

Originally prepared for Desert Ridge Middle School Albuquerque, NM

Illustrations by the students of Desert Ridge Middle School

HISTORICAL FLOAT QUESTIONS

Why do you make and launch floats; I did not really understand?

Why are the floats all around Antarctica?

We launch the floats to gather the data necessary to better understand the flux (movement) of carbon dioxide in and out of the ocean waters around Antarctica. We know little about this region. Prior to SOCCOM, we had very little wintertime data around Antarctica due to the ice coverage and bad weather. The floats supply these data all year long and for much lower cost than other methods of data gathering.

How did you come up with the idea of a floats? When were SOCCOM floats invented? When were the floats first used?

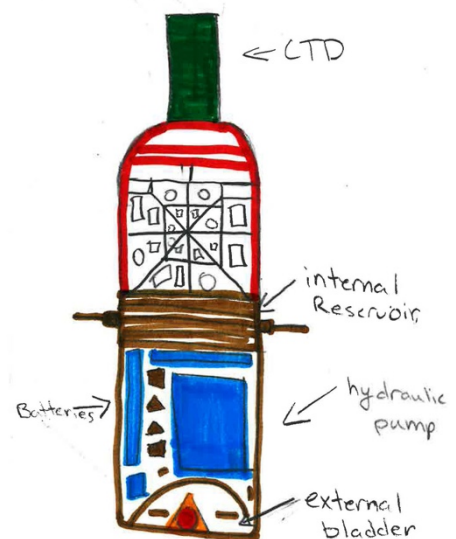
Argo floats were developed during the 1990s to provide open ocean data at higher density than possible from ships or fixed buoys and more accurately than from satellites. Early versions were called ALACE floats. At first the floats measured only temperature. Next salinity was added. SOCCOM is a natural extension of those ideas with additional chemical sensors that have been invented recently.

Who decided to make these floats and what did they look like back then?

The earliest ALACE floats were built by Russ Davis' group at UCSD. They looked very similar to SOCCOM floats except that they had only the temperature probe and antenna extending out the top.

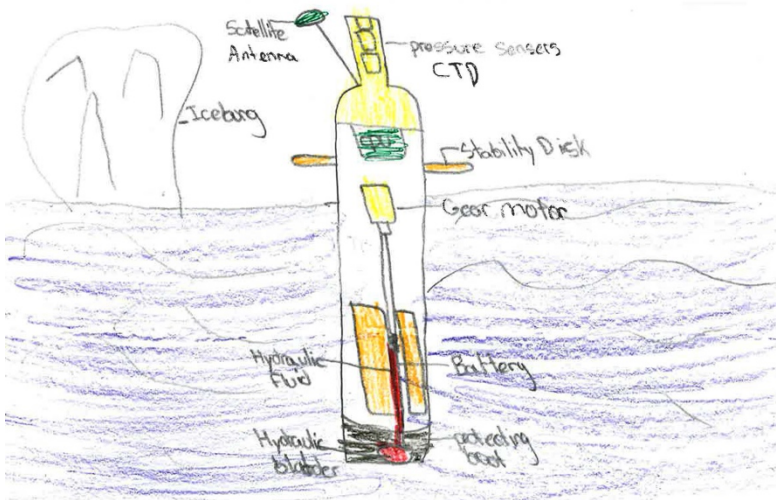
What is the first ARGO?

I don't understand this question – unless you are referring to the mythical Greek ship, Argo, that was sailed by Jason and his comrades



ARGO

FLOAT CONSTRUCTION QUESTIONS



How many years did it take to develop the floats?

The ALACE/Argo/SOCCOM float design has been under continual design change and improvement since the early 1990s.

What are ARGO floats made out of and how heavy are they?

Argo float cylinders are typically made of steel or aluminum. They weigh about 22.8 kg (50 pounds), but far more important than the weight is the density (mass/volume). The density must be very close to the density of seawater - about 1.028g/cm^3 or kg/liter .

How did the scientist decide what shape to make the floats?

The shape had to be strong and yet capable of containing the instrument electronics plus batteries plus the bladder system. A sphere would have been ideal for strength, but not very good for mounting instruments or keeping the antenna up. The cylinder was a very nice compromise.

Why did scientist make the float so big?

The float volume (size) had to be large enough to contain the equipment and batteries AND to have enough volume to make the density be 1.028g/cm^3 .

How do you build the floats?

SOCCOM buys basic Argo type floats. They are sent to Univ. Washington where additional sensors are added. Some of those extra sensors are built at MBARI. Each float is "hand built", but we are trying to encourage/train commercial companies to start making SOCCOM floats.

How cool is it to make SOCCOM floats?

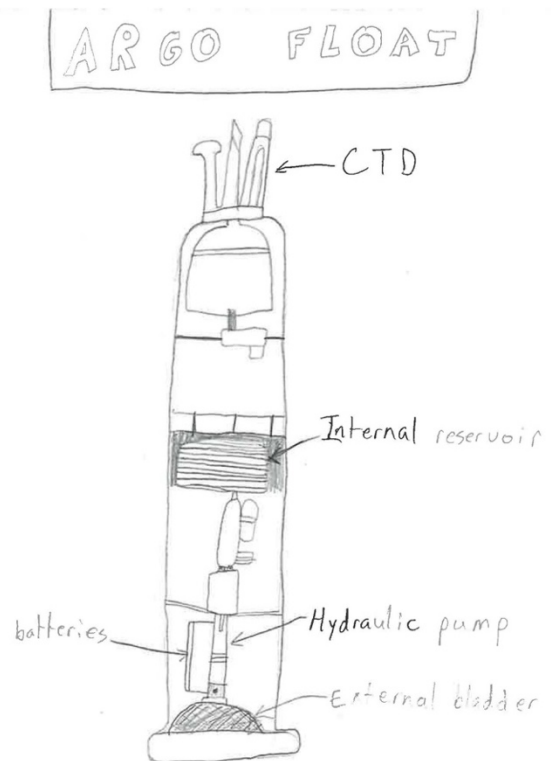
VERY

How long does it take to make an ARGO float?

As you'd expect, this depends on how many technicians are working on the project. With our current manpower we are able to make about 30-40 SOCCOM floats/year (after purchasing the Argo float that is used as the "base").

