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1.3.6 Quiz: How does fishing level affect what can happen to fish populations in the long term?

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To answer the following questions, you'll want to work with your graphs of $\frac{dP}{dt}$ versus P with arrows indicating how the population is changing. (Alternatively, you can work with the qualitative solutions from the optional section).

Question 1

1/1 point (graded)

Suppose we start with a population of fish which is not at equilibrium ($\frac{dP}{dt} \neq 0$). If the fishing rate α is zero, which of the following are possible long-term behaviors of solutions? If there is more than one possibility, choose all such.

(**Note:** more than one possibility means that some different starting populations have different outcomes over time.)

Hint: If you're not sure how to answer this, go back to our graphs and break the domain of P-values into regions on which the derivative is positive or negative, then analyze the behavior of the function on each region.

☐ Tend toward extinction

☐ Tend toward a non-zero stable population value below carrying capacity

☑ Tend toward a non-zero stable population value at carrying capacity ✓

☐ Other

✓

Explanation

There are only two equilibrium points, $P = 0$ which is unstable and $P = 40,000$ which is stable. Thus, for $P > 0$, the only option is to tend toward that stable population $P = 40,000$, which is the carrying capacity. Thus extinction is not possible, according to this model. (Note: Values near an unstable solution always tend away from that solution, in this case $P = 0$).

Submit You have used 2 of 3 attempts

Answers are displayed within the problem

Question 2

1/1 point (graded)

Suppose we start with a population of fish which is not at equilibrium ($\frac{dP}{dt} \neq 0$).

If the fishing rate α is positive but smaller than 1000 (the critical value), which of the following are possible long-term behaviors of the solution? If there is more than one possibility, choose all such.

- ☑ Tend toward extinction ✓
- ☑ Tend toward a non-zero stable population value below carrying capacity ✓
- ☐ Tend toward a non-zero stable population value at carrying capacity
- ☐ Other

✓

Explanation

There are two equilibrium points (both at positive P values). The smaller one is unstable and the larger one is stable. For $P <$ the unstable one, the only option is to tend away from it and toward 0 (extinction). For P between the two equilibrium points, the only option is to tend away from the unstable one toward the stable one, which is still below 40,000, carrying capacity. For populations greater than this larger equilibrium point, they must also tend toward that point since $\frac{dP}{dt}$ is negative for populations above the larger equilibrium point.

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Answers are displayed within the problem

Question 3

1/1 point (graded)

Suppose we start with a population of fish which is not at equilibrium ($\frac{dP}{dt} \neq 0$).

If the fishing rate α is greater than 1000 (the critical value), which of the following are possible long-term behaviors of the solution? If there is more than one possibility, choose all such.

☑ Tend toward extinction ✓

☐ Tend toward a non-zero stable population value below carrying capacity

☐ Tend toward a non-zero stable population value at carrying capacity

☐ Other

✓

Explanation

There are no equilibrium points, and $\frac{dP}{dt}$ is always negative, so the population can only decrease toward extinction.

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Question 4

1/1 point (graded)

Suppose we start with a population of fish which is not at equilibrium ($\frac{dP}{dt} \neq 0$).

If the fishing rate α is equal to 1000 (the critical value), which of the following are possible long-term behaviors of the solution? If there is more than one possibility, choose all such.

☑ Tend toward extinction ✓

☑ Tend toward a non-zero stable population value below carrying capacity ✓

☐ Tend toward a non-zero stable population value at carrying capacity

☐ Other

✓

Explanation

There is only one equilibrium, and it is semi-stable and below carrying capacity ($P = 40,000$). For P below this semi-stable point, $\frac{dP}{dt}$ is negative so P decreases away from it and to 0, extinction. For P above it, $\frac{dP}{dt}$ is negative so P decreases toward the non-zero equilibrium point.

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Answers are displayed within the problem

Question 5

1/1 point (graded)

Suppose we start with a population of fish which is not at equilibrium ($\frac{dP}{dt} \neq 0$).

For which values of the parameter α will the population approach the carrying capacity in the long-term, no matter what the starting population?

(Recall 1000 is the critical value of α.)

● $\alpha = 0$ ✓

○ $0 \leq \alpha < 1000$

○ $\alpha = 1000$

○ $\alpha > 1000$

Explanation

The population tends toward the carrying capacity only for $\alpha = 0$. For alpha less than or equal to the critical threshold value, the population could approach a stable non-zero population but it would always be a value less than the carrying capacity.

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Question 6: Think About It...

1/1 point (graded)

In the case of $\alpha = 1000$, the critical value, why does Wes refer to the single equilibrium as “precarious”? Is it stable, unstable or semi-stable?

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semi-stable
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✓

Thank you for your response.

For populations just above that equilibrium , the system will tend towards that equilibrium. For populations just below, the system will tend away from the equilibrium toward extinction. So there are two very different outcomes possible depending on which side of the equilibrium the population starts, and for this reason, we might refer to it as precarious. This type of equilibrium is called semi-stable.

Note that when the population is at the equilibrium point of exactly 20, 000, according to our model, the popu- lation will stay at that level forever. However, in a real situation, there are always slight fluctuations, and any reduction in the fish population would eventually lead to extinction were it to follow the model.

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Answers are displayed within the problem

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