

# Is Oceanography Science?

Language, Culture, and Standards of Proof

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ATOC6020: Oceanography Seminar, Fall 2009

Duane E126 8/31/09, 16:00-17:00



# Outline

- What is science anyway?
- How Oceanographers Use Language
- The Oceanographic Culture
- What is proof in oceanography?



# What is Science?

- Karl Popper: The Problem of Demarcation
  - 1) Easy to look for confirmations of theory
  - 2) Confirmations must be risky
  - 3) Good theory prohibits something
  - 4) Theory that can't be refuted isn't science
  - 5) Every test attempts to prove theory wrong: genuine test
  - 6) Confirmation comes only from genuine tests
  - 7) Disproven theories may continue to be useful, but their scientific status is lowered.

From Curd&Cover: Philosophy of Science:The Central Issues



# What is Science?

- Kuhn: The Problem of Demarcation
  - 1) The majority of scientists do not enter the realm of testing laws
  - 2) They do so only in a private manner--trying out new ideas
  - 3) Thus, the majority of science is not like Popper's idea
  - 4) Instead, it is a process of systematic thinking and puzzle-solving.
  - 5) Failure of a researcher to solve a puzzle results in blame for the researcher--not his tools.

From Curd&Cover: Philosophy of Science:The Central Issues



# Oceanographic Language: Equivalent Barotropic

- Barotropic=density and pressure surfaces aligned; baroclinic=deviations from alignment
- Barotropic and baroclinic are \*colloquially\* in the oceanographic literature as synonyms for depth-independent and depth-dependent
- Equivalent Barotropic is the term for a moving set of upper layers over a motionless abyss--it \*can't\* be barotropic!
- Even worse--Meteorologists call something else equivalent barotropic!



# Oceanographic Language: Equivalent Depth

- Equivalent depth is the depth of a hypothetical homogeneous-density layer with a gravity wave speed matching the internal gravity wave speed of a mode of a stratified system.
- However, the \*actual\* depth--vertical scale--of the internal wave is \*not\* the equivalent depth
- So, isn't it just easier to use the speed of the internal wave?



# Oceanographic Language: Article Length

- Word limit: J. Phys. Oceanogr.: 7500 words
- Word limit: Phys. Fluids: None
- # pages average in last JPO: 16 (>7500 wds!)
- # pages average in last Phys. Fluids: 13



# Oceanographic Language: Few Equations per Article

$$\begin{aligned} & -\overline{u'w'} \frac{\partial \overline{U}}{\partial z} - \overline{v'w'} \frac{\partial \overline{V}}{\partial z} - \overline{u'w'} \frac{du_s}{dz} + \overline{w'b'} \\ & - \frac{\partial}{\partial z} \left( \overline{w'E} + \frac{1}{\rho} \overline{w'p'} \right) - \epsilon = 0, \end{aligned} \quad (1)$$

where  $\overline{U}$  and  $\overline{V}$  are the horizontal components of the current parallel and perpendicular, respectively, to the surface stress; the overbar denotes an average;  $w$  is the vertical component of the current, taken to be positive upward;  $\rho u'w'$  and  $\rho v'w'$  are the components of Reynolds stress vector, where the primes denote fluctuations from the mean;  $\overline{w'b'}$  is the turbulent buoyancy flux;  $\overline{w'E}$  is the turbulent energy flux;  $\overline{w'p'}$  is the pressure work flux;  $\epsilon$  is the dissipation rate due to molecular viscosity; and  $\rho$  is density. The Stokes drift is assumed to be parallel to the surface stress.


In Eq. (1) the first two terms on the left-hand side represent production of TKE due to shear in the mean current, the third term is production due to the Stokes shear, the fourth is the production or destruction of TKE through buoyancy forces, the fifth term represents transport of TKE due to turbulent fluctuations of the vertical velocity and pressure, and the final term is the destruction of TKE due to viscosity. The three shear terms in Eq. (1) feed energy into different velocity components. The terms involving the current shear feed energy into the horizontal turbulent velocities, while the term involving the Stokes shear feeds energy into the vertical component. Note that the Stokes term does not feed energy directly into the lateral component of the current; rather there is an exchange of energy between the lateral and vertical components, which does not appear in the TKE budget (Skillingstad and Denbo 1995).



