



ICE - Second Derivative, Concavity



Figure 1: Official Dolphin Safe logo created by the U.S. Department of Commerce.

Most tuna products are now labeled “Dolphin Safe” (the official logo designed by the U.S. Department of Commerce is shown in Figure 1¹).

Prior to 1950, very few dolphins (if any) were hurt or killed as a result of tuna fishing. However, during the 1950’s, fishermen discovered that large, commercially valuable yellowfin tuna (*Thunnus albacares*, see Figure 2²) often swam underneath large schools of dolphins³. The fishermen then began to switch to purse seine nets to catch yellowfin tuna (see Figure 3⁴).

The fishermen would find a large school of dolphins and encircle them with a net (see Figure 3). The fishermen then pulled the bottom of the net closed and drew the net up to catch the tuna that were swimming beneath the school of dolphins. Unfortunately for the dolphins, they tended to be either crushed when the net was drawn up, or else became entangled in the net and drowned (See Figure 4⁵. Estimates⁶ suggest that during the 1960’s as many as 400,000 dolphins were killed every year in purse-seine nets.

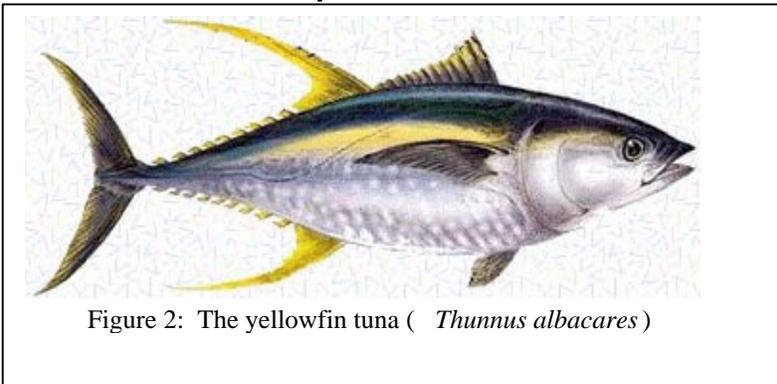


Figure 2: The yellowfin tuna (*Thunnus albacares*)

¹ Source: U.S. Department of Commerce, <http://swr.usdc.gov/dsl.htm>

² Image source: http://www.bajanet.com/Species/yellowfin_tuna.htm

³ Source: Monterey Bay Aquarium, 886 Cannery Row, Monterey, CA 93940.

⁴ Image source: <http://www.europacifictuna.com/purseseine.htm>

⁵ Image source: Greenpeace International, <http://www.greenpeace.org>

⁶ Burk, E. H. (1997) “Dolphin protection and tuna seining.” Congressional Research Service Issue Brief for Congress #96011.

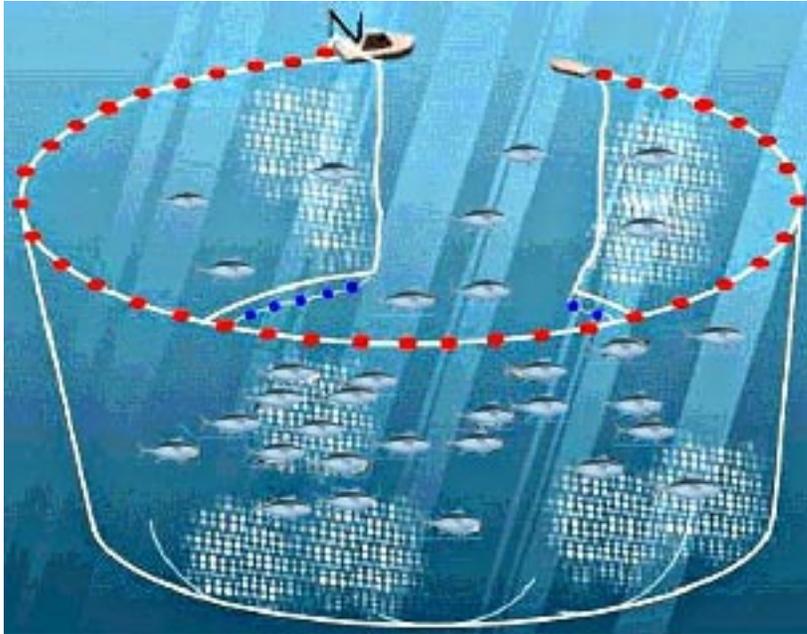


Figure 3: Illustration of a commercial fishing vessel capturing tuna using a purse-seine net.