How many parts are in the float?

This answer depends critically on your definition of "part". If a circuit board is a "part", then there are around 100 parts. If a chip on a circuit board is a "part" then 1000 would be a better guess. If a transistor inside a chip is a "part" then perhaps 1,000,000?



How do you assemble the pieces of the float without breaking them?

This must be done carefully, but for a trained person it isn't too difficult. The pieces are reasonably robust.

Are all the floats the same weight?

Yes. Since each has the same volume, the mass must be the same otherwise the density would not be the correct value (1.028g/cm^3)

Is the float waterproof?

Yes. If any seawater got into the cylinder or any area of a sensor that was not designed to be wet, electrical shorts would kill that sensor or float.

How much pressure can the floats take?

The only way to know that value accurately would be to actually crush one with uniformly applied pressure. Since they cost so much that would be an expensive experiment. However, we KNOW that they can take more pressure than what they experience at 2000m depth and we can calculate that value:

- A. For every 10m deeper into the ocean, they experience 1 atmosphere more pressure*
- B. 1 atmosphere is 14.7 psi (pounds/square inch) pressure*
- C. $2000/10 = 200$ atmospheres*
- D. $200 \text{ atmospheres} * 14.7 \text{ psi}$ is just under 3000 psi*
- E. Engineers typically design in a "safety factor", in this case about 30%. **The actual tested crush** weight of an average sized car on each square inch of the surface! We have pictures of an empty container that was crushed in a test (no instruments). It is also possible that the lid with all the sensors would fail prior to that.*

If a float didn't work how could you test it or know it wouldn't work?

If a float failed immediately after being launched you MIGHT be able to go back and pick it up for return to the lab and testing. Otherwise, there is no way for testing. Generally, we do test them on shore before the boat sails, but after launch they either work or they are lost in almost all cases.

What are all the sensors in the float?

There are eight sensors on the floats. They include temperature, salinity, pressure, oxygen, nitrate, pH, chlorophyll and particles.

How do the sensors work?

Each works in a different way. To properly answer this question would take many pages. If you navigate to the SOCCOM web page and dig deep enough you can find references that describe the operation of each sensor.

How much are the instruments in the ARGO float?

The total cost for each float is about \$110,000. This includes the labor required for assembly.

What is the pH used for?

The pH measurements are used in calculating the amount of carbon dioxide in the sea water. pH is a measure of how acidic/basic a solution is. Open ocean seawater is slightly basic.

Why can't we use cameras on the floats?

Cameras use a lot of energy, i.e. batteries. The floats would need to be much larger to carry the additional batteries or the power would not last very long.

Do the floats have a really high-grade technology?

Yes and no. The technology for some of the sensors (temperature) has existed for decades while that for the pH and nitrate sensors is very new.

How much does a SOCCOM float cost? Why does buying one float cost so much?

The total cost is about \$110,000 per float. A significant fraction is labor. With research it usually turns out that parts are inexpensive but trained people are not. The SOCCOM grant is very unusual in that about 50% of the total funds are devoted to equipment (floats)

Are there different types of floats?

There are different brands of the basic float, but they are all very similar. A SOCCOM float can use any of the commercially available basic floats as a base instrument – then the extra sensors are added. To date SOCCOM floats are either Navis or Apex.

Will you ever upgrade the float?

A SOCCOM float IS an upgrade of an Argo float. Undoubtedly, improvements and increased capabilities will continue. For example, we'd love to have a sensor that directly measured dissolved inorganic carbon or alkalinity, that could work on a float.

Can engineers make bigger and more powerful versions of the floats?

The only reason to make a new version would be to include either new or improved measurements. As soon as improved sensors are invented/developed the SOCCOM float will be adapted to use those sensors. Larger floats could be constructed, but the only reason right now would be to carry additional batteries. A larger float would be more expensive and more difficult to launch.

What type of batteries do the floats use? Why do you use D cell batteries in the float? How many batteries do the floats use? How much does it cost for batteries in a float? How many batteries do you buy at one time?

In my early presentations I said that the floats use high quality D-Cell batteries. That was NOT correct (yes, we make mistakes too ☺). Now for the correct information:

There are some variations but, generally speaking, there are four 15-Volt packs that power the float; each pack consists of four individual cells. So, I could reasonably respond that the float is powered by four battery packs or else sixteen cells.

In addition, there are five cells that maintain the reference state of the pH sensor. These cells do not power the float.

Each pack costs \$300.

We buy them by the pallet-load from Electrochem, the original manufacturer. We buy about 400 packs once each year...all at once, in order to get volume discounts.

How long do the batteries last? How do the batteries last so long?

SOCOM floats are designed to last about 5 years with a cycle time of 10 days using the normal number of batteries. If the cycle time is shortened the lifetime would be shortened. The batteries last so long because the sensors are designed to use as little power as possible.

What makes a SOCCOM float smart enough to know exactly how to do its job without messing up?

Each float contains a computer that controls all operations. We can program that computer so that the float does whatever we want within the design specifications.

How do they program the float?

The program is developed on a “regular” computer then copied onto semi-permanent memory on the float computer. Some parts of the programming can be changed after the float is launched using the satellite communication.

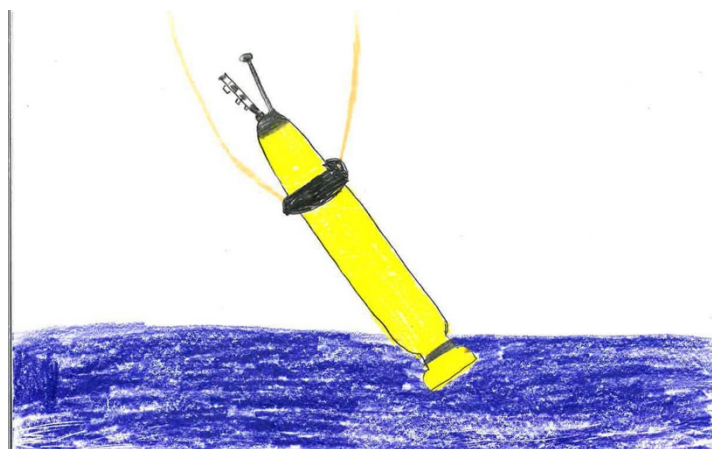
How long do most floats stay under water?

