Name:____Date:__________________Period:___

Fisheries Management:

How Catch-Per-Unit-Effort Data Can Help a Community Conserve its Resources

Student Handout

To understand how to create a more sustainable fishery, you must first understand the population dynamics of the resource and the way in which the fishery functions in the first place.

The two videos below will help provide this context. Watch the short clips from each video and answer the questions below.

Fisher in Ancón Harbor
Image Credit: TNC

Watch the video "Fisheries Economics & Policy: Intro to Fisheries Management" (4:44)
https://www.youtube.com/watch?v=Z4AXnZOsrK8

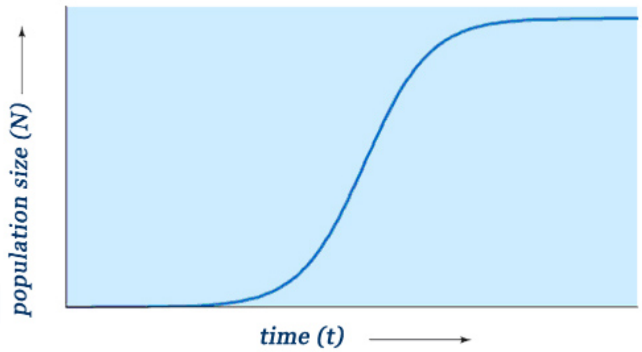
1. Describe the potential problems with common pool resources.

2. What does "open access" mean?

Watch from 0:00-3:05 of the video "Fisheries Economics & Policy: Maximum Economic Yield"
https://www.youtube.com/watch?v=7DNhqtYf47E

3. Explain the ways that fishing effort can increase.

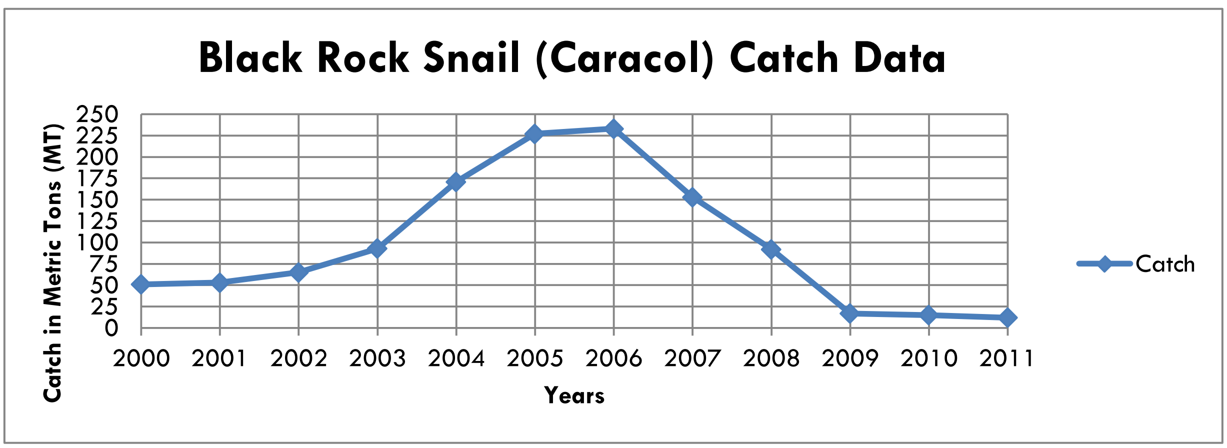
4. If fishing effort increases, but the catch stays the same, what does that indicate about the fish population?



Population Growth Over Time
Image Credit: Licensed under Public Domain via Wikipedia

5. Using the graph above for reference, give a basic description of how fish populations behave and include in your explanation how population size relates to the growth rate.

6. Describe how a population's carrying capacity can shift over time.



7. The graph above shows catch data for Black Rock Snails, which are harvested by benthic divers. Based on the amount of snails caught every year, describe what you think might be happening with the population.