# Oceanographic Culture: Days of Yore

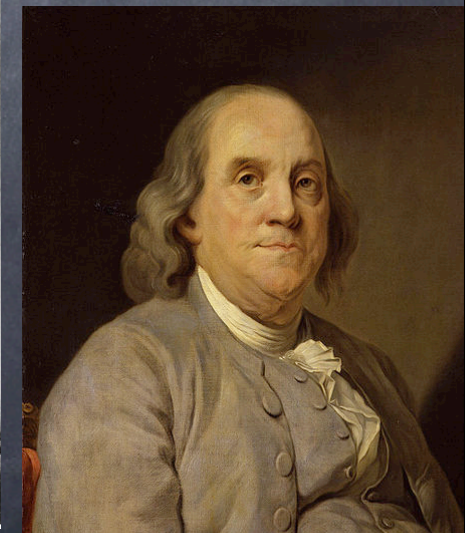
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While still a young man,  Charles Darwin joined the scientific elite



Topical Press Agency/Alton Archive/Getty Images





# Oceanographic Culture: Beginnings of Modernity

- The Scientists vs. the Crew--Bernard & Killworth
- There is now a cultural divide between oceanographers and mariners
- Mariners are Navy--organized, neat, hierarchical
- Oceanographers are scientists--erudite, erratic, reliant upon talent not order.



# Oceanographic Culture: Beginnings of Modernity

Years ago people (in marine science) were more at home on the sea. . . . They really were generalists and they knew how to handle themselves nautically as well as scientifically. Now our students are highly focused on a single problem from early-on in their careers.

voyage. Several scientists (mostly graduate students) attempted a behavioral change to affect communications with the crew. Specifically, they began peppering their speech with colorful swear words, in imitation of the mariners. Eight crew members interviewed on the subject uniformly said they did not feel that this was the way those graduate students talked naturally. Nevertheless, they felt that it was good that these men could “cut loose,” “be less reserved,” and “at least try to communicate.” One deckhand mused “I was going to say it’s good to see them let their hair down once in a while. But since they have such frigging long hair anyway it’d be hard to do.”

From Bernard & Killworth 73



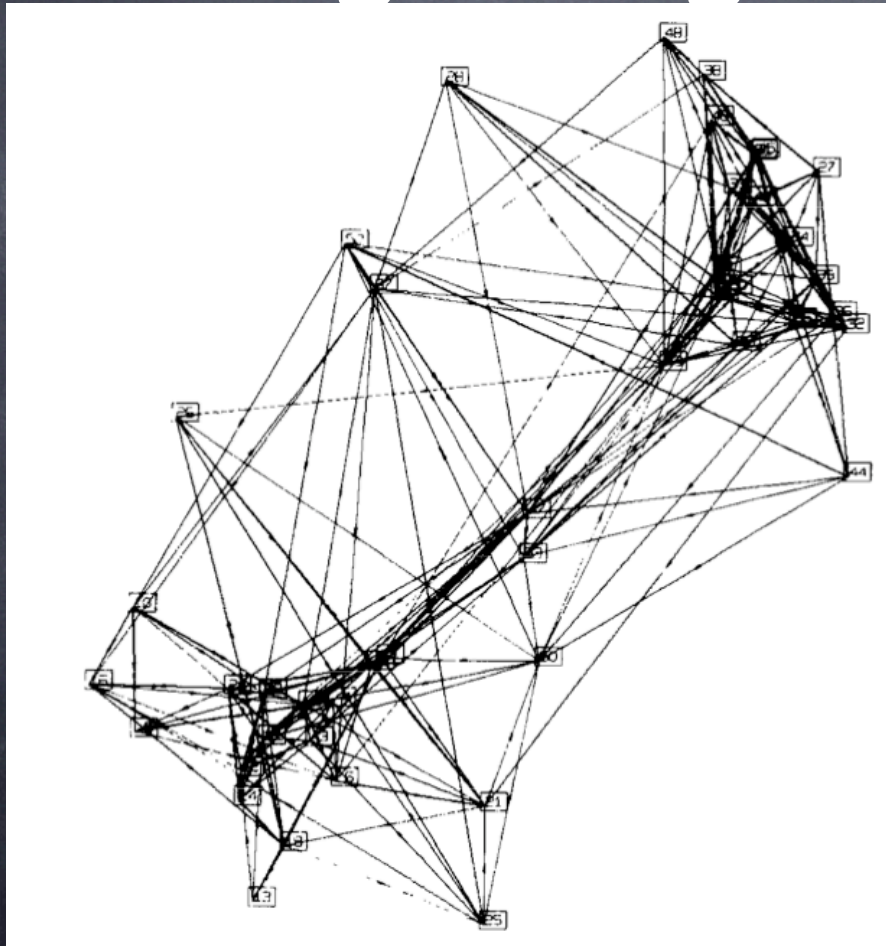
# Oceanographic Culture: Beginnings of Modernity

