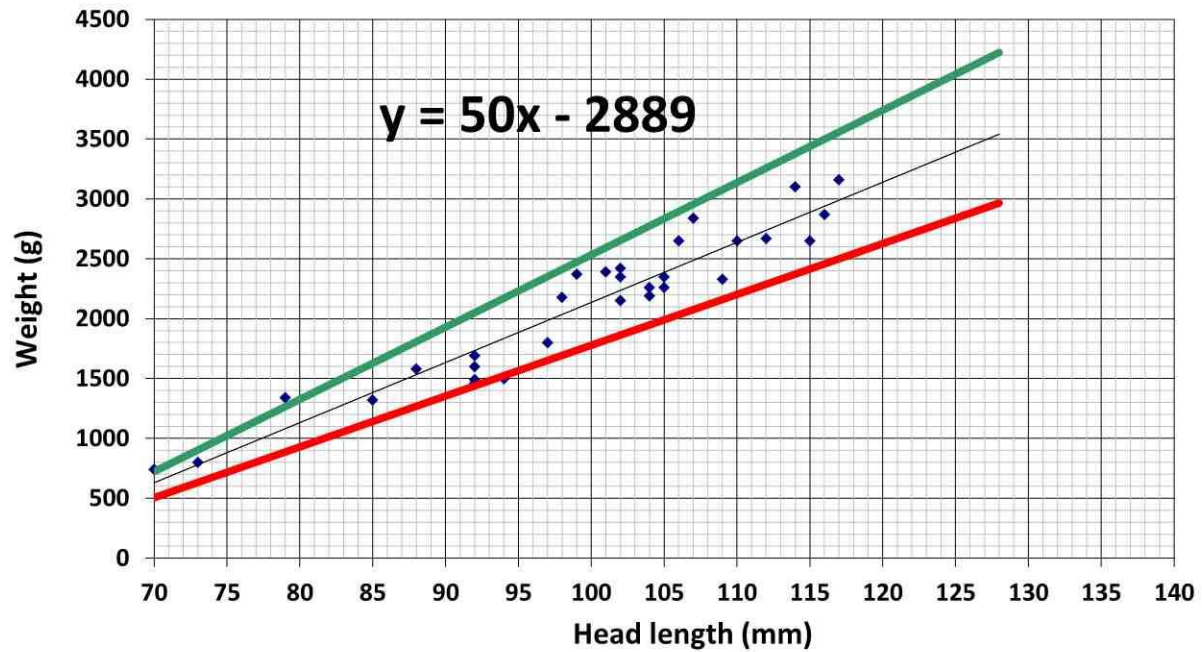
Chick condition data for March 2018 plotted onto a graph:

Chick Measurements

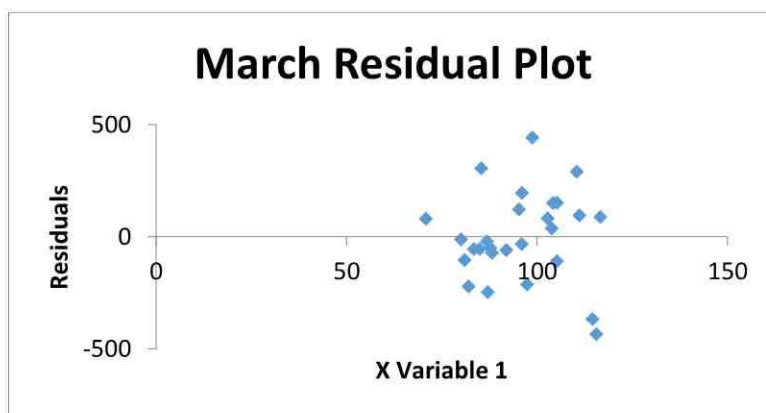


Chick condition data for August 2018 plotted onto a graph:

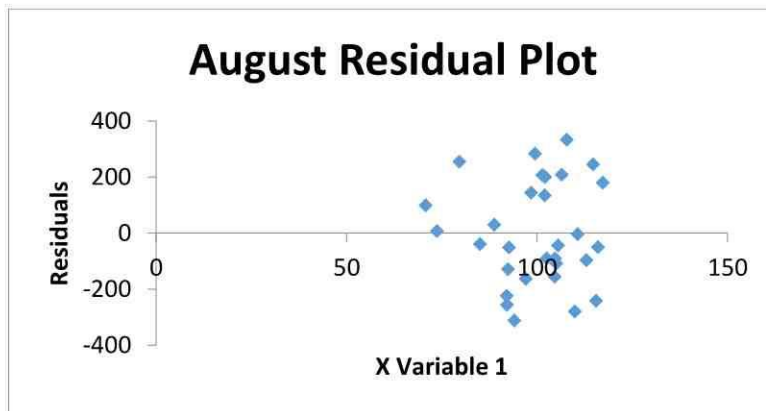
Chick Measurements



R Square (March) 0.88686



R Square (August) 0.915048



(Graphs and data handmade; not taken from a source)

In both of these graphs, the bottom line represents the 5th percentile, while the top line represents the 95th percentile. The data points on the graph represent the chicks and their measurements. Chicks whose data points fall below the red line means they aren't receiving enough food and aren't receiving proper nutrition. These chicks are projected to die before reaching adulthood. If chicks fall above the green line, then that means they are over fed and are fat. This doesn't necessarily mean they will die, but just that they are receiving too much food, which may be a benefit for survival. In this way, this data and chart gives information on the quality and quantity of fish that the penguins have available. This information is helpful as it can explain trends among the seabirds and be used to argue against the fisheries to stop overfishing in the oceans around the penguin colonies.