8. What factors might influence the "catchability" of the snails? Do you think that the amount of snails caught directly correlates with the size of the population or might there be other factors and so what are they?

9. What more do we need to know in order to truly assess the snail population?

Catch vs. Catch Per Unit Effort (CPUE)

When you observed the trend in Black Rock Snail catch in question 7, you may have realized that you need more information than the amount of catch to truly understand the population, especially when the goal is to manage the fishery. The amount of a resource caught does not accurately reflect the population size.

To effectively manage a fishery, managers need to know how many fish are in a population at a given time. Fishery scientists use stock assessments to determine the abundance (number and size/age) of fish in a population. One of the simplest stock assessment methods requires almost no knowledge about the biology of the stock. However, good information about the fishery is required.

In this simple assessment, the fishery manager only needs to look at the **history of catch** for the stock and the **effort expended** to catch the seafood. The key word here is **effort**.

Catch data (the amount of fish caught per year) alone are not very useful. Catch can fluctuate for a variety of reasons. Some of those reasons include:

- the amount of hours spent fishing
- the weather
- the number of fishers
- the type of fishing gear used by the fishers

A trend of decreased catch may be a cause for concern, but the amount of effort made by fishermen to catch the stock helps tell the real story.

In order to account for effort, fishery biologists use the terminology catch-per-unit-effort (CPUE). To determine the CPUE, the catch is divided by the amount of effort expended to make the catch.

For example, if a fisher goes out on a boat for 2 hours and catches 10 chinook salmon weighing a total of 200 pounds, then the fisher's CPUE could be expressed as either 5 fish per hour (10 fish caught in 2 hours) or as 100 pounds per hour (200 pounds caught in 2 hours of fishing).

The catch-per-unit-effort is directly related to the amount of fish in the stock. While CPUE doesn't tell you how many fish are in the stock, it provides an index of abundance that can be easily compared from one year to the next. **A decline in CPUE usually indicates a decline in the stock. A decline in both CPUE and catch provides even more evidence for a decline in the stock.** Decreasing CPUE indicates less efficiency – or that more effort is needed relative to the quantity of catch. In contrast, a higher CPUE corresponds to greater efficiency.

A number of fisheries have followed a pattern in relation to the catch-per-unit effort. The following statements describe trends that occur over time **after a new fishery is established**:

- At the beginning of a new fishery, the catch-per-unit effort is high and the effort is low.
- As interest in catching fish grows, the effort increases, the catch increases and the catch-per unit effort usually levels off or declines.
- Finally, as more effort is applied, the catch declines and the catch-per-unit effort declines even more. When both the catch and the catch-per-unit effort decline, it is an indication that the stock is probably overfished. This means that too many fish are being removed before having the chance to reproduce. Catches decline despite increasing effort.

Additional factors that might increase or decrease catchability are as follows:

- Catchability often increases over time as the fishers improve their fishing gear and boats.
- The catchability of a species can be greatly affected when fishers change their targeting practice from one species to another. In general, catchability increases for the new target species, and decreases for the previous target species. However, if the new target species is the predator of the original target species, this could later have a positive effect on population size of the original target species (the prey) as the predator is removed by fishing.
- The environment can have a large influence on catchability. For example, El Niño/La Niña conditions can impact the availability of nutrients and food for fish stock. Additionally, warmer water temperatures caused by El Niño could push the fish stock into deeper, less accessible waters, making it harder to catch.
- The dynamics of a fish stock can also influence how catchability changes over time For example, fish that swim in large groups are fairly easy to catch, so CPUE might not necessarily decline until the population has totally crashed. Other fish that don't aggregate together will become scarcer and more difficult to catch.

10. What is CPUE? Why isn't information on catch alone enough to know the health of a fish stock?

11. Consider the information in the reading above and the equation for calculating CPUE. Describe some scenarios that might cause an increase or decrease in CPUE.