A SOCCOM float can be programmed to stay under as long as we choose. For this program the floats will stay down for 10 days then rise toward the surface making measurements on the way up. If the ocean surface is ice covered the float will go back down without coming all the way to the surface. We’ve had floats that stayed under ice for as long as 9 months before making it all the way to the surface.

Why are the cycles so long?

The 10-day cycle time is a balance between power consumption and the processes being studied. If we cycled at 5 days the floats would only last half as long. Our scientific questions primarily require seasonal data and changes between seasons. If each season is about 90 days, we get 9 cycles/season. That is enough data to resolve the seasonal signals.

FLOATS IN THE WATER



How many floats are there?

How many floats will be launched?

The number of Argo floats (usually about 4000) can always be found at.

<http://www.argo.ucsd.edu> The number of SOCCOM floats (currently 128) can be found at <https://socom.princeton.edu> We were funded to launch about 180 SOCOM floats and have a proposal that will, hopefully, extend the program and the number of SOCCOM floats.

What was the first SOCCOM float to go into the water?

The first official SOCCOM float was launched Dec. 5, 2014 from the R/V Polarstern. We did launch a few un- official floats in March 2014. The primary difference is funding source.

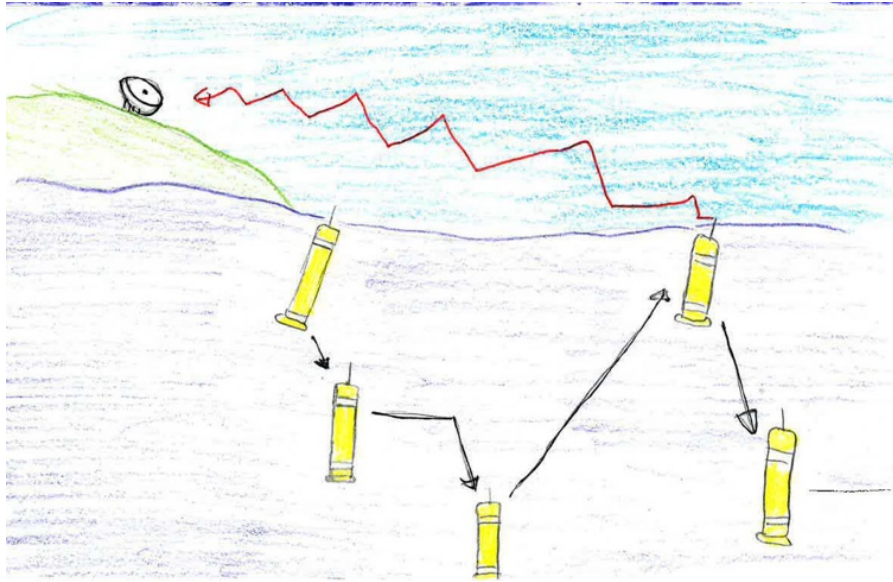
How often do you launch the SOCCOM floats?

The floats are launched from available research vessels during the Southern Ocean summer season; late November – early May. We typically launch about 30-35 floats per year.

Do you put the SOCCOM floats in the same place?

How do you pick the location to launch a float?

On one occasion we did launch 2 floats from the same location at the same time, but this was for a very specific experiment. Typically, we want to evenly distribute the floats around the Southern Ocean. Launch position is chosen by examining the existing positions of previously deployed floats and using computer models to try to predict where the float will drift after launch.



Why do floats go down for a while and go about 10,000 meters?

The floats sink to 1000m (not 10000) and drift at that depth for 10 days. At this depth the drift is a bit more predictable and more importantly, the biological contamination of the sensors is much less than at the surface. Once the 10 days pass the float sinks to 2000m then samples up to the surface. How far each float drifts (horizontally) is unlimited and controlled by the local current strength.

How long does it take to make one SOCCOM dive?

It takes about 1.75hr to get from the surface to 1000m. After waiting 10 days it takes another 1.75hr to then descent to 2000m. The rise to the surface while making measurements lasts about 3.5hr.

How long does a SOCCOM float spend under water?

The duration of each cycle can be changed by programming. SOCCOM floats are set to stay down 10 days/cycle. However, if the surface ocean is ice covered, the float can stay down much longer. The current record is over 9 months. No data is lost as long as the float eventually makes it back to the surface.

How do the SOCCOM floats know when they have reached the depth they need to go?

The floats measure pressure and pressure is VERY closely related to depth.

How does the bladder work?

Do you help to sink the floats?

How do the floats come back up?

Each float is equipped with a piston that can move oil into a bladder or allow oil to be expelled from the bladder. The piston movement is controlled by a motor. The motor/piston/bladder together are called the buoyancy engine. When oil is forced into the bladder the bladder expands (like air into a balloon) and the float rises. When oil leaves the bladder, it flattens and the float sinks.

How long does it take the float to come up?

The floats rise at a rate of 6 m/minute, so it would take about 3.5 hours for them to ascend from 2000m. Rates are about the same going down.

Do the floats always follow currents when they are dropped into the ocean?

The floats move with the water that surrounds them, but there are other (smaller scale) motions than currents. The most common small-scale motion would be an eddy that is like a little whirlpool. Sometimes a float gets into an eddy and moves in little circles while the entire eddy is carried along by a current. Sometimes deep currents move in different directions than surface currents. In this situation a float can move in one direction when it is deep and a totally different direction when it is shallow. When averaged over time the floats do move with the current. Interestingly, if we put a float in a place with no strong current it will often migrate toward a nearby current. Floats tend to converge into strong currents.

How long can a float last underwater?

What if the float is under a big piece of ice and can't get out?

