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NOTES BY W. N. ENGLISH ON MEETING OF USN/ONR ADVISORY COMMITTEE ON LONG RANGE TELEMETERING BUOY DEVELOPMENT

December 9 - 11, 1963.

Scripps Institution of Oceanography, LaJolla, California

by

W. N. English

April 1964

Department of Mines and Technical Surveys
Marine Sciences Branch
Canada

USN/ONR ADVISORY COMMITTEE 9 DECEMBER 1963

ON

LONG RANGE TELEMETERING BUOY DEVELOPMENT

ATTENDANCE LIST

A.E. MAXWELL	ONR WASH
F.D. JENNINGS	ONR WASH
J.L. REID	SCRIPPS
P.E. SEELINGER	PACIFIC MISSILE RANGE
ROY D. GAUL	TA&MU
J.F.E. SAUR	BUCOMMFISH (STANFORD)
N.P. FOFONOFF	WOODS HOLE OCEANOGRAPHIC INSTITUTE
ROBERT G. PAQUETTE	G.M. DEF. RESEARCH LABS SANTA BARBARA
WM. S. RICHARDSON	UNIV OF MIAMI
JIM SNODGRASS	SIO
WM. N. ENGLISH	BEDFORD INSTITUTE OF OCEANOGRAPHY HALIFAX
CDR J.E. AYERS, USN	ONR LONDON
LT D.J. STEWART, USN	FLT WEATHER FACILITY SAN DIEGO
HERBERT L. SATHER	FLT WEATHER FACILITY SAN DIEGO
WM. HAKKARINEN	NATL. BUREAU OF STANDARDS, WASH.
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HUGH J. McLELLAN	TEXAS A&M UNIV
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ROBERT G. WALDEN	WHOI
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WALTER C. SANDS	UNIV OF WASH
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K.A. MORGAN	GD/CONVAIR
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S.T. UYEDA	GD/CONVAIR
J.D. ISAACS	SIO
GEORGE SCHICK	SIO

USN/ONR ADVISORY COMMITTEE

ON

LONG RANGE TELEMTERING BUOY DEVELOPMENT

Notes on Meeting
December 9, 1963
La Jolla, California

MAXWELL

Convair Contract for buoy development.

Past year's experience:

1) Mooring not so simple as hoped. Many buoys lost; mooring affects measurement.

2) Sensors good for 1 year calibration are not available.

3) Effects of small scale movements on larger scale measurements has become evident.

4) Need to decide function of buoy specifically. General purpose buoy doesn't seem promising.

5) Buoys aren't end of everything: one buoy won't solve all problems.

6) Our buoy seems like maximum size (he hopes). At least it is costwise.

JENNINGS

Convair project started March 1962; requirement is 100 channels; 4 times/24 hrs.; telemeter 2000 miles.

1) 14 scale models tested for drag in Convair towing tank.
   8 scale models used for wave stability studies in Convair towing tank.

   a) Problems re resonance to waves, in pendulum type buoy. These have high drag too.

   b) Surface floats are non-resonant and low drag.

   c) Symmetrical shapes are best (NIO work on wave spectra from symmetrical buoys).

2) Telemetry from tilted antennas. Radio is substantial part of buoy power. "Discone" found better than whip for low radiation angles; suffers less from motion. Feed is at top (disc).

3) Buoy power 2400 watt hrs./24 hrs.
18250 amp. hrs./year.
75-100 watt hrs./day = 3.6 amps continuous.

Need temp storage plus energy conversion. All possible systems studied (isotope power supplies $80,000. ea.). Thermoelectric and piston engine (propane) best. 100 watts continuous. Test October 1962 - July 1963 on propane generators.

Added to Contract February 1963.

Electric power at sea
Sea tests including effect of ice on stability
Electric power life tests ashore
Mooring, single & multiple
Radio ionospheric telemeter SD-Hawaii
Prototype buoy 40' diam. design and two to be built
1670 hrs. of operation on engine (at dock) - 3 years equiv.

Basin & Other Recent Studies by Convair (reported by Samples and his staff).