In this remainder of this activity, you will examine catch and CPUE data for the two species in the table below. The Lorna Drum is a demersal fish – in other words it lives in the water column close to the ocean floor. The Black Rock Snail is a benthic species – one that lives on the rocky bottoms of the ocean floor. The characteristics of these two organisms will be useful in answering the questions that follow.

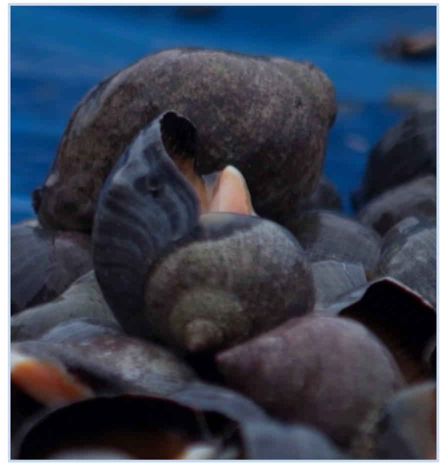
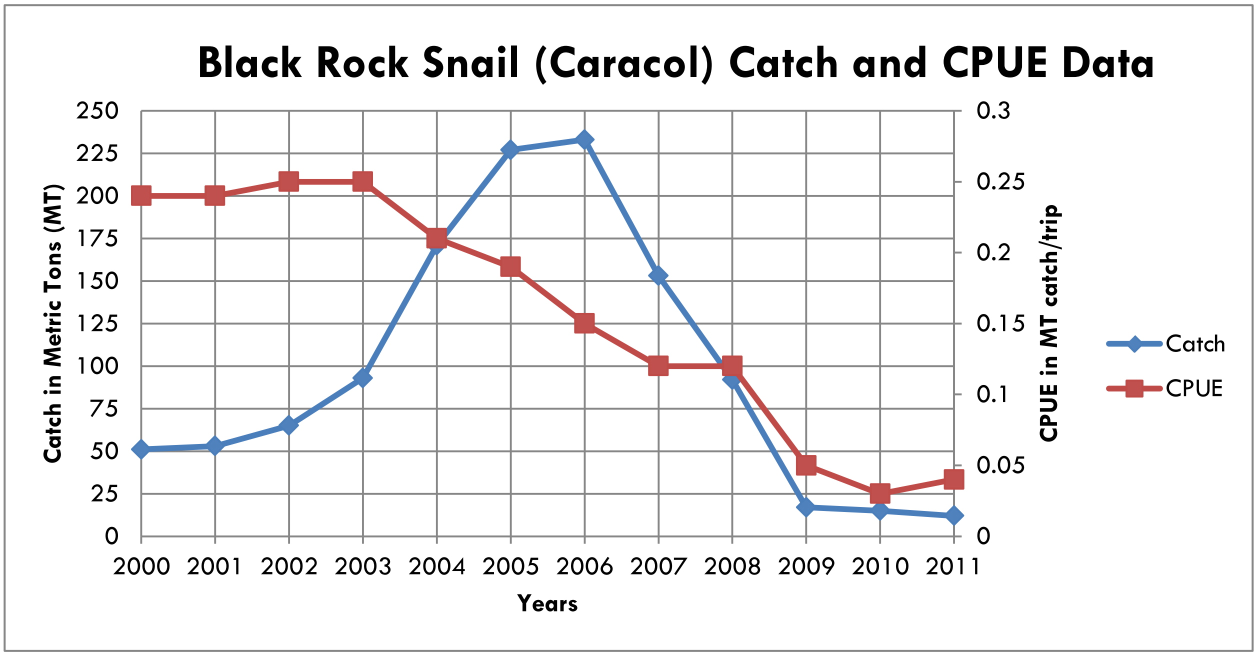


