

# Spare the Snail-Eaters: Design a Net That Lets By-Catch Escape

**Investigation question:** Can your team design a net that keeps the large fish a village needs while letting at least 8 of every 10 small snail-eating fish slip through, using no more than 20 strands of string?

Engineering design challenge

Groups of 4

1 session

Setup 5 · Activity 45 · Cleanup 5 min

MS-ETS1-1 · practice

MS-LS2-5 · practice

MS-ETS1-2 · practice

Name \_\_\_\_\_

Group \_\_\_\_\_

Date \_\_\_\_\_

## Your role today

- ☐ **Measurer and designer:** Measures the pasta, proposes the spacing, marks tick lines on the cardboard border and checks the spacing with a ruler as strands go on.
- ☐ **Builder:** Tapes strands snugly across the window at the marked spacing and keeps count against the 20-strand budget.
- ☐ **Hauler:** Runs every haul the same way: same pour height, same straight lift, five gentle shakes counted aloud.
- ☐ **Data manager:** Counts kept and escaped fish of each kind, fills the tables, calculates percentages and posts the group's results on the class chart.

## Safety

- Wheat allergy or celiac disease: dry pasta sheds flour dust. Students with a wheat allergy use the plastic-bead version described in the low-cost alternative, or take the data-manager role and wear gloves.
- The pasta is not food once it has been handled: no eating it, and wash hands after the lab.
- Only the teacher uses the craft knife, before class. Students use blunt-tip scissors to trim string.
- Dropped pasta is slippery on hard floors and breaks into sharp little shards; sweep it up rather than stepping on it, and never throw pasta.

## Procedure

1. Measure your fish. Measure the narrowest width (the tube diameter) of 3 rigatoni and 3 ditalini to the nearest millimeter, record them and find each average. Answer q1.
2. Sharpen the problem. Read the starting criteria and constraints. In q2, add one criterion or constraint of your own, written so it can be checked with a number or a yes/no test.
3. Plan design 1. Choose the spacing between strands in each direction (center to center), work out how many strands it needs on a 12 cm window (no more than 20), sketch the grid, and predict the percent of

- each fish it will keep (q3 and the sketch).
- Build design 1 in 12 minutes or less. Mark tick lines on the cardboard border at your spacing. Tape one set of strands across the window, pulling each snug, then a second set at right angles to make a grid. Tape only on the cardboard, never across the window. Record the strands used.
  - Haul test. Lay the net flat in the bottom of the empty tub. Pour the haul cup (10 rigatoni, 20 ditalini) onto the window from about 5 cm above, and push any fish resting on the cardboard border onto the window. Lift the frame straight up about 15 cm, hold it level, and shake it gently side to side 5 times, counting aloud. Fish still on the net are kept; fish in the tub escaped.
  - Count and record the kept and escaped fish of each kind, return all 30 to the cup, and repeat for three hauls in all with the same hauler, pour height and number of shakes. A ditalini stuck inside a rigatoni counts as kept.
  - Calculate the percent of large fish kept ( $\text{large kept} \div 30 \times 100$ ) and the percent of small fish released ( $\text{small escaped} \div 60 \times 100$ ), and check each criterion and constraint.
  - Modify. Use your results to change one thing (the spacing in one or both directions, the number of strands, or how the strands are fixed), build design 2 on a fresh frame, write your evidence in q4, and run three more hauls.
  - Measure the clear opening of your better design: the gap between the edges of neighboring strands, not center to center, at three places, then average. Post the opening, strands used and both percentages on the class chart, and plot the class data on your graph: percent of large fish kept and percent of small fish kept against opening.
  - Clean up: bag the pasta for reuse, strip tape from the frames, sweep up broken pieces and wash hands. Answer the analysis questions on your own.

## Record your observations

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### Lab 2 recording sheet: Spare the Snail-Eaters

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A fishing village on a large lake needs its large fish for food and income. Small fish of another species eat the snails that carry the bilharzia parasite, so the village wants them left in the lake. **Rigatoni = large target fish. Ditalini = small snail-eating fish.** Your net is a lift net: it rests on the bottom, the fish gather over it, and it is lifted straight up.

#### Measure your fish (narrowest width, mm)

| Fish                          | Piece 1 | Piece 2 | Piece 3 | Average |
|-------------------------------|---------|---------|---------|---------|
| Rigatoni (large target fish)  |         |         |         |         |
| Ditalini (small snail-eaters) |         |         |         |         |

**Starting criteria and constraints** — **Criterion 1:** keep at least 24 of the 30 large fish (80 percent) over three hauls. **Criterion 2:** let at least 48 of the 60 small fish escape (80 percent) over three hauls. **Constraint 1:** no more than 20 strands of string per net, because string is costly for the village. **Constraint 2:** build each net in 12 minutes or less. **Constraint 3:** after three hauls, every strand is still taped in place.

1. Use your measurements: what range of clear openings, in millimeters, should let the small fish through but stop the large fish? Explain your range.

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2. Write one more criterion or constraint of your own, stated so that it can be checked with a number or a yes/no test.

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3. Design 1 plan: spacing between strands in each direction (mm, center to center), number of strands, and your predicted percent of large fish kept and small fish released.

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-  Sketch design 1's grid from above. Label the spacing in millimeters in both directions and number the strands.