- Towing basin icing and other tests 1/50 scale.
- Built special wind machine to equal 150 knots (scaled).
- Larger machine for 150 knots at 1/10 scale is under construction, will deliver 80 fps using two 50 h.p. motors.

Computer modelling tied in with towing basin studies to expand range.

- Power system: gg in environmental chamber (20' x 20' x 40')
300 amp. hr. nickel-cadmium battery
200 gal. propane bottle
extremes of cold and humidity now
later extremes of heat

Engine must start & stop: start hard when cold
stop hard when hot.
2700 hours operating on first engine so far equals 7 years at sea.

- Radio experiment SD-Hawaii, Month of August 1963.
7.7; 13.; 16.265; 20.8; 26.8; mc/s
transmission from discone antenna every six hrs. 200 watts square pulse plus frequency modulated, 20-200 bits/sec.

Results: 1) Fair agreement with NBS predictions (transmission better than predicted).
2) A two or three frequency f.m. buoy can handle 100 bits/sec at any time of day or night.
3) Bad interference problems despite fact frequency assigned. 200,000 watts teletype transmitters on the same frequency are tough competition.

- Prototype hull design - original model unstable above 100 knots wind speed. Testing procedure being revised to study this region.

- Construction of first buoy could begin March-April 1964. Ready for instruments June 1964.

- Pulse code modulation and single sideband transmitter would be used for interrogation and reply.

- Tests: Palos Verdes, S. Barbara, & Point Sur will be used for truck tests of overwater paths.

- Discone antenna design underway. Tests to be carried out on shore using artificial ground plane.

- Model tests; 150 knot wind, unstable waves 60′ high, 10 knot current all simultaneously.

Q.A. Spray into engine?

Intake 25′ above sea level, exhaust 20′ above sea level. Each have labarinth. No sign of corrosion, so believe no spray problem.

Q.A. Weight of power supply?

900 lbs. including snorkel for present model. 300 amp hr. battery 800 lbs., plan two independent engine generators 400 lbs. each.

Q.A. Power drain:

Light & rx	$<$ 20 watts	
Data acq.	500 watts	__ times/hr.
Tx	600 watts	4 times/day.

Q.A. How are waves scaled?

Scaling by getting 60′ equivalent wave in tank, believed good for slope but not for energy. Tests done free floating and moored (1 point) former is more stringent.

Q.A. Is there a propane explosion hazard?

Snorkel purges itself before and after engine operation, using explosion-proof fan. Engine is switched off by shutting off fuel. Ni-Cd battery is vented but also charged at low rate to reduce gassing to minimum.

FOFONOFF:

What measurements do we want to make from buoys?

Peoples' interests differ - no general answer. Dr. Fofonoff wants measurements of parameters of equations of motion, Navier-Stokes Equation, i.e. V, P.T.S. of ocean.

Measurements:

1) Lagrangian methods
Swallow Float
(not strictly)

2) Eulerian methods
Moored buoys (not strictly because of buoy motion)

For H.F. motions, Eulerian looks like correct approach.
For L.F. motions not necessarily true.

We can't say yet whether ocean dynamics, especially in the low frequencies, is space problem or a time problem.

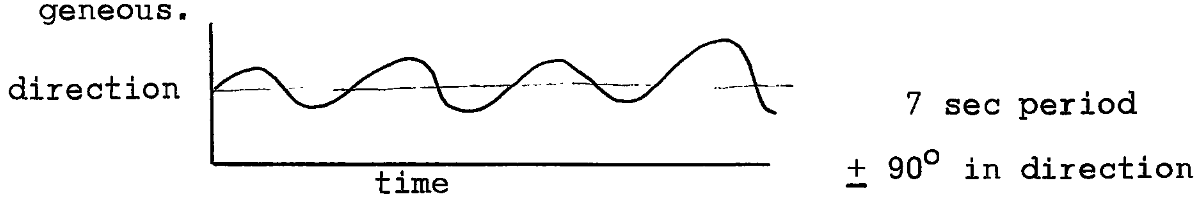
3) Towing sensors is a third possibility which combines 1) and 2).