It wouldn't be so bad if those *scientificos* wouldn't treat us like goddam bus drivers. They don't know shit about running a ship but they like to play seaman once in a while for laughs. They go to sea for two weeks, get off in Tahiti, spend a week having a ball, go home for four months and then maybe take 2 more weeks at sea. And when they get back on the ship they're all fired up, fresh from the beach, and bombing out to get data. Meanwhile, we're still *on* this piss-pot and we don't have any grants to screw around with in Rio and Tahiti. We get a ticket home at rotation time and the goddam thing is dated the same day we get off the fucking boat.

From Bernard & Killworth 73



# Oceanographic Culture: Beginnings of Modernity



Scientists

Technicians

Captain & 1st Mate

Crew

From Bernard & Killworth 73



# Oceanographic Culture

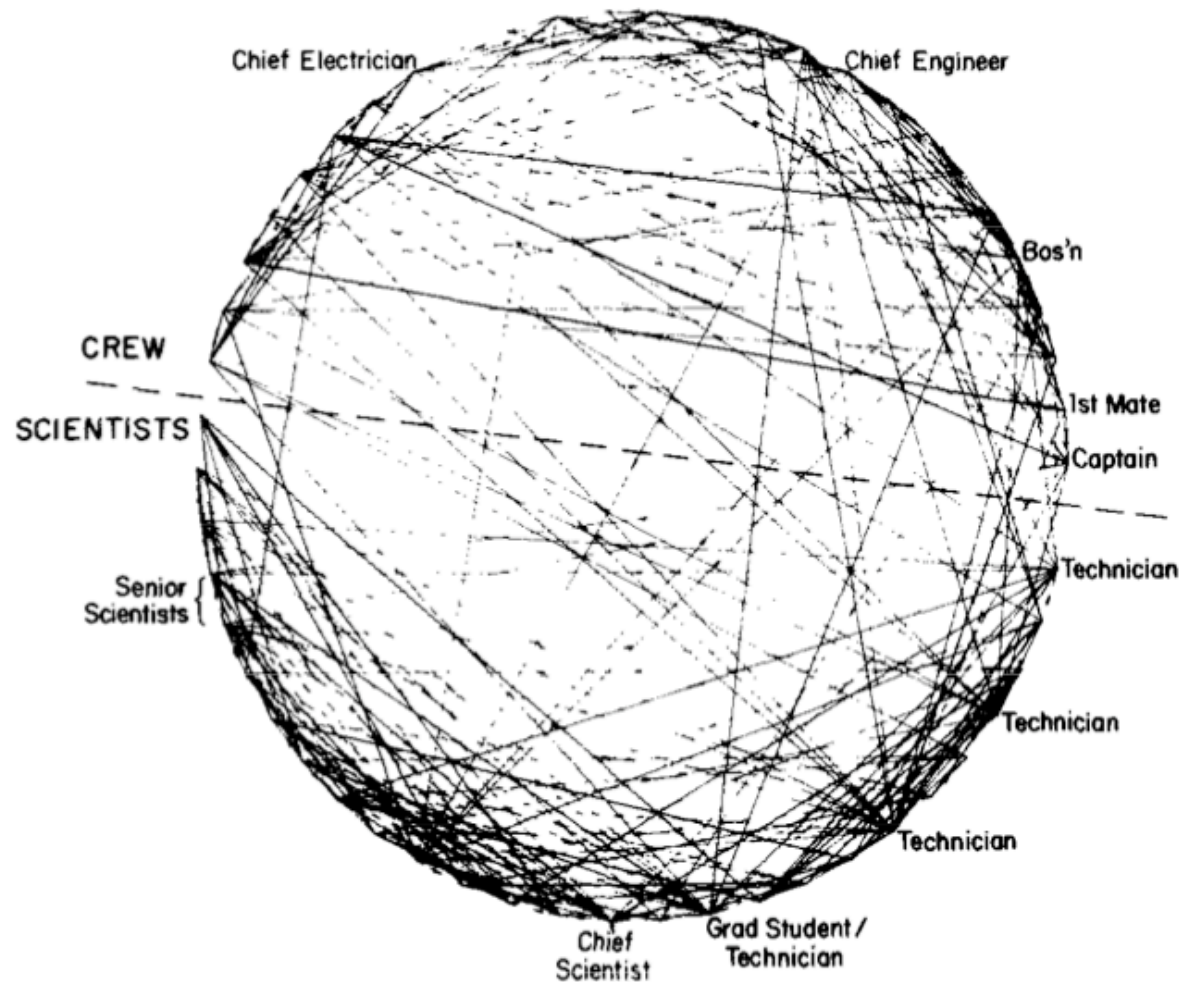


Fig. 8. Lines of perceived direct interaction. Beginning with the Captain, and reading anticlockwise, the identified persons are numbered 1, 2, 5, 11, 19, 30, 31, 41, 43, 47, 50, 53, respectively.

From Bernard & Killworth 73



# Oceanographic Culture: Persistently Salty, though



Roger Revelle after presenting Sir Edward Crisp Bullard with the Albatross Award of the American Miscellaneous Society in Edinburgh Scotland

**Albatross Award of the American Miscellaneous Society**  
Scripps Institution of Oceanography Archives



# Oceanographic Culture: Persistently Salty, though

The Albatross Award was established by the American Miscellaneous Society (AMSOC). AMSOC was christened by Gordon Lill and Carl Alexis of the Geophysics branch of the Office of Naval Research (ONR) in the summer of 1952 over a pile of proposals to that office that could be categorized no more closely than one at a time, i.e., they were all miscellaneous (Knauss et al., 1998; Shor, 1978). Knauss et al recounts (1998) that AMSOC was formed “to see the lighter side of heavier problems.” Carl Alexis provided AMSOC’s motto, *Illegitimi non Carborundum ... don’t let the bastards grind you down* (Knauss et al., 1998).