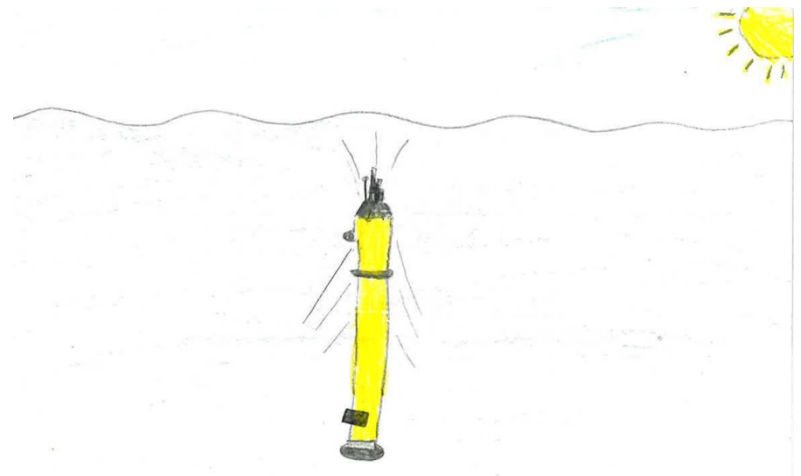
Theoretically a float could function underwater its entire life (about 5 years). However, if that happens it wouldn't have any value since it can only transmit data when it is at the surface. We had one float that got "stuck" in bottom sediments and stayed under about a year before it broke free. Another spent about 9 months under ice before surfacing. Once these two got to the surface they transmitted all the data collected while under water and then continued normal operation. One other issue, when the float moves under ice we do not know where it goes – all we really know is where it went down and where it finally came up.

What happens if a float is coming up and hits an iceberg or hard surface?

It would probably break the satellite antenna. The float would not be able to communicate and thus would effectively be dead. The other sensors on top of the float are also somewhat fragile.

How does the float's coding tell it to stop when there is ice above? Does the float only come back up when it has calculated the temperature?

The ice-sensing algorithm (math) coded into the floats exploits the notion that in winter, under Antarctic sea ice, there is generally a surface mixed layer in temperature, salinity, and density that is at least 100 m thick and has a temperature near the freezing point of seawater (at the local surface salinity and zero pressure). The temperature between the shallowest point, a depth of 13–15 meters, and about 80 meters is constant to within about 0.02°C. This is typical of the mixed-layer under Antarctic sea ice in mid-winter. The ice-sensing algorithm used on SOCCOM floats simply computes the median temperature T_{med} of the water column between depths of 50 m and 20 m on board the float during ascent and compares this to a reference temperature T_{ref} , chosen for University of Washington Argo and SOCCOM floats to be -1.78°C . If $T_{med} < T_{ref}$, it assumes that ice is present above and the float terminates its ascent, stores its profile data, and begins to descend back to its parking depth p_{park} to begin its next cycle.



How many ARGO/SOCCOM floats come up every year?

All of them that are still functioning

Have any of the floats stopped working? What happens if a float is damaged and how is it repaired? Do you ever take the floats out of the water?

Eventually, every Argo/SOCCOM float stops working. To date, a few thousand Argo floats and about 20 SOCCOM floats have died. The most common cause is loss of power (dead batteries), but leaks sometimes develop and instrument sensors also fail. We do the best job we can to build a reliable float, but the ocean is a very difficult environment for electronic equipment. Damaged floats are almost never repaired because it is MUCH too expensive and difficult to retrieve them. On one or two occasions we have taken advantage of a passing ship and had them retrieve a functioning float so that we could test the float calibration. You can always check the status of every SOCCOM float at this website
http://socom.ucsd.edu/floats/SOCCOM_float_stats.html

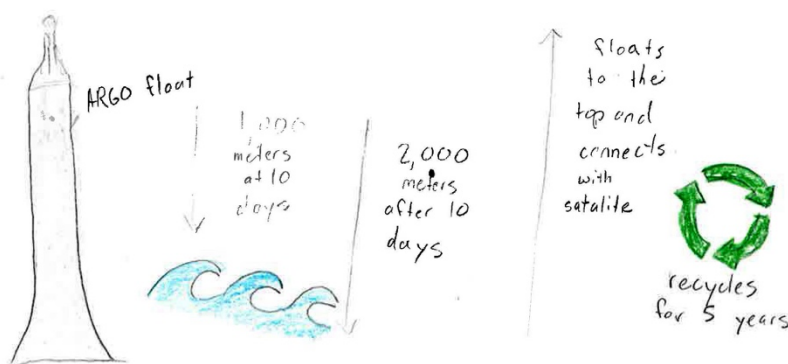
What will you do if a fisherman catches one of the floats? How many animals attack the float? Does a leopard seal or penguin mess with your equipment? Have any of the floats been destroyed by plants?

I'm not sure, but would guess that a few Argo floats have been "caught" by fishermen. There is nothing we can do about that, but if the float is not damaged in the process we would know where the fishermen took the float. So far, no SOCCOM float has been "caught".

There would be no reason for a student to ever bite the leg of their desk – it wouldn't taste very good and you might chip a tooth. For the same reason it is unlikely that any large animal would ever attack a float – they just don't look like food. On the other hand very very small plant-like organisms as well as animals (plankton and similar) will attach to and grow on the float sensors if the float spends very much time near the surface. This sort of growth will almost always mess up the measurements and if bad enough totally stop the sensor from working.

Do barnacles latch onto the float to make it heavier?

If a SOCCOM float is functioning normally, it doesn't spend enough time near the surface for barnacles to attach. If a small one did somehow attach, the trip down and pressure change would likely kill it. If not that, then the rapid ascent from 2000m certainly would.



Thank You!

What happens to the float after it finishes a 5-year cycle?

Eventually the batteries die and the float sinks.

Why do you guys just leave the ARGO floats at the bottom of the sea? Isn't there a way to replace the batteries?

It would probably cost \$1,000,000 to retrieve one float from the seafloor and replace the batteries (assuming it survived the pressure at the bottom).

We can build 9 new ones for that amount, so retrieval just isn't practical.

What are the difficulties of the SOCCOM floats?

The more common problems are: sensor failure; sensor drift (measurements change with time); water leak; short battery life, and of course the various costs.

Does your team ever become attached to the floats as though they are pets?

Some of the technicians that launch the floats have a special interest in their performance but I don't believe they think of them as pets. My favorite so far is "The Floating Falcon" because it spends so much of its time under the ice.

DATA AND SATELLITE COMMUNICATIONS

How can the float hold so much data?

The floats use memory chips that are similar to ones used in your smart phone.

What do the satellites look like?

There have been variations, but for one example see

<https://www.satellitetoday.com/launch/2019/02/07/iridium-officially-completes-iridium-next-constellation-upgrade/>

How long do you spend gathering data? How long does it take to gather all of the information from the floats? How long does it take to transfer the data from a single profile?