There are scales of motion for which buoy measurements are particularly suited. We need to know dynamic response and measurement duration. Most stringent problems of buoy motion arise in measurement of velocity, measurement of PTS is less critical. Temperature structure has been sampled and studied. The salt figures of Stommel are important in deep ocean.

It is very important to know the reliability of measurements. He has had firsthand experience with Richardson meters (surface float, plastic lines, semi-taut mooring).

- H.F. signal he calls "mooring noise" is almost #1 problem in buoy measurements - periods 5-10 seconds, fairly large variations in amplitude and direction.

  eg. one 2000 meter record had 7 sec characteristic period. The same period showed up at other levels, but was less evident where current was greater. Sampling rate was 2/sec, no wind, light 2-3' swell, structure at meter nearly homogeneous.



Possible source - surface waves inducing meter mooring instability (yaw). Feels shallow water problem is quite different.

Not much between these frequencies and tidal oscillations. Vdt shows little activity in internal (deep) waves (period several minutes to hours). This does not apply to thermocline where we expect substantial activity.

Outside of major currents mooring noise seems well separated from real motion.

Meter yaw would probably not be important for temp. measurement.

Complete rotation of vane (3 minutes) occurred during slack waters.

Q.A. ISAACS: Possibly a sticky pivot?

RICHARDSON: No. Meters put out in pairs, we know pivots don't stick.

FOFONOFF continued:

Trial November 1963 - 150 miles S. of Woods Hole. 15 miles off shelf.

Plaited nylon mooring in 2500 meters of water.
2000 meters pair (10 meters apart) showed SW
1500 meters one showed NW
1200 meters pair showed N

Thus, very large change of velocity and direction with depth. Integrated over 4 minute intervals - very little H.F. below "mooring noise". Dr. Fofonoff didn't expect such large changes of velocity and direction.

MAXWELL says "THRESHER" operations were not far from this area and showed (qualitatively) same effect - sizeable internal wave contribution at tidal period.

"Dancing" of meter may give contribution to measured current through rectifying action of Servonius rotor.

Velocity differences were "alarming."

Peak velocities 5-7 cm/sec 2000 meters
10-12 cm/sec shallower
60 cm/sec off Bermuda - surging effected noted.

Q.A. ISAACS: Has vortex shedding effect been seen in "mooring noise" frequency range?

This has been seen at very low velocity in towing tank.

Q.A. FOFONOFF: Cone of compliance of mooring does remove some real current.

$$\frac{\pi D}{T} = v = 7 \text{ D Km}$$ e.g. 1 Km mooring circle gives

v = 7 cm/sec

Tidal cm/sec

This is bad in 1000 meter region, and makes multiple point moorings attractive. Servonius rotor is a non-linear device responding non-linearly especially to changes in velocity. Not well understood at all - needs work.

FOFONOFF: Data handling.

10^5 velocity vectors per operation - working on data handling techniques. Suspects we must devise new methods. No theoretical knowledge of relation between effects. The similarity conditions of turbulence don't necessarily apply. May need full 3-dimensional measurements to separate spaces of time variations.

MAXWELL: Dr. Fofonoff and Dr. Knauss have been asked to propose the first experiment with the buoys.

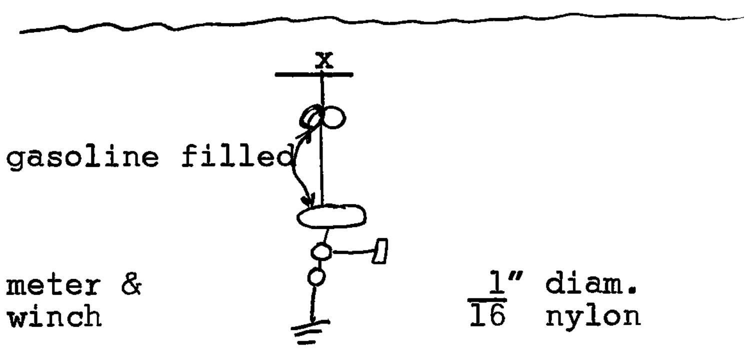
Q.A. RICHARDSON: Same talk could have been given about Swallow Float with "low" substituted for "high". Any system must have its response studied and reliability established. Dr. Fofonoff agreed.