Image credits: Drum - Matias Caillaux and Snail - TNC

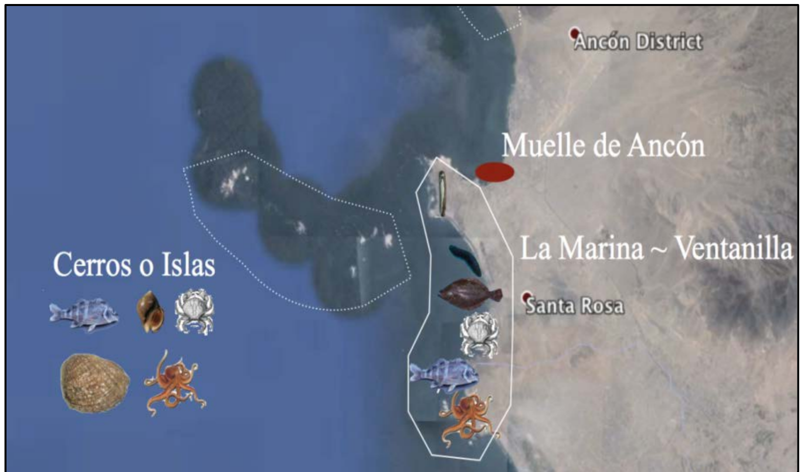
Common Name	**Lorna Drum**	**Black Rock Snail**
Latin Name	*Sciaena deliciosa*	*Thais chocolata*
Spanish Name	Lorna	Caracol
Habitat	Demersal, moves along the water column close to the ocean floor	Live on the ocean floor, mainly on rocky bottoms, does not move around a lot
Food	Feeds on benthic worms, gastropods, bivalves, and crustaceans (which eat phytoplankton)	Carnivorous snail - feeds on mussels, limpets, bivalves and other crustaceans
Fishing Gears Used	Purse seines, gill nets, hook and line	Compressor Diving (Huka), Free Diving



12. The graph above combines the catch data from question 7 with CPUE data for the same time period for the Black Rock Snail. Using the information in the graph above, describe the trend in **CPUE** for the black rock snail.

13. Based on what you know about the relationship between catch and CPUE, describe what you think is happening to this fishery and the health of the snail population.

Case Study: Ancón, Peru



The circled areas represent the fishing grounds around Ancón District Symbols indicate types of organisms caught in each area. Credit: TNC

The town of Ancón, located just north of Lima, Peru is home to approximately 300 fishers. Artisanal and small-scale fisheries are an important economic engine for coastal communities. They provide almost 80% of the seafood consumed in the country. More than 44,000 fishers are directly employed in this sector.

Despite the importance of the small-scale fisheries sector to the economy, very little information on the condition of stocks, levels of fishing effort, efficacy of management, or performance of the fishery is available. Other impediments to sustainability include weak governance, limited market access, and very low capacity for producing value-added products. These obstacles have led, in many instances, to overharvesting stocks and destructive fishing practices, resulting in poor outcomes for fishers and the environment.

For background on artisanal and small-scale fishing in Peru, view the short story map on the fishing community of the Ancón District found here: http://arcg.is/1l7wF5n and answer the question below.

14. Based on the information in the story map, describe the artisanal fishing sector and contrast it with the industrial sector.

In the activity that follows, you will play the role of a fisheries management specialist from a conservation organization. You are working with local fishers to combine their expertise with scientific data to determine how to make their fishery more sustainable. You will examine the population change over time of two species, the Lorna Drum and Black Rock Snail, which are important to the small-scale fishing community of Ancón.

From 2000-2011, you and the fishers have been collecting data on their fishing grounds. Your aim is to help them to make choices on how to collectively manage their fishing grounds so that they can continue to fish without their resources being depleted. Using your knowledge of catch and catch-per-unit-effort you will conduct a stock assessment and provide management suggestions. The two types of management strategies that the fishers are willing to experiment with are seasonal closure and catch limits.

