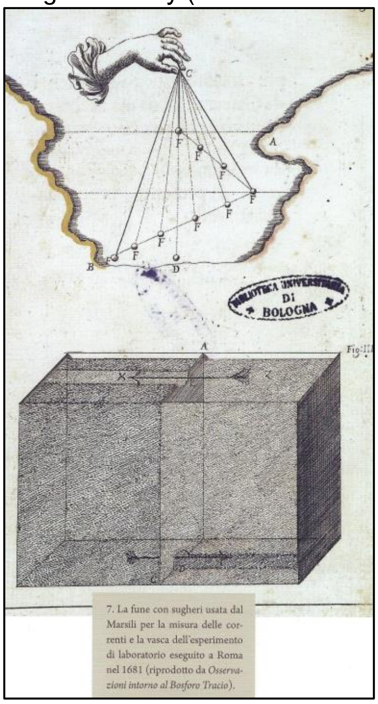
Exploring current flows through straits
Testing the L. F. Marsili model of Bosphorus currents (1680)

Count Luigi Ferdinando Marsili (1658-1730), an Italian genius, is often called the founder of modern oceanography. He was a soldier and diplomat for the Republic of Venice.

When he was on a diplomatic mission to the great city of Constantinople (now Istanbul) beside the Bosphorus Strait at the entrance to the Black Sea (shown on the map) he observed two currents flowing in opposite directions through the channel. He saw low density and less salty water flowing from the Black Sea (rainy area) along the surface towards the Mediterranean; then from the Mediterranean, denser and saltier water flowed towards the Black Sea at the bottom of the channel.

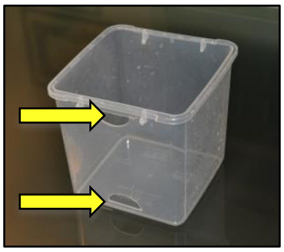
Location of the Bosphorus Strait
Image: Google Earth

Marsili took measurements of seawater density and of current flow and, when he returned to his home in Bologna in Italy, he modelled the currents in his lab using a tank. He divided the tank in two with a central wall with two openings in it (one at the bottom and one on top) to allow the water to flow according to density (see Marsili's drawing).



Marsili's measurements and model, *from: L.F.Marsili (1681) Osservazioni intorno al Bosforo Tracio, Rome*.

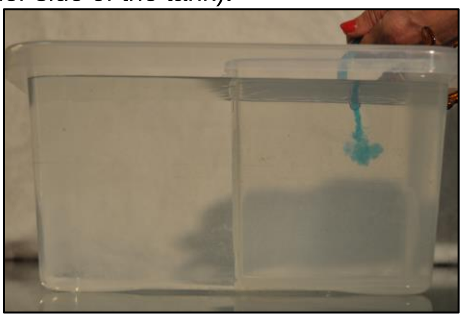
First make your Marsili tank by using a small transparent storage box (the tank) and a smaller transparent plastic kitchen box of similar height that fits inside the larger one.



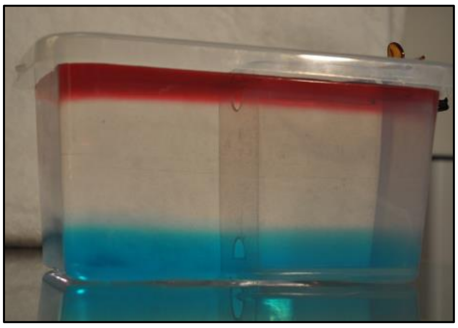
Cut two openings on the same vertical side of the smaller box: one near the bottom and the other near the top as shown in the photograph. Put the smaller box inside the larger one, so that the openings face the open space between the two boxes. Fasten the two boxes with a clip, clothes peg, or hairgrip, to stop the smaller box moving when the tank is filled with water (see photo in the 'Context' section below).