FOFONOFF: This is first system that has given enough data to ask these questions.

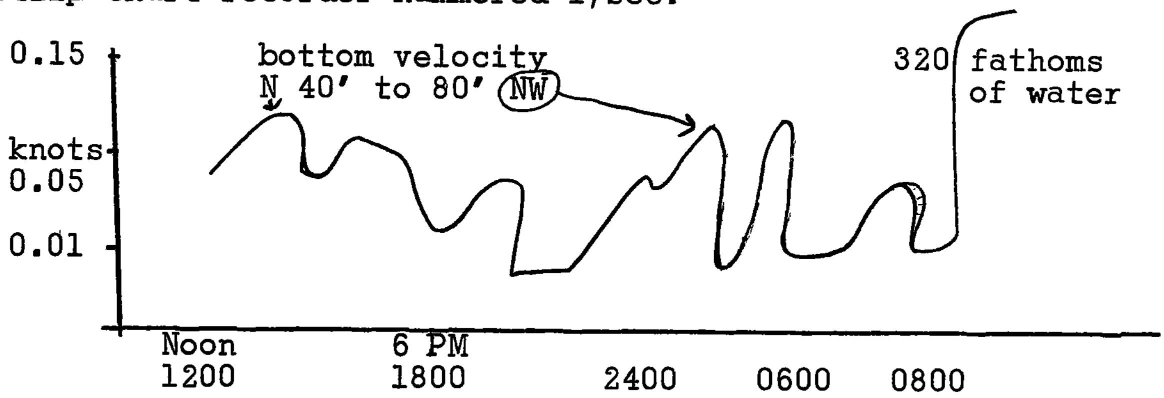
MAXWELL: Vertical components might give you more confidence. How about a scalar sensor?

ISAACS: Isn't it better to stay out of the disturbed surface layer? We have a bottom-moored meter that slowly reels itself up to 1000' in 6 weeks then cuts itself loose. Then you wait for a Mexican to find it for you.

SCHICK & ISAACS:

