Simulation Assignment Analysis

Introduction

The aim of this analysis is to investigate which fishing regulations would be most beneficial for the purpose of sustainable fishing. The two methods considered were: adding fishing bans when fish populations were too low, and opting for seasonal fishing in order to allow populations to replenish.

1. The Fish

In order to assess how the fish population would react if there was no fishing: the model was run 10 times with only fish – 33 yellow fish, 66 red fish and 100 green fish – in order to see how the initial number of fish would affect the populations ability to regenerate. The graphs to the right show the fish population over the year for each species, with the grey lines being the individual runs and the thicker colored line being the average of the runs. Figure 1 shows the fish population over a year with the death rate and reproduction rate set at 0.3. This led to the populations on average remaining fairly stable throughout the year. The model was then run with death rate at 0.35 and reproduction rate at 0.4, this led to an increasing population, with the larger starting populations increasing at a faster rate.

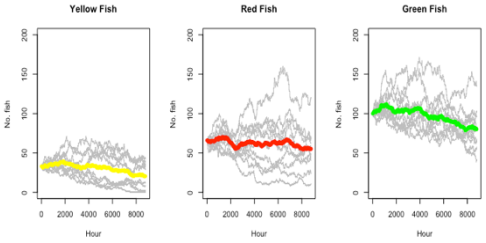

Figure 1: Stable fish populations over the year

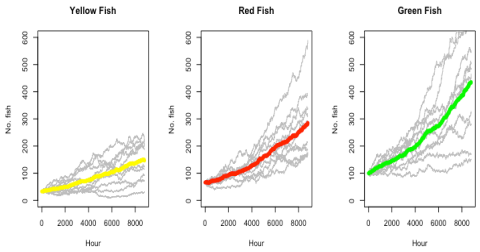

Figure 2: Increasing fish population over the year

For the rest of the analysis, it is assumed that there is an increasing fish population, and so the death rate was set at 0.35 and the reproduction rate at 0.4. The initial fish populations are assumed to all be 100.

In order to test how the suggested regulation implementations would affect the fish populations, with there being an array of fishing methods utilized, the remainder of the simulations were set to have 1 red hook-and-line, 1 green purse-seine, 1 yellow purse-seine, and 1 trawler, all with a net size of 15 meters. The model was run on a small area of sea, the effects of overfishing would therefore be exaggerated, however, the simulations allow us to visualize the effectiveness of the regulation implementations.

2. No Regulations

A base case for the comparison, with no regulations, was implemented. This led to all fish populations being depleted within the first 6 months, with an exception of a few red fish in some of the model runs as can be seen in Figure 3.

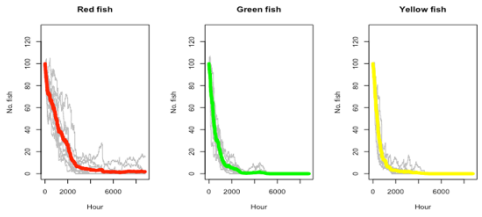

Figure 3: Fish population over the year

The average number of fish caught over the year was 116.8 for red, 107.2 for green and 106.4 for yellow. Hook-and-line caught the least amount of fish on average being 38.8; the two purse-seine vessels caught the most fish on average being 165.6, with 6.22% of it being bycatch; the trawler caught on average 126 fish, with 76.19% of it being bycatch. The conclusion is that with no implemented regulations, this model would be unsustainable.

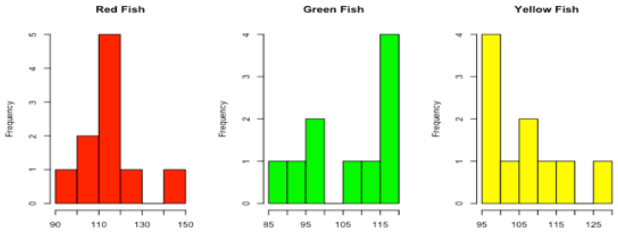

Figure 4: Histograms of fish available at the end of the

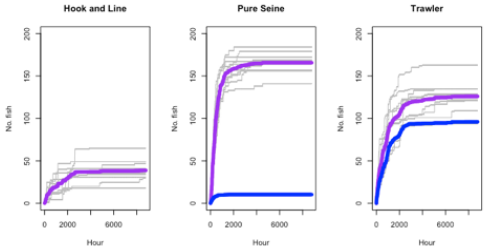

Figure 5: Number of fish caught per fishing method

3. Fishing Bans

The simulation was rerun with the addition of fishing bans, meaning, fishing of specific species was banned if the population dropped below 50 fish. Fishing was then permitted if the specie's population had regenerated and grown above 80. As can be seen in figure 6 this led to fish being caught throughout the year, with their being steps in the number of fish being caught which indicates the time periods in which fishing bans were implemented.