Ask the pupils to do the following:

- Fill the tank with tap water until the upper slot in the small box is covered.
- Measure the volume of the water (= X litres)
- Consider how to transform tap water to the same salinity as seawater (by adding salt). Given an average seawater salinity of 35‰ (i.e. 35 parts per thousand) and a water volume of X litres, calculate how much salt is required.
- Make the calculations and weigh out the salt.
- [To simplify the demonstration for younger pupils, tell them the amount of salt required.]
- Pour the weighed salt into the tank and mix the solution until the salt is dissolved.
- Prepare a cup of salt-saturated solution (by adding salt until it does not dissolve any more) and colour it with one of the food colourings.
- Prepare a cup of tap water alone and colour it with the other food colouring.
- Predict and note down what you think will happen if the saturated solution is poured into the small box.
- Fill the syringe with the salty solution and carefully pour the first solution into the smaller box just under the water surface. Observe the coloured salty solution (it will sink in the water, flow through the bottom opening and reach the other side of the tank).



- Predict what will happen if the coloured tap water is poured into the tank.
- Rinse the syringe, fill it with the coloured tap water and carefully pour it into the smaller box just under the water surface.
- Observe the coloured tap water (it will remain at the surface, crossing the top opening and reaching the other side of the tank)



A modern Marsili tank.
All Marsili tank photos: Giulia Realdon

The experiment can be repeated with water of the same composition in the tank and in the coloured solutions, but at different temperatures, e.g. water at room temperature in the tank and very cold/ hot water for the coloured solutions.

Conclude by explaining that similar processes also occur at the Gibraltar Strait entrance to the Mediterranean Sea and in other narrow entrances to larger water bodies around the world.

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The back up

Title: Exploring current flows through straits

Subtitle: Testing the L. F. Marsili model of Bosphorus currents (1680)

Topic: Model the flow of seawater of different densities through straits.

Age range of pupils: 11-16 years

Time needed to complete activity: about 30 minutes (+ time to make the model)

Pupil learning outcomes: Pupils can:
- make predictions about the consequences of adding liquids of different densities to “seawater” in the tank
- test their predictions;
- explain the factors causing water flow through marine straits;
- [make calculations and measurements to reproduce seawater in the tank].

Context:
This activity addresses several concepts within Earth sciences (concentration, density, diffusion) by means of modelling typical of a science investigation, with an example taken from the age of the Scientific Revolution.

The model with a hairgrip clipping the tanks together is shown opposite.

Following up the activity:
Students can apply their learning to the study of ocean currents, appreciating how currents transport matter and energy and their global dimensions.

Underlying principles:
- Oceans are generally viewed as separate geographical entities; however they actually constitute a single global water mass which moves matter and energy around the planet.
- Thermohaline circulation moves seawater due to density differences between water masses.
- Narrow straits do not impede water circulation, so that in about 1000 years a water particle is able to travel all around the world
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Thinking skill development:
Students will address the concept of density through its effects on water movements, constructing a pattern that can be applied [bridged] to understanding of the global ocean interconnections.

Resource list:

- a rectangular transparent storage box (volume about 4 litres)
- a smaller kitchen box (e.g. Tupperware™ type) of similar height that fits inside the larger one with an opening cut in the upper side and another one cut in the lower side
- a cutter to make the openings
- food colouring (two colours)
- a syringe without needle, of at least 60 ml, connected to plastic tubing about 20 cm long
- salt
- kitchen scale or electronic balance

Useful links:
Additional resources:
E-book (free): L.F.Marsili (1681) Osservazioni intorno al Bosforo Tracio, Rome
https://books.google.it/books?id=eXVUAAAAcAAJ&printsec=frontcover&hl=it&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false
N. Pinardi (2009) Misurare il mare: Luigi Ferdinando Marsili nell'Egeo e nel Bosforo, 1679-1680. Bononia University Press

Source: Giulia Realdon, University of Camerino, Italy – UNICAMearth group.