In 1972, Congress passed the Marine Mammals Protection Act (MMPA). This act prohibited U.S. ships from collecting any kind of marine mammal. This act also put observers on U.S. ships that operated in proximity to marine mammals, including tuna fishing vessels.

A far-reaching measure of the MMPA was to require U.S. fishing vessels to change their fishing methods to minimize the number of dolphins killed or injured.

By 1986, the total number of dolphins killed in tuna nets (US and foreign) dropped to approximately 133,000 per year⁷. Dolphin safe logos were introduced on tuna products in 1986 in response to consumer pressure on the U.S. tuna canning industry. Products carrying a dolphin safe logo certified that no dolphins were encircled with a purse seine net, and that no dolphins were deliberately killed in the pursuit of tuna.



Figure 4: Dolphins within a purse-seine net. It is still possible for these dolphins to escape, if they swim over the line of floats before they become entangled in the net.

⁷ Source: Monterey Bay Aquarium.



Figure 5: An eastern spinner dolphin (*Stenella longirostris orientalis*)

Despite these efforts, several species of dolphin (including the northeastern spotted dolphin, *Stenella attenuata*, and the eastern spinner dolphin, *Stenella longirostris orientalis* – see Figure 5⁸) have been reduced “depleted” status⁹ according to the National Marine Fisheries Service.

- **Table 1 (below) shows the instantaneous rate at which dolphin were caught and killed by US tuna fishermen from 1980 to 1986¹⁰. The units of the instantaneous rate are thousands of dolphins per year. Use the axes provided at the **BOTTOM** of the next page to plot the data.**

Year	T	Instantaneous rate at which dolphins killed (thousands of dolphins per year)
1980	0	15.305
1981	1	18.780
1982	2	23.267
1983	3	8.513
1984	4	17.732
1985	5	19.205
1986	6	20.692

Table 1: Instantaneous rate at which dolphins killed by US tuna fishermen.

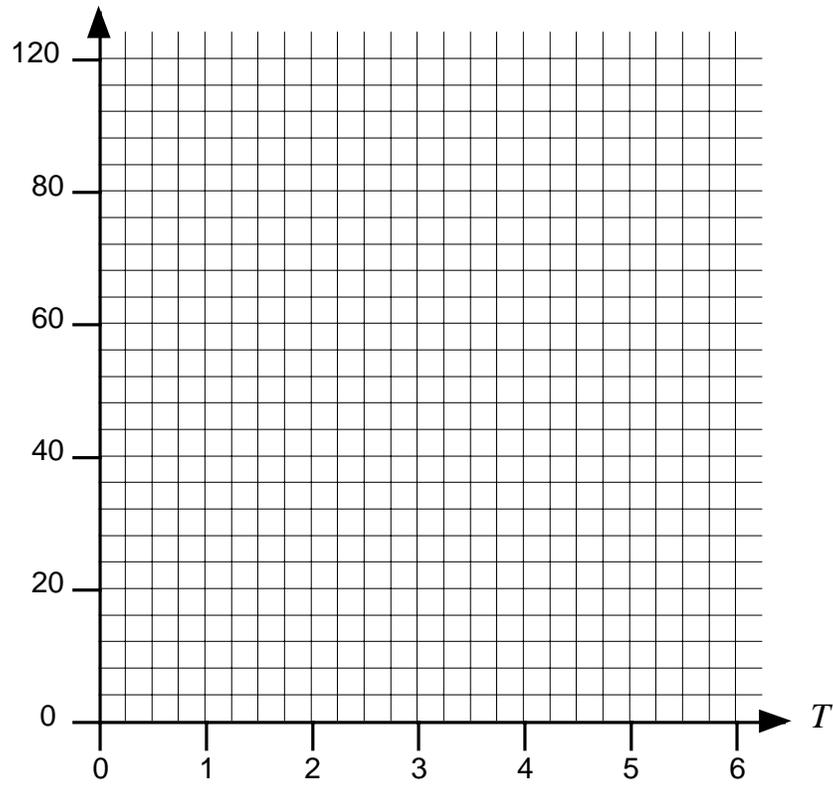
- **What kind of polynomial function would do a reasonable job of representing the pattern in the points that you have plotted? Use the regression capabilities of your calculator to find an equation for this function and record the equation here.**