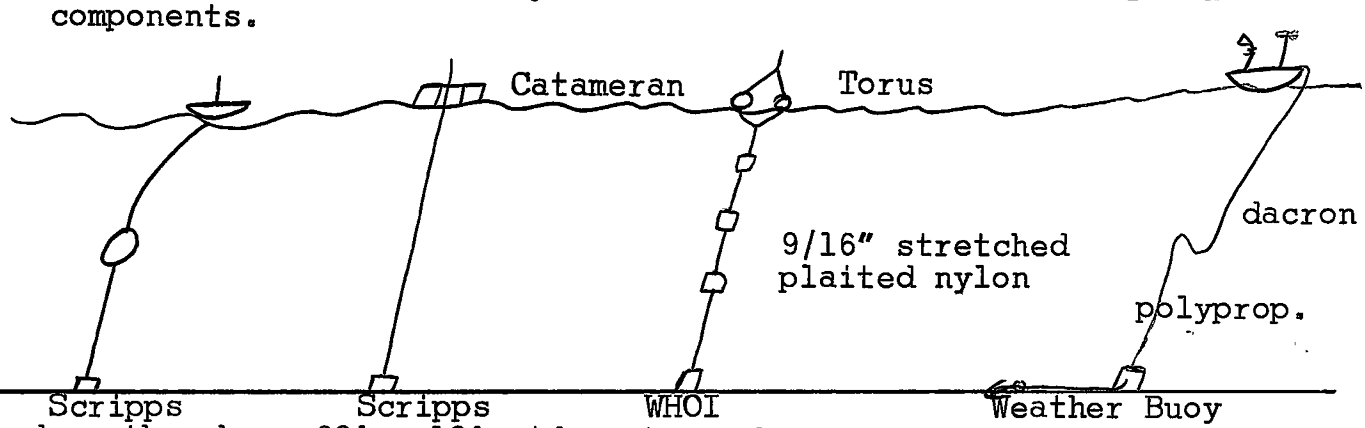


Rises at 40'/day from bottom - pressure case 2500f. Sensitive to direction plus or minus 5°. No swivels. Whole apparatus starts near bottom and comes up. Approximately 20 lbs. positive buoyancy could be redesigned for greater. Tilt is trivial for $< \frac{1}{4}$ knot. Whole rig $500. including $100. strip chart recorder hammered 1/sec.



PAQUETTE: Historical Review.

Ship moorings use scopes usually 2:1, a few 1.3:1 for several days, and 1.05:1 for a day. Have detected tidal and inertial components.



Nomad weather buoy 20' x 10' wide put out by Bunavweps. Some troubles with upper termination of cable. Worth $80,000. instrumented.

Mamos - externally same, U.S. Weather Bureau - seven in order.

Tongue of Ocean Lockheed in 5000' of water.

3-point 3 x 75 ton anchors, triple subsurface float. Have lasted a year or more.

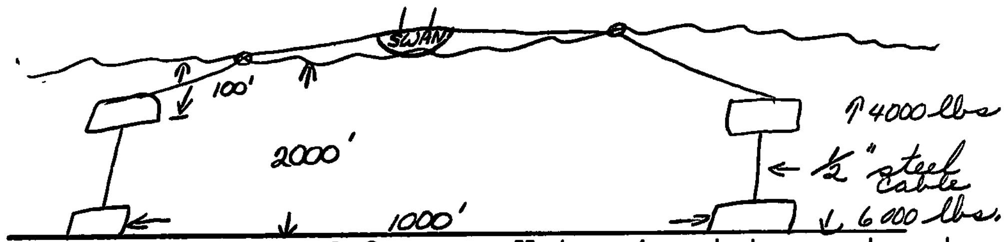
Minneapolis-Honeywell 30 days $1\frac{1}{2}$' x 12' cylinder

Russians tapered steel wire subsurface float.

<u>Coast & Geodetic</u> 3 point moor off Catalina
3000' and 6000' (for magnetometer). Platform 100' below surface, stayed level within $\frac{1}{4}^{\circ}$. Got good tidal records from pressure element on platform.

<u>Bell Telephone</u> submerged polypropylene single mooring.

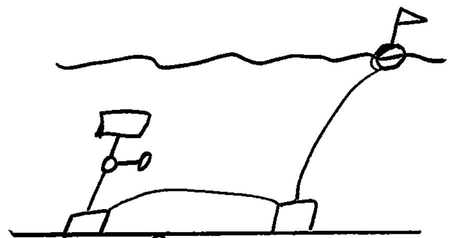
<u>G.M. Santa Barbara</u>



Have also anchored "Swan" in Tongue of Ocean. Using 4 point mooring in 40 knot winds. Plus or minus 25' in ship position.

<u>Mooring Problems</u>

1) Single point slack useless for current and some other measurements.
2) Single point "taut" is relatively taut only.
3) Recommends buoy submerged below mixed layer.



Q.A. <u>FOFONOFF</u> Tried off Bermuda in 3000 m. of water, a 45° angle 3 point mooring with WHOI torus buoy and layed polypropylene rope. Lasted 24 hrs. Instruments were on 4th rope with anchor; was successful in attaching and removing 4th line. Drag was much increased by multiple mooring. After 3rd leg broke, there was approximately 1000 lbs. downward on torus. (had floats on each line). 10% stretch in polypropylene, other ropes would be better. New fibreglass rope has very low stretch. Parallel dacron has 6% stretch, nearly neutral buoyancy.