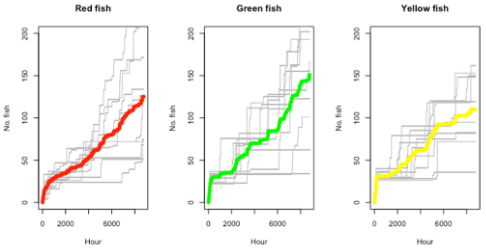

Figure 6: Number of fish caught

This led to the fish populations remaining fairly stable over the year, with a good number of fish remaining at the end of year 1: 105 red fish, 69 green fish and 75 yellow fish. This population would then allow for a similar fishing season the following year, and shows that the implementation of fishing bans is greatly beneficial to the sustainability of the fish populations.

The average number of fish caught over the year was 125.3 for red, 151.1 for green and 110 for yellow. Hook-and-line caught on average 106.9 fish; the two purse-seine vessels caught the most fish on average being 242.8, with 8.2% of it being bycatch; and the trawler caught the least amount of fish on average being 36.7 fish, with 69.75% of it being bycatch.

This led to more fish being caught over the year, so not only did the fishing bans increase the sustainability of the fish populations but it also increased the long-term supply for fish being caught. In this simulation the trawlers caught the least amount of fish as they were banned if any species dropped below the regulation limit, because of this, the amount of bycatch was drastically reduced which further helps the sustainability.

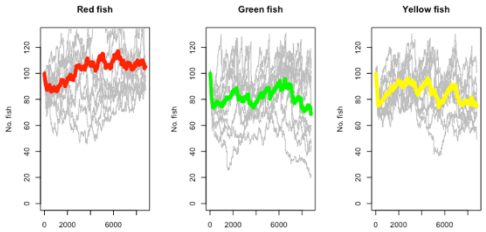

Figure 7: Fish populations over the year

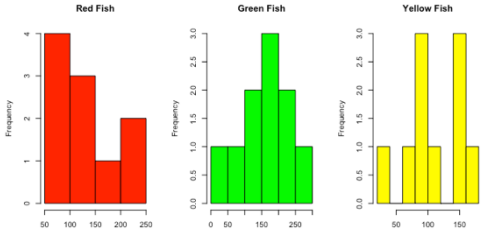

Figure 8: Histograms of fish available at the end of the year

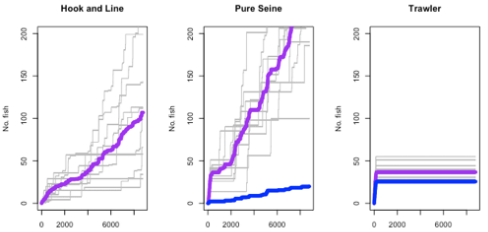

Figure 9: Number of fish caught per fishing method

4. Seasonal Fishing

The simulations fishing limitations were removed, and the model was rerun with the implementation of seasonal fishing, season 1 was for yellow fish, season 2 for red fish and season 3 for green fish. The hope being that between seasons the fish would have enough time to regenerate for their next fishing season. This typically led to the fish populations depleting during their respective fishing seasons. Figure 10 shows that all fish are caught during all seasons due to the trawler, however, the amount caught increased rapidly during the species season and causes the species population to become depleted.

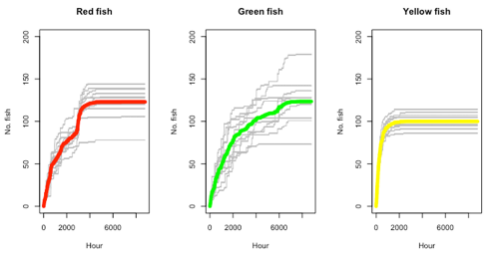

Figure 10: Number of fish caught

The average number of fish caught over the year was 123 for red, 123.5 for green and 100 for yellow. Hook-and-line caught the least amount of fish on average being 12.9; the two purse-seine vessels caught on average 115.8 fish, with 10.53% of it being bycatch; and the trawler caught on average 217.8 fish, with 87.1% of it being bycatch. This simulation was therefore unsustainable as there was no fish remaining at the end of the year, furthermore, with most of the fish being caught by the trawler there was an extremely large amount of bycatch. Fishing seasonally also did not increase the amount of fish caught too drastically.