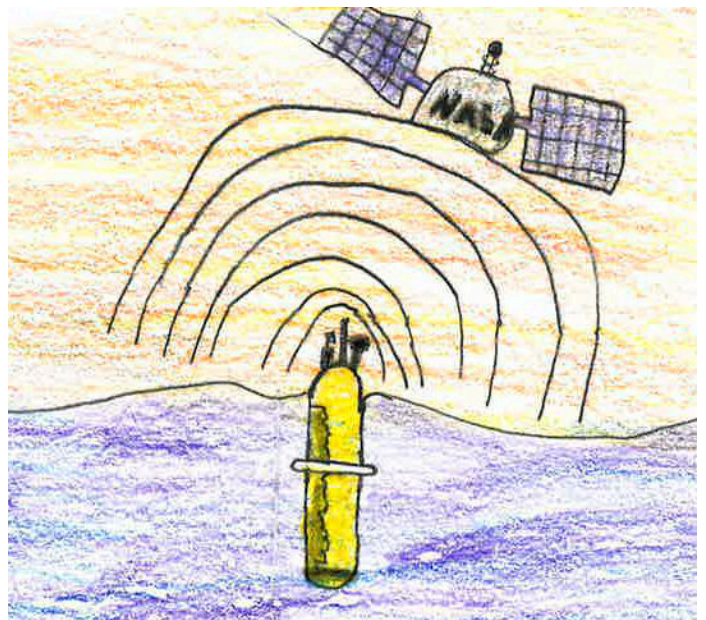
All the data, including engineering logs, from 1 profile is about 110 kbytes. Iridium in theory transmits at 4800 baud. So $110,000 \times 8 / 4800 = 183$ seconds = 3 minutes. That ignores any errors, retries, disconnects....

The float is allowed 15 minutes to transmit and receive data. So, it could send up to about 5 profiles in one surfacing. Then it goes back down.

How do the signals get to the satellite?

How does the satellite give the information to the scientist?

Signals travel back and forth to the satellite as electromagnetic waves. This transmission is identical to that for people who get TV signals from a satellite rather than by cable.



How long do you spend at your computer receiving data?

When things are working properly, it only takes a few minutes to transfer the data from one profile back to shore. If a float has been under the ice for months, it still collects profiles (except for the very surface). In this case only a portion of the accumulated data is transmitted each time the float finally does surface.

How long does it take to go through all the data?

So far, we are still learning the best ways to calibrate the float data. That can take many hours and lots of tests. The total time depends on how well the float sensors behave. Once we have decided on a calibration procedure for the float, subsequent data processing is generally done automatically. However, someone always looks at the data to make sure that calibrations haven't changed with time. Once all of the "bugs" have been solved most of the data processing will be automated.

BEING AT SEA

How long do the teams who go to Antarctica stay there?

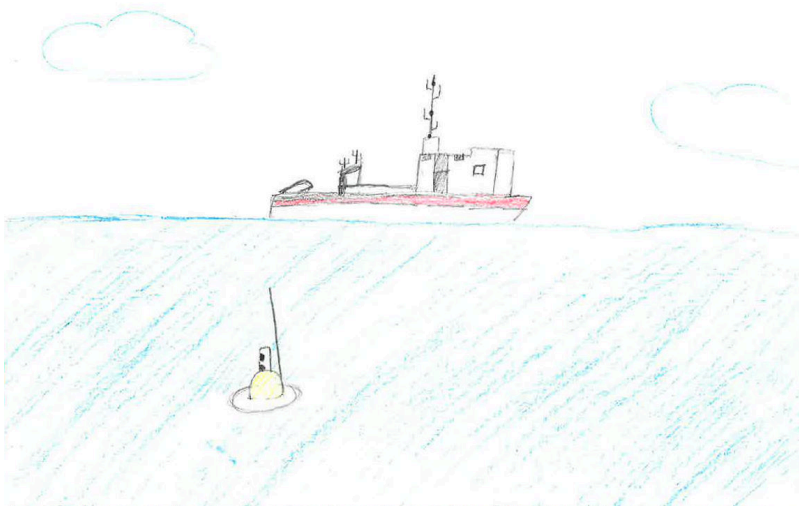
Scientists who work on Antarctica typically go for a summer season (about 3 months). A smaller number "winter over" (6-12 months). Cruises into the Southern Ocean are shorter, typically lasting 6-10 weeks.

What else did you do around Antarctica other than the floats?

Launching floats is usually only a small part of what happens on a research cruise to the Southern Ocean. For SOCCOM launch cruises most of the effort is dedicated to collection and analysis of water samples aboard the ship. The exact list of measurements varies from one cruise to the next. Some cruises are biologically oriented rather than for chemistry and physics. On a biological cruise very different sampling methods are used (net tows, filtrations, fish/plankton catches, etc.). Other cruises are geologically oriented and they frequently focus on collecting sediment samples or doing seismic surveys.

How do the Rosettes collect water samples?

A Rosette holds twelve or more sample bottles. Each bottle consists of a plastic tube with two plastic end caps. The caps are attached to each other by a spring that passes through the middle of the bottle. While the Rosette is being lowered the caps are held in the open position by cords. The other end of each cord is attached to an electronically controlled release device. Whenever the person running the cast wants a water sample he has the winch operator stop the ascent. The operator then pushed a button that releases the cords holding the end caps. The spring pulls the two end caps into the closed position thus capturing a bit of the water from that depth. The seal between the caps and the sampler tube/body is both watertight and gas tight so that no contamination occurs as the Rosette is subsequently raised.



How are the icebreakers built?