**Design 1: haul results**

| Haul  | Large fish kept | Large fish escaped | Small fish kept | Small fish escaped |
|-------|-----------------|--------------------|-----------------|--------------------|
| 1     |                 |                    |                 |                    |
| 2     |                 |                    |                 |                    |
| 3     |                 |                    |                 |                    |
| Total |                 |                    |                 |                    |

**Design 1: summary**

| Strands used | Percent of large fish kept | Percent of small fish released | Criterion 1 met? | Criterion 2 met? | All constraints met? |
|--------------|----------------------------|--------------------------------|------------------|------------------|----------------------|
|              |                            |                                |                  |                  |                      |

4. What will you change for design 2, and which result from design 1 is your evidence for that change?

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**Design 2: haul results**

| Haul  | Large fish kept | Large fish escaped | Small fish kept | Small fish escaped |
|-------|-----------------|--------------------|-----------------|--------------------|
| 1     |                 |                    |                 |                    |
| 2     |                 |                    |                 |                    |
| 3     |                 |                    |                 |                    |
| Total |                 |                    |                 |                    |

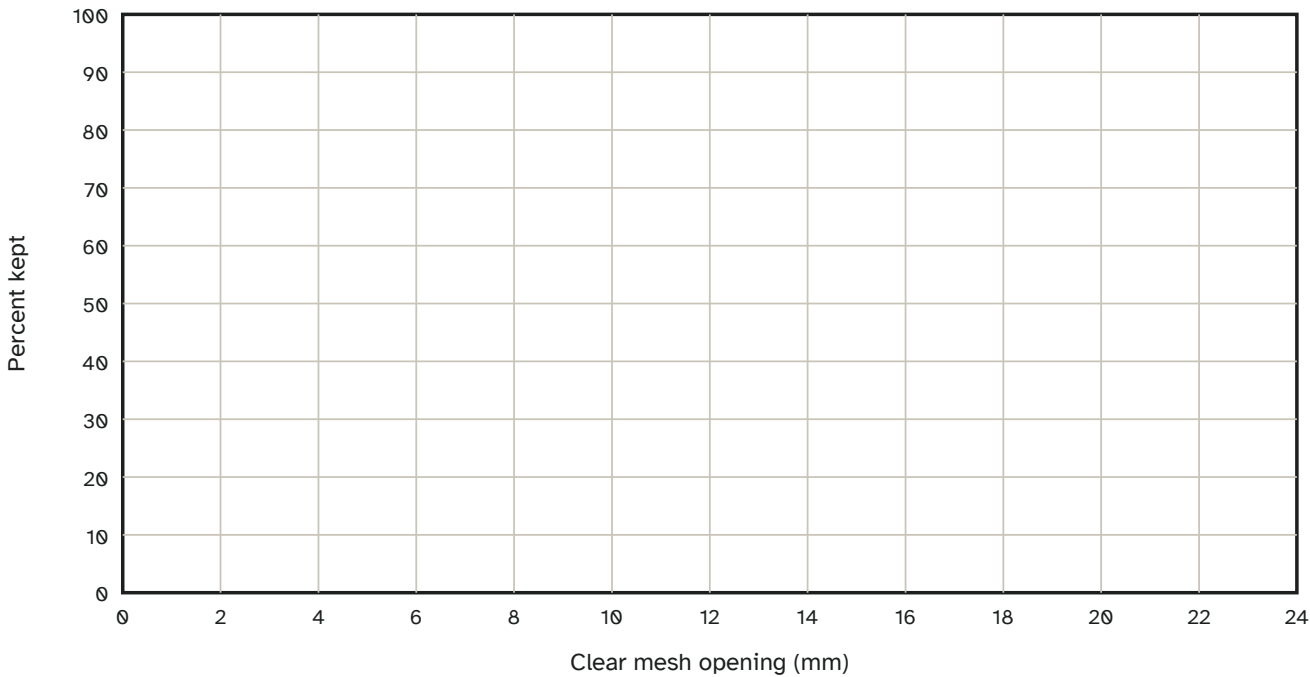
**Design 2: summary**

| Strands used | Percent of large fish kept | Percent of small fish released | Criterion 1 met? | Criterion 2 met? | All constraints met? |
|--------------|----------------------------|--------------------------------|------------------|------------------|----------------------|
|              |                            |                                |                  |                  |                      |

Class chart: every group's better design

| Group | Clear opening (mm) | Strands used | Percent of large fish kept | Percent of small fish kept | Met both criteria? |
|-------|--------------------|--------------|----------------------------|----------------------------|--------------------|
|       |                    |              |                            |                            |                    |
|       |                    |              |                            |                            |                    |
|       |                    |              |                            |                            |                    |
|       |                    |              |                            |                            |                    |
|       |                    |              |                            |                            |                    |
|       |                    |              |                            |                            |                    |
|       |                    |              |                            |                            |                    |

Class selectivity graph: percent kept against mesh opening



## Analysis questions

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5. A net's strands are taped 14 mm apart, center to center, and the string is 1.5 mm thick. What is the clear opening? Would a fish 8 mm wide fit through it? A fish 15 mm wide? Show your work.

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6. Did design 2 meet more of the criteria and constraints than design 1? Use your percentages to explain what your change did.

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7. Use the class graph. What range of clear openings met both criteria? Explain why nets with smaller openings failed one criterion and nets with larger openings failed the other.

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8. Some small fish stayed on nets whose openings were much wider than a ditalini. Give two reasons from your observations.

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9. A fishing boat lands 600 kg of its target fish a day. With its old net, by-catch made up 40 percent of each haul's mass. A new net cuts by-catch to 10 percent of the haul and still lands 600 kg of target fish. How many kilograms of by-catch does the new net avoid each day? Show your work.

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10. At Lake Malawi, why did sparing the small fish matter to people as well as to the fish?

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11. Shrimp trawl nets can catch sea turtles, which are far larger than shrimp. Explain why changing the mesh size cannot solve that by-catch problem, and describe a design that could.

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12. Name two ways the pasta test differs from fishing a real lake, and say how each might change the results.

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