MO MATH
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Mathscapes
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Title

We're All In This Together

Real world event

Earth Day

Problem

Four fishing families share the same body of water. Each family sends out some (possibly different) number of fishing boats. If S is the total number of boats sent out by all families, then each boat catches $100 - S$ fish. (The formula is inspired by the Gordon-Schaefer model for fishery economics.)

To simplify analysis, assume that boats and fish can be fractional, in the sense that if the families send out A, B, C, and D many boats each (where they can be non-integers), then in terms of the sum $S = A + B + C + D$, the first family catches a total of $A \times (100 - S)$ fish, etc.

Question 1: If the families cooperate and share the proceeds, what is the largest total number of fish they can catch?

Question 2: Suppose each of the 4 families independently decides how many boats to send, maximizing their own family's catch. A (pure) Nash equilibrium is a list of 4 numbers (possibly the same), specifying how many boats each family sends, which satisfies the property that if any one family independently changes their number of boats, that family would not catch more fish. It turns out there is a unique such equilibrium. How many total fish do the 4 families catch in that equilibrium?