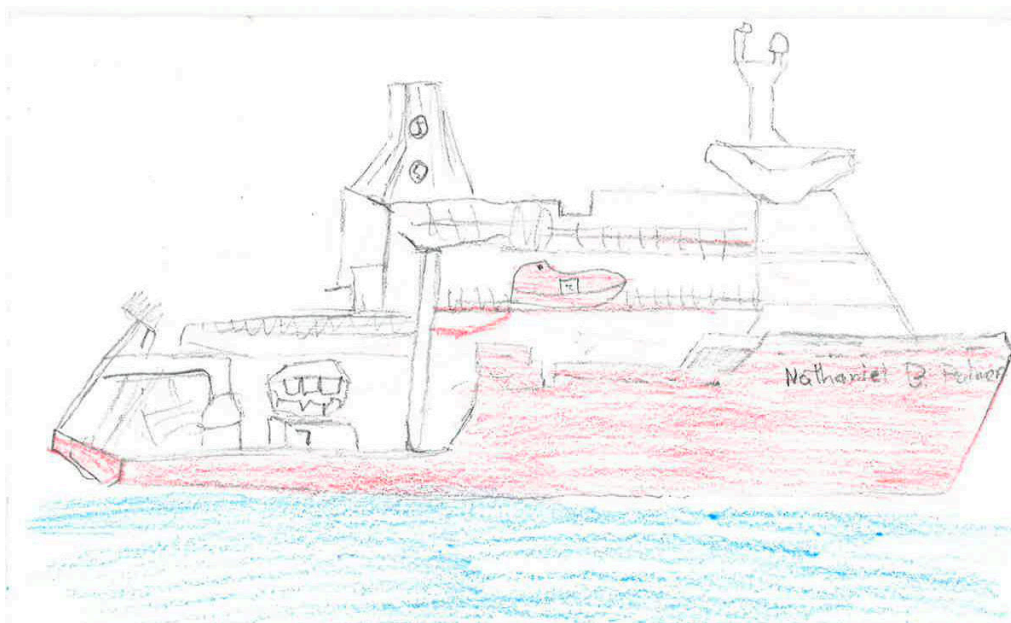
Icebreakers are normal ships except that they have an exceptionally thick hull with a rounded bow and they generally have much stronger engines than other ships of comparable size and use. The R/V N.B. Palmer was built in a normal shipyard in Louisiana.

Why doesn't the US have big icebreakers like Russia?

The U.S. has no need for large (nuclear) icebreakers because all U.S. territories have access to ocean waters that do not freeze over. The U.S. has no large ports in Arctic waters.

How heavy is the US Icebreaker?

I have no idea. The gross tonnage for R/V Palmer is 6174, but this is a measure of the internal volume, not the mass. To calculate the mass, you would need to know how much water the ship displaced. This will change depending on how the ship is loaded. Fuel and water are probably the greatest variables in the mass or weight. Like anything else, a floating object displaces its own mass.



When was the R/V Palmer finished?

The R/V Palmer was launched and put into service in 1992.

How much does the boat cost?

I don't know what it cost to build the R/V Palmer. Operational expenses are in the ballpark of \$60,000/day for ship, crew, food and fuel. All the science is extra and paid from different budgets.

What type of fuel do the boats use?

I believe that all the larger boats in the research fleet are "diesel-electric". This means that diesel engines turn generators to produce electricity. That electricity is used to power electric motors that propel the boat.

How many people are on the boat?

For the major research vessels the number of crew + scientists vary between 25-60. The icebreakers have about 60.

Where do you sleep on the R/V Nathaniel B. Palmer?

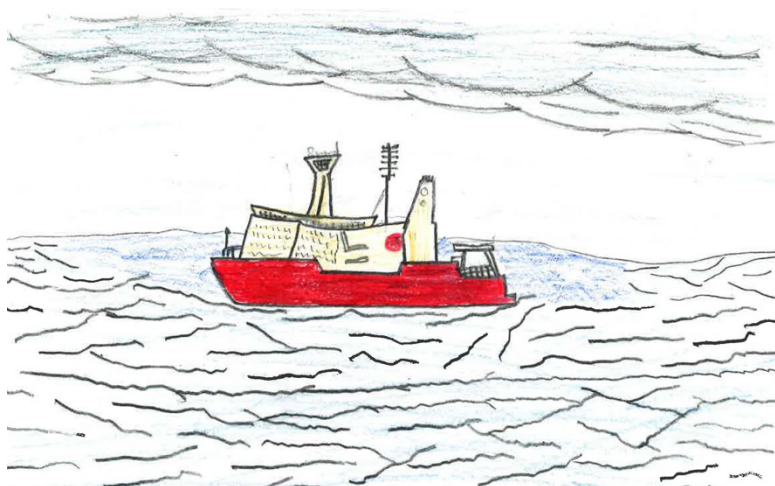
Scientists stay in "staterooms", generally 2 people/room. On the R/V Palmer most scientific staterooms are either one deck above or one deck below the main deck.

What do you do for entertainment while traveling to places like Antarctica?

Recorded movies, ping-pong, exercise room, reading, card games, walking the deck, wildlife watching, looking at polar lights.

Have fish ever hopped on the ship?

Yes. In warmer waters flying fish are often found on the main deck in the morning. Occasionally, one will collide with someone walking on deck. It's a huge surprise, but I don't know anyone who was ever hurt by such a collision 😊



What's the best/favorite food on the boat?

What food is on the ship?

How did they preserve it and make it warm?

Research vessels are fitted with very large freezers and refrigerators. When they sail from port both are generally filled to capacity. What you eat and the quality of the food is highly dependent on the ship and the cooks. It is not unusual for the style to reflect the home port. So, for example, food on the R/V Palmer has a

southern and Cajun flair while the food on boats that have Woods Hole, MA as home port are more typical of New England cooking. Regardless of the vessel, fresh food (salads, fruit and similar) always runs out before the cruise is over. Ice cream, on the other hand, almost never runs out. Overall, the food tends to be rather good. Many people, if they are not careful, will gain weight during a long cruise. Cooking aboard a research vessel is the same as on shore except that all the ovens and cooktops are electric (no natural gas).

Has anyone you've known died from the cold on this job?

No. Occasionally there is a death on a research vessel, but most commonly it is from stroke or heart attack. There have been accidental deaths, but that is rare. I have not investigated, but it would not be surprising if freezing had occurred for someone wintering over on Antarctica. Death by natural causes is kept to a minimum by having all shipboard members undergo a **very** thorough physical exam prior to sailing.

SCIENCE QUESTIONS

Is it cold in the Antarctica and the ocean?

The lowest temperatures ever recorded on Antarctica (-89.2°C ; -128.6°F) are much colder than over open ocean water. When I was aboard Palmer while in the ice with winds blowing off the continent, we had a low air temperature of about -40°C .