The Effect of El Niño on a Fishery

There is one more factor that you must consider when making a stock assessment in this area. The waters off the coast are affected by El Niño, an abnormal weather pattern that is caused by the warming of the Pacific Ocean near the equator, off the coast of South America. Throughout the year, a northward cool current prevails because of southeast trade winds, causing upwelling of cool, nutrient-rich water. However, during late December the upwelling relaxes, causing warmer and nutrient-poor water to appear. The nutrient poor water leads to a reduction in phytoplankton, which is the base of the food chain in the Humboldt Current Ecosystem. An El Niño event may lead to fewer fish in the area, either because they die-off from lack of food or move to cooler waters out of the fishing area. In order to understand if an El Niño event is responsible for the population changes of the target species, you must first identify the years during our study period in which an El Niño occurred.

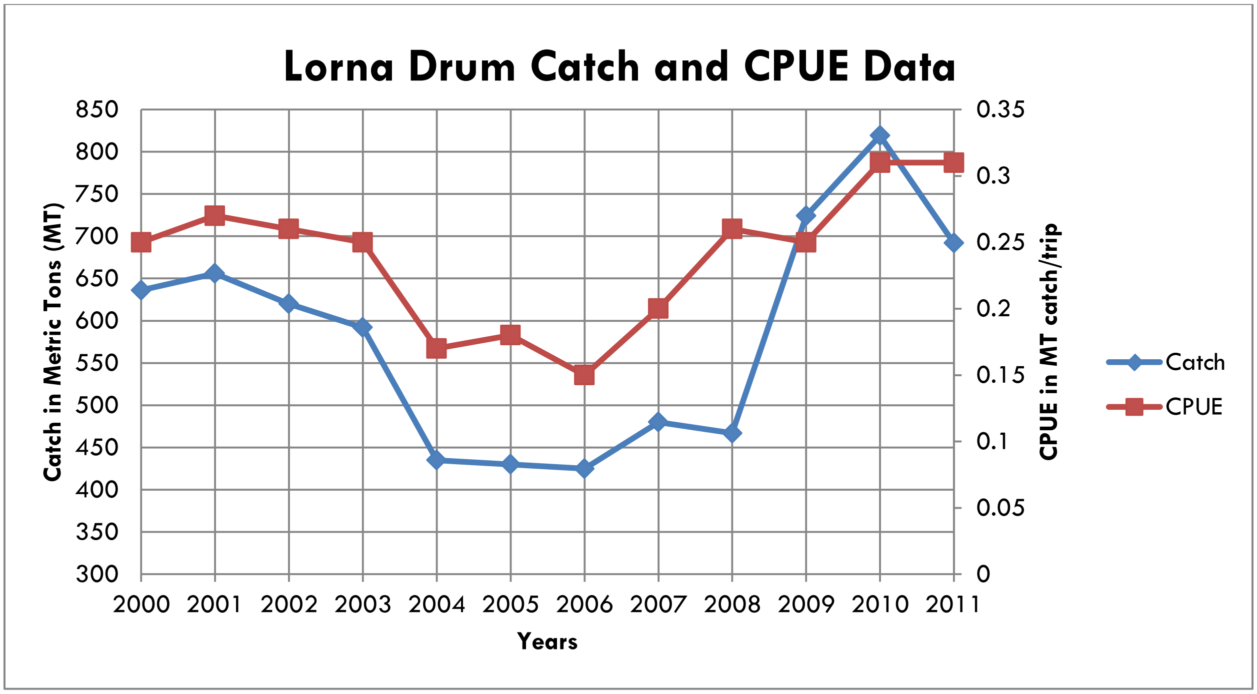
Scientists use the Oceanic Niño Index (ONI) to measure anomalies or deviations from normal sea surface temperatures. When sea surface temperature in the Pacific Ocean deviates by more than 0.9 degrees Fahrenheit (0.5 degrees Celsius) above normal for at five successive three-month periods or more, this indicates an El Niño event. Likewise, when SST deviates by 0.9 degrees Fahrenheit below normal over five successive three month periods, this indicates a La Niña event.