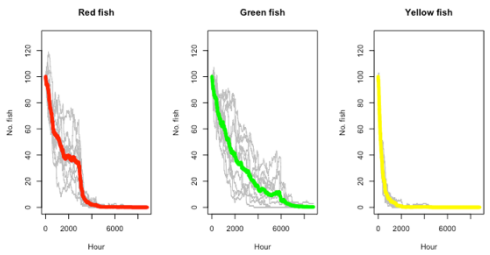

Figure 12: Fish populations over the year

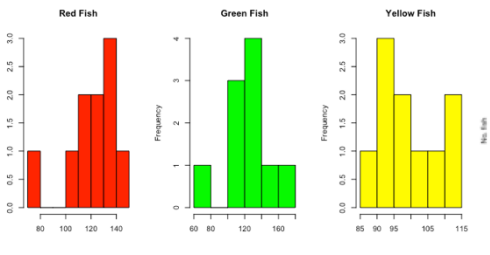

Figure 11: Histograms of fish available at the end of the year

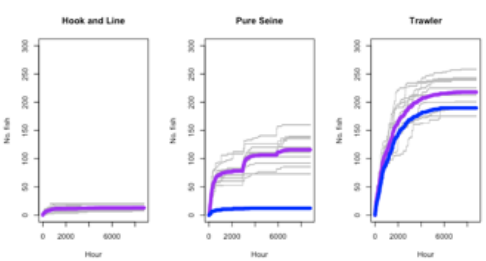

Figure 13: Number of fish caught per fishing method

5. Fishing Bans And Seasonal Fishing

The model was rerun with the implementation of both the fishing bans and the seasonal fishing. The amount of each species being caught in their season increased rapidly as the season begins, and then increased gradually between bans as indicated by the visual steps in the number of fish caught. The amount of fish able to be caught increases as the seasons progress as the fish have had time to grow and so there is more fishing opportunity when the later seasons arise.

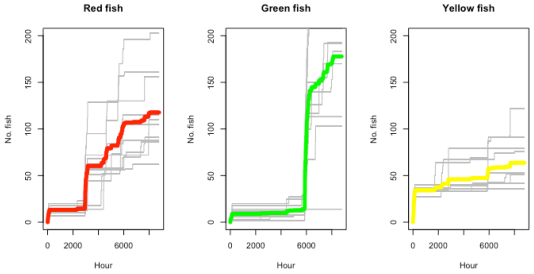

Figure 14: Number of fish caught

The average number of fish caught over the year was 117.7 for red, 177.8 for green and 63.8 for yellow. Hook-and-line caught the least amount of fish on average being 13.7; the two purse-seine vessels caught the most fish on average being 302.6, with 11.07% of it being bycatch; and the trawler caught on average 43 fish, with 78.6% of it being bycatch.

This simulation was **by far the most sustainable**, with reduced bycatch as a result of the reduction in trawler fishing and time allowed for the fish populations to replenish between seasons. The total number of fish at the end of the year included 134.5 red fish which had recovered from the previous season, 90 green fish giving them a good population to regenerate from, and 170 yellow fish which had regenerated well from the first season, ready for the start of their new fishing season in the new year.

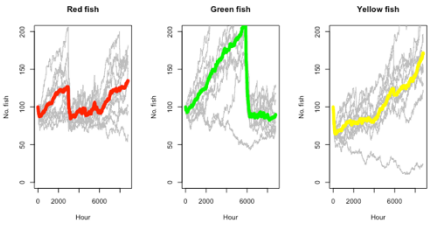

Figure 15: Fish populations over the year

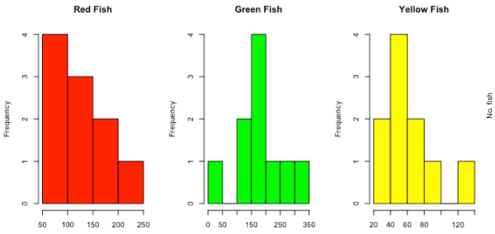

Figure 16: Histograms of fish available at the end of the year

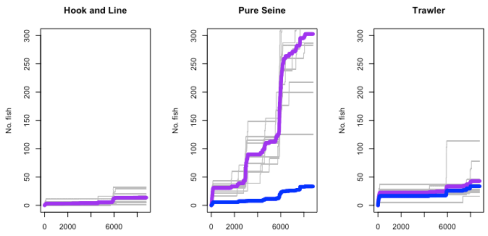

Figure 17: Number of fish caught per fishing method

Conclusion

Overall it is evident that fishing bans are necessary in order to provide fish species the opportunity to regenerate, if bans are not in place, fish populations would become low and struggle to grow back to a sustainable level. Although adding in seasonal fishing resulted in fewer fish being caught overall; it is the most beneficial having the greatest populous of fish remaining at the end of the year, this larger number of fish at the end of the year would typically lead to more fish being caught in the following years and so could be considered the best sustainable option overall.

	No Regulation	Fishing Bans	Seasonal Fishing	Bans & Seasonal
Red Fish Caught	116.8	125.3	123	117.7
Green Fish Caught	107.2	151.1	123.5	177.8
Yellow Fish Caught	106.4	110	100	63.8
Total Fish Caught	330.4	386.4	346.5	359.3
Red Fish Left	0	105	0	134.5
Green Fish Left	0	69	0	90
Yellow Fish Left	0	75	0	170
Total Fish Left	0	249	0	394.5
Hook-and-Line Caught	38.8	106.9	12.9	13.7
Purse-Seine Caught	165.6	242.8	115.8	302.6
Trawler Caught	126	36.7	217.8	43
Purse-Seine Bycatch	6.22%	8.2%	10.53%	11.07%
Trawler Bycatch	76.19%	69.75%	87.1%	78.6%