How can you find the data the SOCCOM floats have collected?

There are several ways to get SOCCOM float data. The easiest way to get data from a single adopted float is the SOCCOMviz web site <http://www3.mbari.org/SOCCOM/AdoptAFloatviz.htm>

How long does it take one float to go around Antarctica?

The expected lifetime of a SOCCOM float is about 5 years. It would take significantly longer than that to circumnavigate Antarctica.

Is it possible to send the floats to other oceans?

Yes. Both Argo and biogeochemical (like SOCCOM) floats are deployed in every ocean basin except for the Arctic. There are lots of Argo floats, but only a very few biogeochemical floats. We hope to change that!

Why aren't more SOCCOM floats produced?

Right now, all SOCCOM floats are largely assembled in university labs. This is good for development, but poor for large scale productivity. As the problems are solved we will transfer manufacturing from the university setting to a commercial facility. Once that happens construction numbers can be increased and costs may come down.

What is the Antarctic current called?

Why does the Antarctic Circumpolar current only flow east?

The Antarctic Circumpolar Current flows eastward due to the rotation of the earth and the primary wind direction at that latitude

How can getting all the different substances help with calculating the CO₂ levels?

We measure one of the carbon system parameters, pH. Currently no sensor exists that can be placed on a SOCCOM float to measure the other three carbon system parameters, pCO₂, total dissolved inorganic carbon and alkalinity. Fortunately, alkalinity varies in a relatively simple manner with other parameters that

can be measured (temperature, salinity, nitrate and/or oxygen). Mathematical relationships have been developed using shipboard data that accurately quantify alkalinity as a function of these other easily measured parameters. We use those relationships along with data provided by the float sensors to estimate alkalinity. Once we have pH and alkalinity the other two parameters (pCO₂ and DIC) can be easily calculated from known chemical reaction equations.

How much carbon is in the ocean?

The largest pool of carbon in the ocean is inorganic.

1. *The total oceanic inorganic carbon is about 38,000 petagrams C. One petagram is 1,000,000,000,000,000 grams. Multiply those two numbers and you will have the mass of carbon in grams. Divide that huge number by 454grams/pound to convert to pounds.*
2. *Alternately, we could start with an average ocean inorganic carbon concentration of 2000micromoles/kilogram. Divide that by 1,000,000 to get moles/kg then multiply by 12 grams/mole to get grams carbon/kg water. Divide by an assumed density of 1.028 kg/liter to get grams carbon/liter seawater. Estimate the volume of the ocean in liters then multiply to get the answer.*

What is the difference between CO₂ in the oceans?

The chemistry of CO₂ in the ocean is a bit complicated. When atmospheric CO₂ dissolves it is initially just aqueous CO₂. This reacts with water to form carbonic acid (H₂CO₃). The carbonic acid dissociates to form bicarbonate ion and some of that dissociates to form carbonate ion. In normal ocean water most of the CO₂ exists as a mixture of bicarbonate ion (HCO₃⁻¹) and carbonate ion (CO₃⁻²). The relative amount depends on the pH.

Will climate change affect the floats?

No. Climate change will slightly decrease seawater density due to warming, but the floats have more than enough ballast control to compensate.

Will some of the United States be flooded in 2050?

Yes. The real question is, "How much?" Computer models can make estimates of the amount, but the farther into the future one predicts, the larger the uncertainty.

Are the results looking good?

YES! There are disappointments: some sensors fail, entire floats die, batteries don't last as long as predicted, floats don't go where we'd hoped, a few floats have even been mired in bottom sediments! Nevertheless, the floats are provided a huge amount of data with quality near expectations and in places and times where no/little data previously existed. To date (May, 2019) 82 scientific papers have been published and even more articles, dissertations, reports, etc.

What is the most exciting or weird thing that the SOCCOM floats have found?

Have you discovered any new things about the ocean?

The most exciting new data concern the chemistry under the ice and the flux of CO₂ across the air-sea interface. Now that we have winter data the early indications are that the Southern Ocean is not taking up as much atmospheric CO₂ as we had thought. More time and data are needed to support/confirm these early results.

How much does all this cost? How much money does it cost to do this research?

The total SOCCOM budget was about \$25,000,000. About half of this was used to purchase parts and build approximately 200 floats. The remainder was used for shipping, shipboard sample collection and measurement, data management, travel for meetings, publication charges, and graduate student/post-doc funding.

PERSONAL QUESTIONS

Have you ever been to Antarctica?

Have you ever stayed in Antarctica?

Technically no. I have been close enough to swim to shore. I have been close enough to walk over ice to shore, but I have never set foot on the land, just the adjacent ice :-)

How do they warm up the food in the ice restaurant?

The ice “restaurant” at the German research stations is, I think, just for fun. I don’t think they serve food or drinks. One could, however, take food from the dining hall out there to eat if desired. Cold cuts might be a good choice ☺



How many missions have you been on? How many times have you been on a boat? How many cruises have you taken?

I don’t remember how many cruises I’ve been on, but the last time I estimated, the total time at sea was more than three years. Most of my cruises were between 1973 and 1996, the most recent in 2010.

Have you ever fallen in the Antarctic ocean?

Fortunately, no. Falling into water that cold would be EXTREMELY dangerous and quite possibly fatal.

Have you been swept out of that big door when you were watching?

No. I don’t believe that anyone has ever been washed out the equipment hatch on the R/V Palmer.

How many more cruises will you go on? How long do you stay on the boat?

It is unlikely that I will go to sea again for an oceanographic cruise. If I did, it would be one that stopped at Antarctica so that I could get ashore. Most of the cruises that I went on lasted 6 to 12 weeks, but I have been on ones as short as 3-5 days.

How many times have you been on the R/V Nathaniel B. Palmer?

I only sailed aboard the R/V Palmer once. It was in 1996, lasted about 10 weeks and was during the Antarctic winter, so most of the time it was dark 24hours/day.

How many days did you stay on the water near Antarctica?

A total of about 20 weeks on various cruises over the years.

What is the longest amount of time you have been at sea?

Ten weeks without making port; fourteen weeks for back to back cruises.

What was your favorite ocean that you have visited so far?