The top row of the chart below shows the abbreviations for months in three-month groupings. “DJF” indicates the three-month period from December to January to February. The chart below shows temperature deviations for the same period as the fisheries data in this exercise.

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
2000	**-1.6**	**-1.4**	**-1.1**	**-0.9**	**-0.7**	**-0.7**	**-0.6**	**-0.5**	**-0.6**	**-0.7**	**-0.8**	**-0.8**
2001	**-0.7**	**-0.6**	**-0.5**	-0.3	-0.2	-0.1	0	-0.1	-0.1	-0.2	-0.3	-0.3
2002	-0.2	-0.1	0.1	0.2	0.4	**0.7**	**0.8**	**0.9**	**1.0**	**1.2**	**1.3**	**1.1**
2003	**0.9**	**0.6**	0.4	0	-0.2	-0.1	0.1	0.2	0.3	0.4	0.4	0.4
2004	0.3	0.2	0.1	0.1	0.2	0.3	**0.5**	**0.7**	**0.7**	**0.7**	**0.7**	**0.7**
2005	**0.6**	**0.6**	**0.5**	**0.5**	0.4	0.2	0.1	0	0	-0.1	-0.4	-0.7
2006	-0.7	-0.6	-0.4	-0.2	0.0	0.1	0.2	0.3	**0.5**	**0.8**	**0.9**	**1.0**
2007	**0.7**	0.3	0	-0.1	-0.2	-0.2	-0.3	**-0.6**	**-0.8**	**-1.1**	**-1.2**	**-1.3**
2008	**-1.4**	**-1.3**	**-1.1**	**-0.9**	**-0.7**	**-0.5**	-0.3	-0.2	-0.2	-0.3	-0.5	-0.7
2009	-0.8	-0.7	-0.4	-0.1	0.2	0.4	**0.5**	**0.6**	**0.7**	**1.0**	**1.2**	**1.3**
2010	**1.3**	**1.1**	**0.8**	**0.5**	0	-0.4	**-0.8**	**-1.1**	**-1.3**	**-1.4**	**-1.3**	**-1.4**
2011	**-1.3**	**-1.1**	**-0.8**	**-0.6**	-0.3	-0.2	-0.3	**-0.5**	**-0.7**	**-0.9**	**-0.9**	**-0.8**

Data from NOAA’s Climate Prediction Center, full data table here:
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

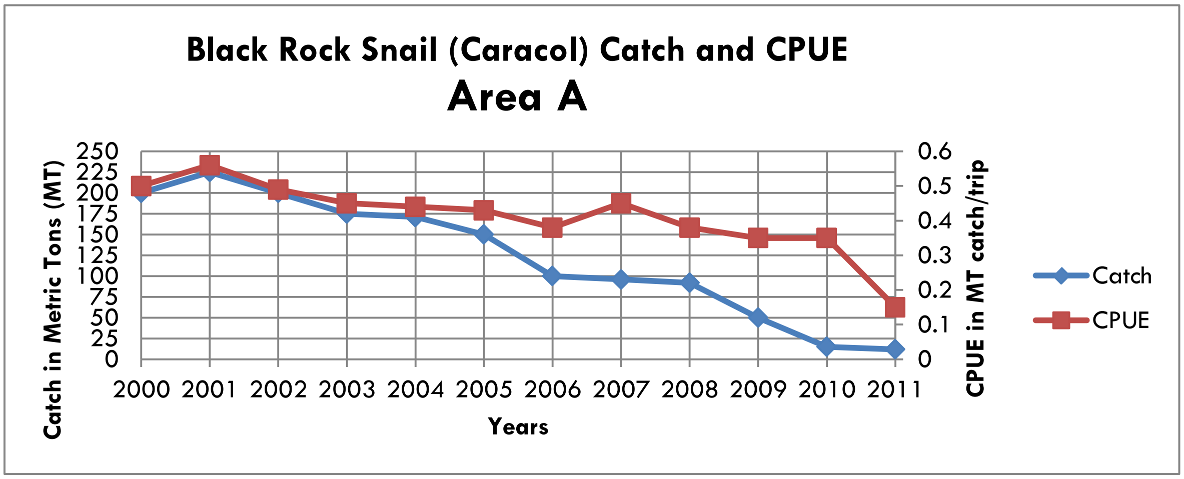
15. Using the chart above, identify the years in which La Niña and El Niño events occurred.