# Oceanographic Culture: Persistently Salty, though

- 1) Gordon Lill, John Knauss, and Arthur Maxwell received the Albatross Award in Washington, D.C. in 1959 “for conceiving the Award.” Knauss et al recounts (1998) that “since it was their idea in the first place, they gave the first one to themselves, knowing they might not otherwise be nominated.”
- 2) Walter Munk received the Albatross Award in New York in 1959 at the First International Congress on Oceanography “for work on tidal friction and the length of the day; for example, drive all cars to Fairbanks.” Knauss et al recounts (1998) that “there is more than one way to change the length of the day.”
- 3) John Swallow received the Albatross Award in Helsinki in 1960 at the International Union of Geodesy and Geophysics meeting “for innovative measurements of ocean currents both AC and DC.” Knauss et al recounts (1998) that “the deep circulation has never been the same since Swallow figured out a way to measure it directly.”
- 4) Harrison Brown received the Albatross Award in Hawaii in 1961 at the Pacific Science Congress “for contributions to political oceanography” Knauss et al recounts (1998) that “Harrison Brown was the first chairman of the National Academy of Science Committee on Oceanography, which is generally accepted as establishing wide-based support for oceanography in both the political and scientific communities.”
- 5) Victor Vacquier received the Albatross Award in Berkeley in 1963 at the International Union of Geodesy and Geophysics meeting “for displacing Pacific Ocean 700 miles.” Knauss et al recounts (1998) that “Vacquier and his magnetometer measured ... magnetic stripes and delineations in the Pacific.”
- 6) Henry Stommel received the Albatross Award in Tokyo in 1966 at the Pacific Science Congress “for having abandoned oceanography’s most cherished chairs.” Knauss et al recounts (1998) that “when Stommel first became unhappy with the Woods Hole administration he went to Harvard, then he accepted a brand new Captain Cook chair at Hawaii, only to say no to both Harvard and Hawaii and settle at MIT.”



