Document ID: 01_07_99_1
Date Received: 1999-01-07 **Date Revised**: 1999-03-22 **Date Accepted**: 1999-04-08
Curriculum Topic Benchmarks: S1.4.2,S1.3.2,M1.3.3,S10.3.7
Grade Level: : [9-12] High School
Subject Keywords: sea level rise, floating, swimming, oceans, flooding
Rating: Moderate

Could a World of Swimmers Raise Sea Level?

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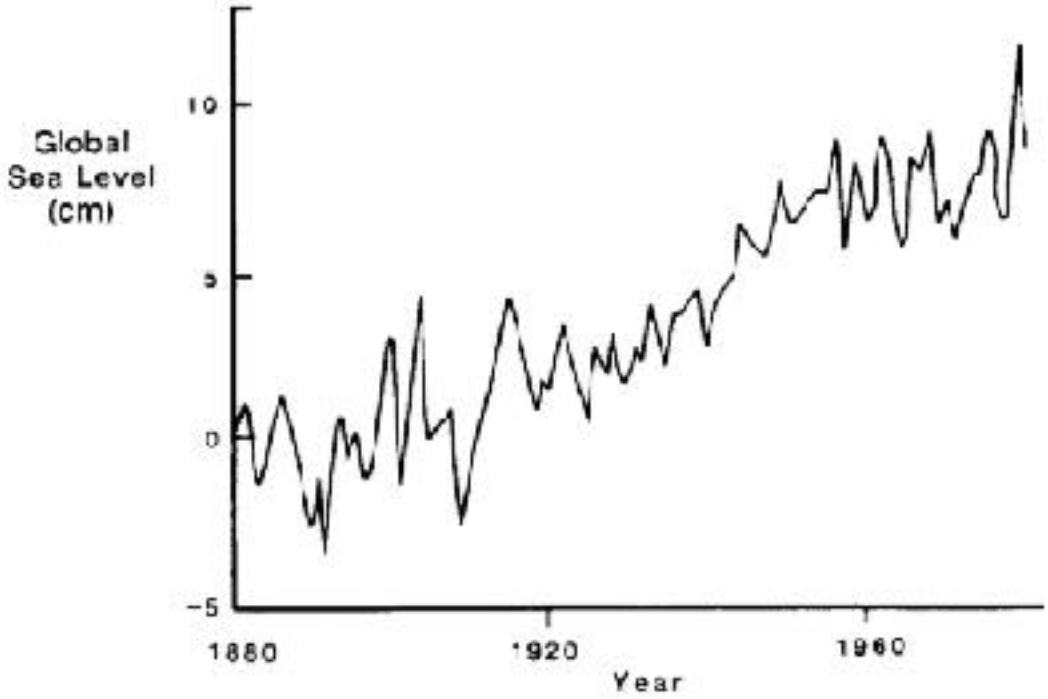
From: The PUMAS Collection http://pumas.jpl.nasa.gov

Audience: Geography, Earth Science, or Physics students in middle school and high school. No math is required beyond basic arithmetic.

Issue: In the state of Maryland, a local politician claimed that sea level is rising because there are too many people putting boats on the open ocean! This is a true story! Is this or similar claims possible? Imagine if all of the people in the world agreed to go float on the ocean at the same time! Could that result in a significant sea level rise, perhaps even destroy low-lying nations such as Bangladesh?

Background: Observations of mean sea level have been recorded over the last 100 years using tide gages. Longer term estimates of mean sea level have been deduced by geologists studying glaciers and the coastline. From all of the evidence gathered, we know that the level of the ocean rises and falls through time.

Sea level is rising. More than 2000 of the world's top scientists have built a consensus that the present natural rise in sea level is being enhanced by the melting of glaciers, which is likely caused by human-enhanced global warming.



(Adapted from Gornitz, V., Lebedeff, S., and Hansen, J. 1982. Global Sea Level Trend in the Past Century. Science 215:1611-1614.)

Preparatory Exercise for Students: The night before the exercise, have students use their bathtub at home to determine how much water they displace. To do this, follow this procedure:
1) Fill the tub up to 4 inches below the rim
2) Mark the water elevation with an eyebrow pencil, a lip liner, or a piece of tape
3) Get in and lie on your back with as much of you submerged as possible
4) Mark the new water elevation yourself or have a family member do it for you
5) Get out of the tub and dry off
6) Fill the tub back up to the lower water line
7) Fill the tub to the upper water line using a 2-liter soda bottle
8) Record how many liters of water it took to do step 7. That is the volume you displaced in units of liters.