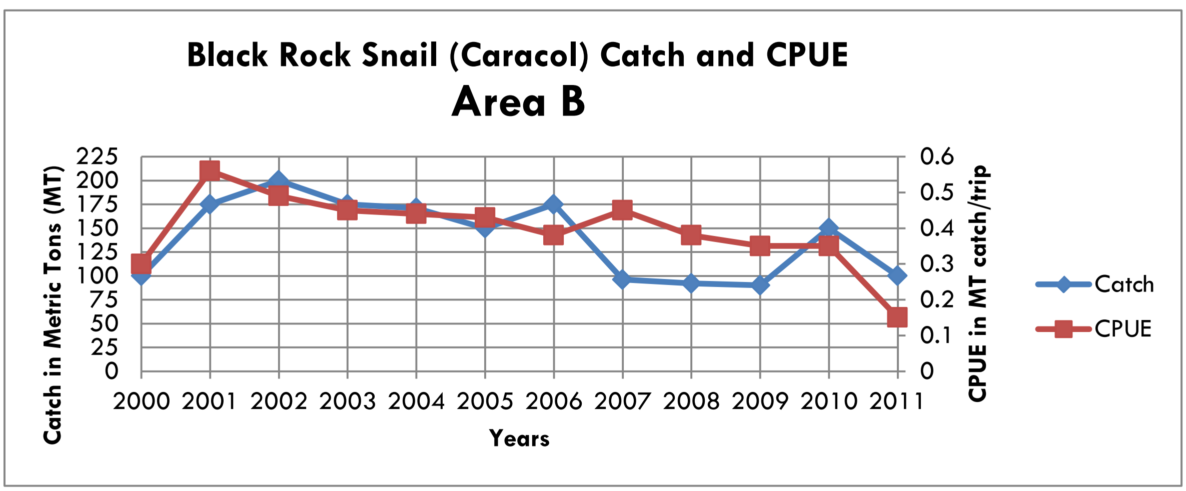
16. In the graph above, circle the El Niño periods with a red pen and circle the La Niña periods with a blue pen.

17. Using the graph above, your knowledge of El Niño and La Niña periods, and the feeding habits of the Lorna Drum to describe how these climactic events might have impacted the Lorna Drum population. What kind of management strategies might you suggest for this species of fish based on these data?