# Oceanographic Culture: Persistently Salty, though

- 7) Sumner Pike received the Albatross Award in Woods Hole in 1968 at a National Academy of Science Committee on Oceanography (NASCO) meeting in Woods Hole in 1968 “for study of the oceans and other liquids after 5:00pm.” Knauss et al recounts (1998) that “Sumner Pike was the wise old man of NASCO, a former investment banker, and a member of the original Atomic Energy Commission. Pike brought wisdom and common sense to a committee otherwise made up of natural scientists.”
- 8) Bill von Arx received the Albatross Award in Tokyo in 1970 at a Joint Oceanographic Assembly “for contribution and confusion resulting from GEK (also for using big words).” Knauss et al recounts (1998) that von Arx was “the inventor and prime exploiter of the Geomagnetic Electro Kinectograph... [which] does measure ocean surface currents, sort of.”
- 9) Roger Revelle received the Albatross Award in Mexico City in 1973 at an American Association for the Advance of Science meeting “for coveting the bird over all other awards.” Knauss et al recounts (1998) that Revelle “was honored with [American Geophysical Union’s] highest honor, the Bowie medal... In his acceptance speech he said there was only one award he would rather have, the Albatross.”
- 10) Sir Edward Bullard received the Albatross Award in Edinburgh in 1976 at the Joint Oceanographic Assembly “for unintelligible geomagnetism.” Knauss et al recounts (1998) that “oceanographers had difficulty comprehending his studies of the Earth’s magnetic field resulting from movement within the core.”

**Albatross Award of the American Miscellaneous Society**

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# Oceanographic Culture: Persistently Salty, though

- 11) J. Tuzo Wilson received the Albatross Award in Toronto in 1979 “for making faults run backwards.” Knauss et al recounts (1998) that “his flamboyant graphics at meetings explaining mid-ocean ridge fronts were spectacular, even if not always acceptable.”
- 12) John Isaacs received the Albatross Award in Woods Hole in 1980 at the Third International Congress on the History of Oceanography “for unique and non-conventional ideas concerning the oceans.” Knauss et al recounts (1998) that “his ideas ranged from extracting energy from ocean salinity gradients to providing Los Angeles with fresh water from icebergs towed up the Pacific from Antarctica.”
- 13) Sir George Deacon received the Albatross Award in Halifax in 1982 at the Joint Oceanographic Assembly “for fathering Margaret and the Institute of Oceanographic Sciences.” Knauss et al recounts (1998) that “need more be said?”
- 14) Paul Scully-Power received the Albatross Award in Vancouver in 1987 at the International Union of Geodesy and Geophysics meeting “for finding a way to observe the ocean without going to sea.” Knauss et al recounts (1998) that he “was the first trained oceanographer to fly in space.”
- 15) Joe Reid received the Albatross Award at the Joint Oceanographic Assembly in Acapulco in 1988 “for his outrageous insistence that ocean circulation models should bear some resemblance to reality.” Knauss et al recounts (1998) that “he is fighting a losing battle, as modelers continue to multiply while those who analyze data scratch for a living.”
- 17) Robert Dickson received the Albatross Award in 1998 “for attempting to stem the flow through the Denmark Strait with a weir of current meters.” Knauss et al recounts (1998) that “it was a yeoman effort with 91 instruments on 20 stations arranged in three arrays.”
- 18) Michael S. McCartney received the Albatross Award in Honolulu in 2002 at the American Geophysical Union Ocean Sciences Meeting “for describing the Atlantic circulation with bewildering simplicity.”

**Albatross Award of the American Miscellaneous Society**

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# Oceanographic Culture: Persistently Salty, though

In 1961 Val [Worthington] became Ambassador to the Court of St. James from the Society of Subprofessional Oceanographers (SOSO), a three-member group which included Henry Stommel as President and Fritz Fuglister as Acting President. According to Fuglister, Val had shown him a story in a ONR newsletter about a new laboratory in Europe that was to be staffed by eight Ph.D.s and fifteen subprofessionals. "That is what we are," he said to Fuglister, "subprofessionals." Fuglister noted "I had to agree with him. By the same token, we both realized that it made Stommel and other subprofessionals an astounding thought!..."





# Oceanographic Proof: Stories vs. Hypotheses

- So evidently what one would have to do very soon -- and it is quite obvious that a lot of people have started to do that, fortunately -- would be to develop a physical theory of the thermocline, how it originates. Well, you will remember, some people have started on that and some have apparently even been successful in describing and forecasting the development of thermoclines. It seems to me that this would be the most fruitful approach to the whole problem, namely, to develop a theory, at first as simple as possible of course, and then see how it checks with the data. Then, as you find the theory does not work, you would either reject the whole theory or make it more elaborate.
- --B. Haurwitz, Conference on the Thermocline, 1953



# Oceanographic Proof: Models vs. Hypotheses

- A cynic's view of the process of model refinement (and tuning) is:
  - 1) Build a model on approximations of sound physical principles.
  - 2) Evaluate the biases of the model
  - 3) Violate the sound physical principles
  - 4) Evaluate the biases of the model
  - 5) Repeat steps 3 & 4 until 'success' is reached.