The waters around Antarctica are certainly the most spectacular for many reasons, but sailing in warm tropical waters is also nice. Being on an oceanographic cruise is hard work, but I always enjoy the simplicity of life at sea and solitude that can come from being out there. Having said this, I should add that there is an old sailor's adage that goes, "No matter how long the cruise, you couldn't stand it one more day!" The simple translation being that is always nice to get back to shore also. My viewpoint is positively biased by the fact that I don't get seasick.

Have you ever encountered a seal, or an orca, or a penguin?

Yes! I've seen all three on various cruises, also some of the larger whales, but I have never seen a sperm whale.

Have you ever seen an iceberg break off?

Never in person, only movies. I have a trip planned to the coast of Alaska next year and hope to see calving there. I have seen icebergs flip in the open ocean and that is also amazing!

Did you ever hit an iceberg so hard you fell over?

No, I've never hit a berg while aboard ship. We did encounter a lot of thick seasonal pack ice aboard my R/V Palmer cruise, but icebergs are quite different. When an ice breaker is making way through pack ice, the ice sometimes does stop the ship, but the stops are not violent/fast. If we hit an iceberg at any speed faster than "dead slow" the ship would be damaged.

Have you ever launched a float? What is the biggest float you've ever launched?

I never launched a SOCCOM float, but I have launched Argo floats and various earlier versions of other floats. All of the floats I launched were the same size (more or less) as the demo SOCCOM float.

When you are on duty are you scared?

Typically, no, but I have been scared twice while at sea:

- 1. In 1979 in the middle of the Pacific we lost all ship electrical power aboard the U.S. Research Vessel Gyre.*
- 2. In 1989 in a horrible storm in the northern Weddell Sea aboard the German R/V Meteor (this was worse than catching the outer part of a hurricane in 1983 aboard the U.S. R/V Knorr in the northwestern Atlantic).*

How far have you gone into the ocean?

I have sailed all the way across the Atlantic, Indian, and Pacific Ocean basins. With respect to depth, I have only been to about 40 meters while scuba diving off Fiji and again near Mauritius (most of my diving was 20-30 meters) and all of my diving was recreational. I have collected water and sediment samples from 12,000 m (7.46 miles) deep.

How bad were the hurricanes you went through?

I do not know what category the two hurricanes I encountered were, however, going through any hurricane at sea is dangerous, destructive, and scary. In the Weddell Sea storm, we experienced 90kt (104mph) winds for almost 36 hours.

How are you at the computer?

If I tell my computer to jump, it asks how high and what direction on the way up ☺. But seriously, I'm pretty good. I ran my first program in 1971, first used a small computer in 1974, and bought my first microcomputer in 1980. On that microcomputer, some of the first programs I wrote were in assembly language. Since then I've primarily programmed with RATFOR, FORTRAN, S, SPlus, R, and Matlab. On the other hand, you are undoubtedly better with your smart phone than I am... if you gave me \$100 I still couldn't take a decent selfie.

How long do you look through data?

I spend about 20-50% of my available time doing various procedures with ocean data sets (collection, assembly, quality control, formatting, etc.) The amount of time it takes me to process the data from one cruise varies greatly and depends primarily on the quality and organization of the data I initially receive from the people making the measurements.

How long have you been working with/on/for SOCCOM?

SOCCOM began in 2014 and I have been a part of the program since the start. SOCCOM covers 33% of my time/salary. The remainder is covered by other projects.

Why do you think your job is exciting? Why do you like your job or SOCCOM so much? What is your favorite part of doing this job?

I enjoy my job for many reasons (in no particular order):

- 1. It involves a lot of travel to really unusual places. I've visited about 60 different countries, sailed in every ocean basin, and seen lots of really neat places and animals.*
- 2. I get to work with smart, interesting people*
- 3. I get to do many different things. Some in the lab, some in the office, and some aboard a research vessel*
- 4. I get to learn new things all the time*
- 5. Occasionally, I know something that no one else knows ☺*
- 6. I get paid a very reasonable salary to do what I love*
- 7. I get to work with interesting and curious young students*

How many years have you been studying all this?

I began studying oceanography in 1973, so about 47 years.

How did you come up with the idea to show people SOCCOM floats?

It wasn't originally my idea. One of the young people working at Climate Central thought of the Adopt-a-Float program. I thought it would be fun for me and the adoptive students if I could have an adoption in every state and additionally visit each of those schools. I don't know if I will complete either goal, but it has been great fun so far and the students seem to enjoy getting to meet a real oceanographer.

How many schools have you visited?

As of spring, 2019 my wife and I have visited:

AL – 1 (electronic)

AR – 1

IL – 1 (teachers conference)

LA – 1

NJ – 2

NM – 1

OK – 1

PA – 3

TX – 2

WV – 1

This fall we hope to visit New England as well as other locations (NY, CT[2], RI, MA, NH, VT, ME[2]) and we're going to try for one more trip in the spring of 2020. I have also scheduled a visit to Sandwell, England in early October.

How much do you get paid a year?

The pay for people who call themselves oceanographers varies all over the place depending on education, exact job and experience. A technician with a BS degree would earn over \$40K. With a MS that would increase to \$40-80K. Significant overtime is possible for technicians when at sea because of the very long hours. Currently, the salary for a new PhD is about \$65K. Past the PhD level salaries range from \$65K-\$300+K. The higher number would be for a full professor at a major research university; government jobs max out at about \$185K, but at low and mid ranks government jobs tend to pay better than university jobs. Jobs with other non-profit organizations (not university or government lab) generally, but not always, have lower salaries. Jobs with professional (for profit) companies tend to be higher for the same level of expertise.

Bottom line is that you earn enough to live comfortably. How comfortably depends critically on life style and location.

What was your childhood dream?

I wanted to be a physician. Fortunately for me, that didn't happen. I'm certain that I'm much happier as an oceanographer!

Could I ever get a job with the floats?

Absolutely! Keep working on your STEM classes. All jobs would require at least a 2-year college degree and most a 4-year degree (BS or similar). Research scientist positions are all Ph.D. level. So, the amount of training depends on what you'd want to do.

Why do you have to measure icebergs if we have the SOCCOM floats to check out the deep water for the temperature?

We do not measure icebergs. There are other scientific investigations that do try to track the total amount of ice included in glaciers, snowpack and seasonal ice. Most of these are done with satellites.