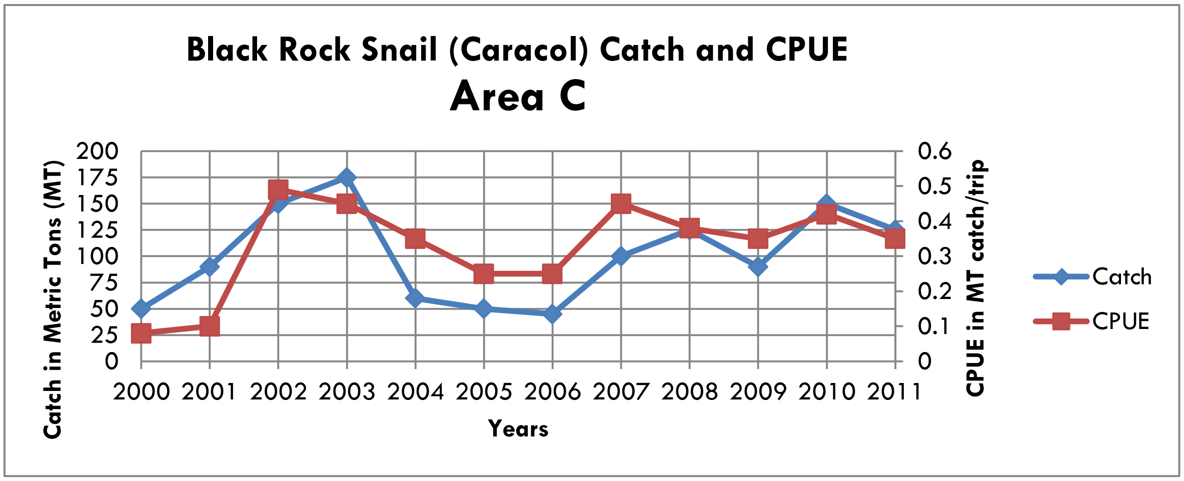
18. There are three areas (A, B, and C) where you and the fishers have been collecting data on the Black Rock Snail. Based on your knowledge of CPUE and catch, below each graph describe what you think is happening to the snail population in that area and describe whether or not you feel the area should be closed to allow the population to rebuild.



Area A Assessment:



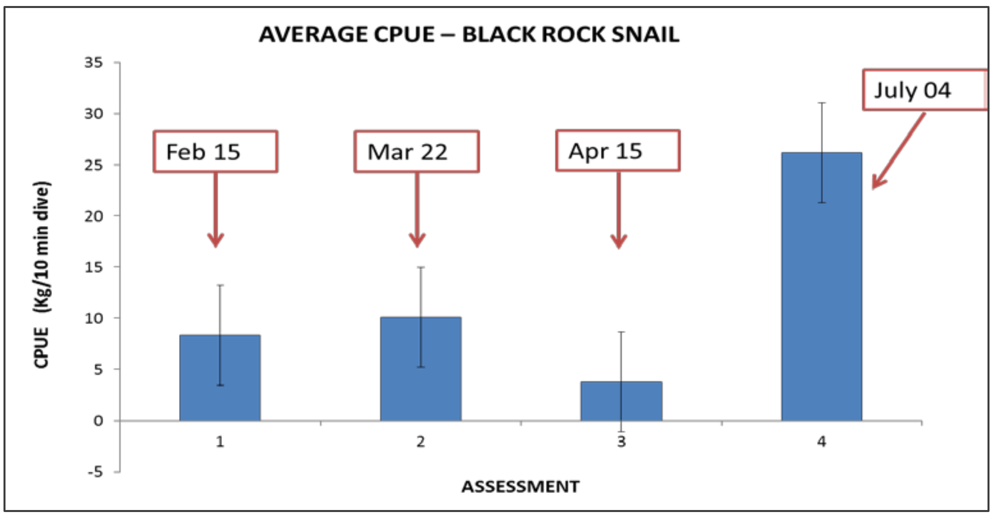
Area B Assessment:



<u>Area C Assessment:</u>

19. The fishers you are working with decided to close off The Isleta, a small island with a perimeter of 1.4 km near Ancón. So far they have closed it to fishing for 5 months. During this time, you've worked with the divers to collect scientific data on the CPUE for Black Rock Snail. Here the CPUE is measured in kilograms of snails collected during a 10 minute dive. Based on the graph below, describe the effect of the closure on CPUE.

The Isleta near Ancón, Peru where a snail fishing area has been closed
Image credit: TNC



CPUE of Black Rock Snail at the Isleta after 5 months of closure. Note that monitoring was not performed in May and June due to poor weather conditions.

20. Now that you have these data, what more do you need to know? Will you continue the closure? For how long? Do you feel that 5 months of investigation is long enough to understand all of the factors involved in the population dynamics of the snail? What further investigations might you propose in order to develop a management strategy for the Black Rock Snail in this area?