⁸ Image source: National Marine Fisheries Service, <http://www.nmfs.noaa.gov>

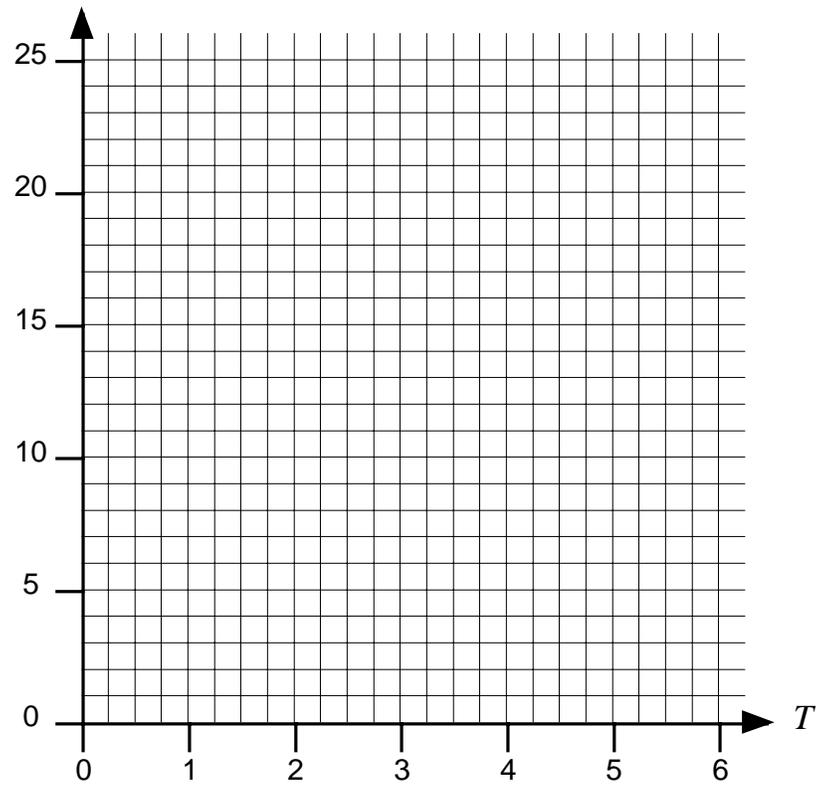
⁹ Buck, E. H. (1997) “Dolphin protection and tuna seining.” Congressional Research Service Issue Brief for Congress #96011.

¹⁰ Source: Buck, E.H. (1997) “Dolphin protection and tuna seining.” Congressional Research Service Issue Brief #96011.

Total number of dolphins killed by US tuna fishermen since 1986.
(Thousands of dolphins)



Instantaneous Rate at which dolphins were being killed by US tuna fishermen.
(Thousands of dolphin per year)



- **Find the intervals where the total number of dolphin killed is a concave up function and the intervals where the total number of dolphins killed is a concave down function of time. Record your results in Table 2 below.**

Approximate intervals where function is concave up	Approximate intervals where function is concave down

Table 2.

- **When did the government experience some success in its efforts to reduce the number of dolphins killed? When was the government not very successful?**

- **Use the equation that you found for the rate at which dolphins were killed to precisely determine the intervals where the total number of dolphin killed is a concave up function and the intervals where the total number of dolphins killed is a concave down function of time. Record your results in Table 3 below.**

Exact intervals where function is concave up	Exact intervals where function is concave down

Table 3.

- ***How could you use the equation for the rate at which dolphins were killed to determine the location of the points where the graph of total number of dolphins killed changes concavity.***

- ***In 1986, in response to mounting consumer pressure, the tuna industry introduced “dolphin safe” labels for food products containing tuna. Consumers have shown a marked preference for “dolphin safe” tuna¹¹. How would you expect the introduction of the “dolphin safe” labels to affect the appearance of the two graphs that you drew? Make sure that you describe the effects on the:***

- ***the increasing/decreasing nature of each graph, and,***
- ***the concavity of each graph.***

- ***Does the equation that you found for the instantaneous rate at which dolphins were killed show the kind of behavior that you would expect after 1986? What kind of polynomial might do a better job of representing the situation?***

¹¹ Source: US Department of Commerce, <http://swr.usdc.gov/dsl.htm>