# The standards are getting better, thanks to you!

- It is now common for grad students to have an appreciation of:
  - Statistics
  - Nonlinear dynamics
  - Numerics/Model errors
- Also, data density is increasing, so:
  - The temptation to 'read' the data beyond what is present is decreasing.



# Floats Change Everything

ALL Subsurface DATA  
Before 1980

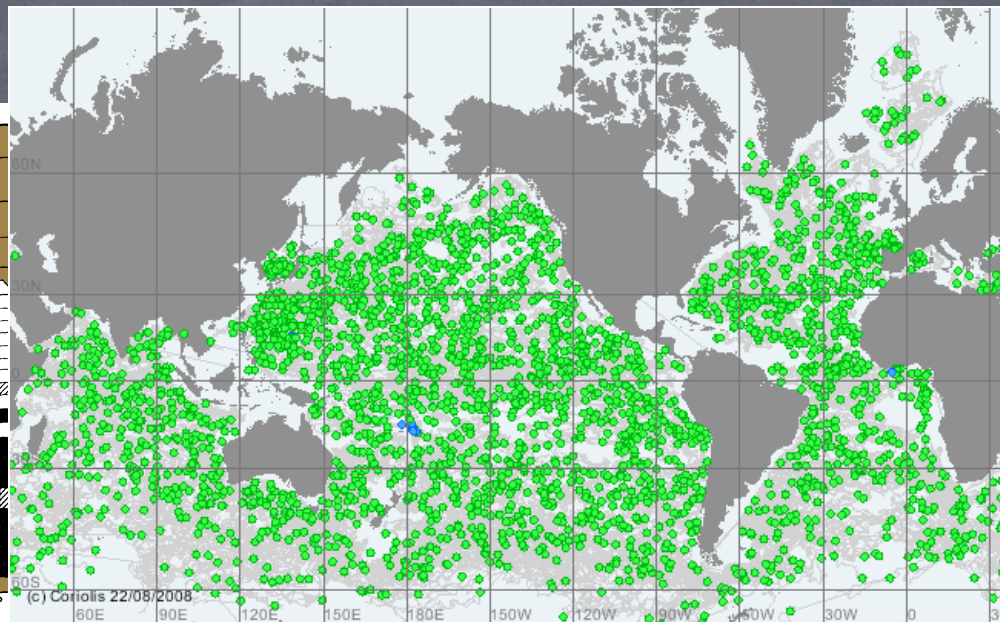
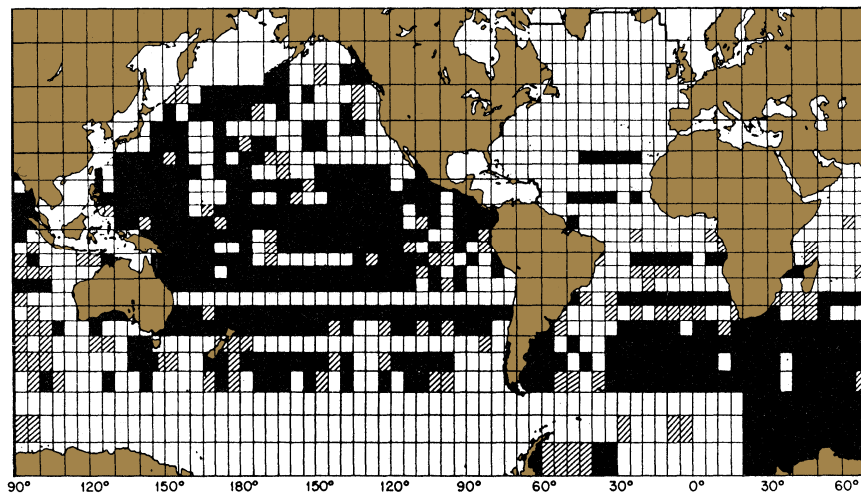


Fig. 2.3. World wide distribution of oceanographic stations of high data quality shortly before 1980. Unshaded 5° squares contain at least one high-quality deep station. Shaded 5° squares contain at least one high-quality station in a shallow area. Black 5° squares contain no high-quality station. Adapted from Worthington (1981)

ARGO FLOATS  
Measuring NOW!

Reid & Mantyla '94  
has 10,000 casts.

100,000 CTD Casts/Year!!



# Conclusions

- Is Oceanography Science? Yes.
- Is it maturing, as physics did? Slowly, yes.
- Should it mature? Probably.
- Will something be lost? Yes.