The chicks measured in March of 2018 had more chicks below the 5th percentile than the chicks measured in August of 2018. This means that in March, there was less fish available for the parents to feed the chicks in the ocean, due to overfishing by fisheries in the ocean. However, for both months the average for the penguin chicks fell between the two percentile lines which

shows there was likely enough fish in the ocean after all for the penguins in both months. If the averages were below the 5th percentile lines or very close, then that would reflect poor fish quality and that the penguins struggled to find enough food for their chicks. This data reflects that overfishing was most likely not a major cause of the decline of the African Penguin population.

From examining the residual plots for both months, a clear random pattern can be seen. For linear models, a random pattern indicates a good fit for the data. This is further supported by the r-squared values among the two sets of data. The r-squared value of 0.8868 for March and 0.9150 for August indicate a strong correlation between the two variables for the two data sets. Because of these two high r-squared values, it would be appropriate to use the line of best fit equation (shown on graph) for predicting weights based on beak measurements, as it would yield accurate and reliable results. Additionally, by observing the lines of best fit on each graph, it is clear that the data points fall between the two lines for determining the survival chance of penguin chicks. This is reassuring for the chicks, as it means the quality and quantity of the fish in the waters around Robben Island are at sufficient levels for sustaining the penguin colony.

Limitations:

For my experiment, there are a few limitations with data collection. We were only able to weigh the chicks with the hanging scale one time because of the great amount of stress the chicks went under when being weighed. Also, the penguin's heads are only able to be measured twice for this same reason. It would be ideal to take more measurements from each chick for more accurate data.

Conclusion:

The quality and quantity of the fish in the waters around Cape Town and Robben Island is very important to the ecosystem; there are countless water bird species that hunt in these

waters and depend on this source of food for survival. Using methods like measuring the penguin chicks is important to determine if there is enough healthy fish for the penguins, which also gives information about the quantity of fish available for the other species of bird. If the quantity of fish available was insufficient for the survival of the penguins and other bird species, it could be used to argue with the fisheries to not catch as many fish to allow enough for the birds.

The African Penguin population may never recover to their past population numbers, because there are just too many limiting factors for the African Penguin population as it is today. Before the African Penguins can begin to recover their population, these factors need to be addressed, which would require action from many people, perhaps the South African government even. For the months of March and August 2018, the data collected shows that overfishing does not seem to be a major cause of the African Penguin population decline. This would mean that there are other major threats to the African Penguins that need to be examined and understood further.

The African Penguins are an important part of the Robben Island and South African ecosystem. They provide food for predators on the African continent and they produce good fertilizer for the soil or human fertilizer products. Losing the African Penguin would greatly impact the African coastal ecosystem even more than it already has been. Thankfully, more and more people are spreading awareness for the trouble that the African Penguins are in which gives hope for the survival of the species. Hopefully more people will continue to recognize the importance of this valuable species over time.

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Candidate personal code: _____

Extended essay - Reflections on planning and progress form

Candidate: This form is to be completed by the candidate during the course and completion of their EE. This document records reflections on your planning and progress, and the nature of your discussions with your supervisor. You must undertake three formal reflection sessions with your supervisor: The first formal reflection session should focus on your initial ideas and how you plan to undertake your research; the interim reflection session is once a significant amount of your research has been completed, and the final session will be in the form of a viva voce once you have completed and handed in your EE. This document acts as a record in supporting the authenticity of your work. The three reflections combined must amount to no more than 500 words.

The completion of this form is a mandatory requirement of the EE for first assessment May 2018. It must be submitted together with the completed EE for assessment under Criterion E.

Supervisor: You must have three reflection sessions with each candidate, one early on in the process, an interim meeting and then the final viva voce. Other check-in sessions are permitted but do not need to be recorded on this sheet. After each reflection session candidates must record their reflections and as the supervisor you must sign and date this form.

First reflection session

Candidate comments:

The deadline of 1000 words seemed like a large task, but once I jumped into it, it wasn't hard at all. I could have done a bad job on these 1000 words, but I chose to do the best I could and I'm satisfied with what I produced. This will have saved me a lot of time in the future, as I can use what I typed easily in my Extended Essay. This assignment has made me more at ease about writing the complete extended essay. Now the Extended Essay isn't as intimidating as it once was, and I'm confident I can produce quality work by the end of the summer.

Date:

Supervisor initial: _____

Interim reflection

Candidate comments:

Writing the extended essay was not as difficult as initially perceived. The first 1000 words in the first reflection helped me begin my extended essay a lot, and it made the next 2000-3000 even easier. While i still have work to do on my extended essay, it will be very easy to fix and finish it up before the final due date.

My first meeting with my supervisor gave me great insight on what work needs to be done on my extended essay before it is submitted to IB. The meeting was very helpful and gave me reassurance that I can submit quality work.

Date: 8/12/18

Supervisor initials

Final reflection - Viva voce

Candidate comments:

After the viva voce, I was sure that I would be able to submit an above passing EE with ease, and it also allowed me to reflect on my EE writing experience as a whole. The questions my supervisor posed to me made me consider my extended essay in ways I hadnt considered before and view my completed work in a whole new way. Once the viva voce was done, it was a weight lifted from me as the EE was no longer a concern.

Date: 1/7/19

Supervisor initials