Remember that if an object is denser than water, it sinks to the bottom, displacing a volume of fluid equal to its own. If it is less dense than water (as most people are), it floats, and displaces only an amount of water equal to its weight. But if the less-dense object is forced to submerge, it does displace its volume; the extra displaced water creates buoyancy that forces the object back toward the surface. Think about which of these three conditions you create in your tub. [For further discussion about buoyancy and water displacement, look up "Archimedes Principle" or "Hydrostatics" in any good encyclopedia or relevant science textbook.]

Data: The calculations require estimates of human vital statistics (Table 1 or 2) and ocean characteristics (Table 3). For higher accuracy in the answer, advanced students may want to stratify the world's population into different weight classes based on age and sex (Table 2) rather than using the average value for all people (Table 1).

Table 1: Simplified Data on Human Vital Statistics

Variable	**Estimated Value**
World Population	6 billion people
Average Human Weight	542.7 N (122 lbs)
Average Human Mass	55.3 kg (3.8 slugs)

Table 2. 1999 World Population and Recommended Weight (by Age and Sex)

	Population		Recommended Weight	
Age group	Male	Female	Male	Female
0- 4	315628570	297394163	20	20
5- 9	311008116	293303390	50	50
10- 14	308179602	293399542	99	101
15- 19	283262011	269079306	145	120
20- 24	261770907	248373110	160	128
25- 29	254893759	245176835	167	132
30- 34	236110517	231399878	172	135
35- 39	205834307	203010292	174	138
40- 44	185510146	181884511	174	140
45- 49	160679857	159016355	172	142
50- 54	126419727	125609406	170	143
55- 59	102845057	104365988	167	143
60- 64	88374778	93349398	164	143
65- 69	70667375	78431478	161	143
70- 74	52075892	63786813	160	143
75- 79	31981301	44462469	160	143
80+	24370033	43889947	160	143
Total, all ages	3019611955	2975932881		

(Population data from U.S. Bureau of the Census, International Data Base)
(Online population data: http://www.census.gov/ftp/pub/ipc/www/idbnew.html)
Recommended Weight data based on information from the Food and Nutrition Board of the National Academy of Science- Institute of Medicine, 1989)
(Weights are in units of lbs)

Table 3: Earth Constants

Variable	**Estimated Value**
Density of Sea Water	1030 kg/m^3
Surface Area of Oceans	361×10^6 km^2

Source: Gross, M. G. Oceanography: a view of the earth, 5th Edition. Prentice Hall, Englewood Cliffs, NJ.

Solution:
(1) The first step is to determine the volume of water displaced by a person when he/she is floating on the ocean. One might suppose that a person's volume is displaced, but that is not correct for a floating object, so the volume of a human being is irrelevant to this problem. Instead, the volume of water displaced by a person is the volume containing a mass of seawater equal to the mass of the person. To calculate this, divide the mass of a person by the density of seawater:

$$55.3/1030 = 0.0537 \text{ m}^3\text{/person}$$

Advanced students should use the data in Table 2, by converting the weight in pounds (lbs) to mass in kilograms (kg) for each age/sex class. This can be conveniently done by setting up the data in a Microsoft Excel spreadsheet. Note that 1 lb ~ 0.453 kg.

(2) If one person displaces 0.0537 m3, then everybody together displaces that amount times the world's population:

$$6{,}000{,}000{,}000 * 0.0537 = 3.222 \text{ x } 108 \text{ m}^3 = 0.3222 \text{ km}^3$$

(3) To convert the volume displaced by floating people to a sea level rise, divide the volume by the surface area of the world's oceans:

$$(0.3222) / (361 \text{ x } 10^6) = 8.93 \text{ x } 10^{-10} \text{ km} = 0.0009 \text{ mm}$$

Clearly, all of the world's people swimming in unison would not have a measurable impact on sea level!!!

Further suggestions: Collect information on the world's population of boats and do the same calculation to verify for yourself that the politicians are wrong.

Qualifiers: Students are encouraged to consider issues about the assumed characteristics of ocean basins raised in a related PUMAS Example (Document ID 02_10_97_1) entitled "Ice Sheets and Sea Level Rise," by C. Parkinson. For the present example, the small quantity of displacement makes these issues insignificant relative to the potential error in world population and weight estimates, but they are good points to discuss.