<u>RICHARDSON:</u> Design of mooring. Cable is controlling <u>economic</u> element.

$$\frac{\text{strength}}{\text{strain}} = \frac{\frac{\pi D^2}{4} T - \frac{\pi}{4} D^2 L \Delta\rho}{\sum A \quad L D V_{rel}^2} = KD[T - L\Delta\rho]$$

Tensile strength; $\Delta\rho \rightarrow \rho_{rope} - \rho_{water}$

Thus, the larger the diameter the better:

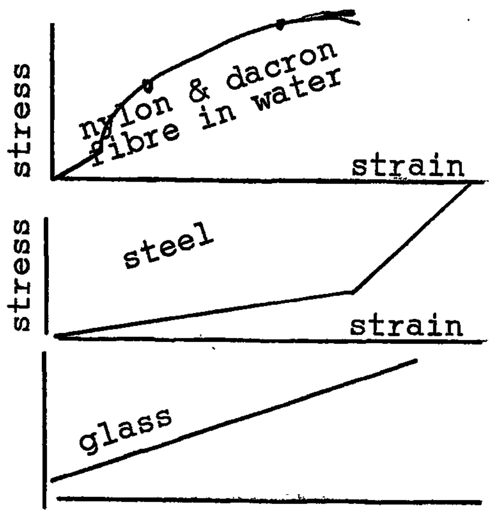
Safety factor is dependent on 1) Diameter 2) Material.

<u>Materials</u>: Stranded rope is historic because of short natural fibres, but synthetic fibres can be infinite in length.

Polypropylene creep breaks in a week from 60% strain but no trouble at 20% of breaking strain.

Nylon dacron - ok at 60% but 80-90% breaks it (but doesn't creep).

	Density	1 mil fibre*	Rope	Parallel*
Nylon	1	T = 80K PSI	25-30K PSI	50-60K PSI
Dacron	1	90K PSI	25-30K PSI	
Steel	7	150K (yield)	150K	
		230-250 (ultimate)	7 of (1/32")	7 of 1/32"
Glass** 2 to 2.5		700,000	↓ 500K	↓ 600K



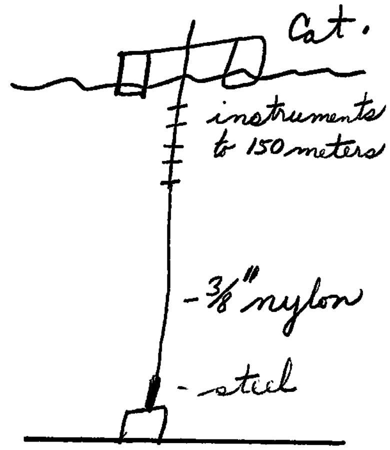
* Not actual continuous filaments but yarn elements encased in light wire braid.

** This 7 strand fibreglass-resin "rope" can bend over 3" pulley, behaves like piano wire.

All ropes - life depends on load. Recommends less than 30% of breaking strain.

Q.A. Conductors can be put in low stretch lines especially parallel dacron. Permanent initial elongation 2.3% laid, 4-5% plaited.

ISAACS AND SCHICK: Scripps mooring experience last 2 years.



One mooring for 20 months in 320 f.
13 other moorings in 320 f.
(100 f (150 f (2000f
(1 mo.(2 mos.(3 mos.

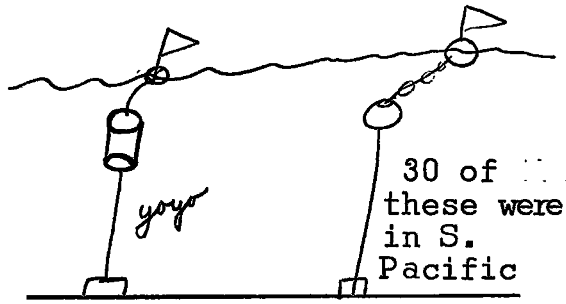
Removed (all depths)	(15)	(2)	(½)	(½)
Lost	6½	6	2	
Lost & Recovered	3	6½ (2300f)		

5/7 or 10 moorings have done six months - half southern California, half central California.

Always schools of fish under float. Catamaran is 6' x 12' made crude and ugly.
Putting out five more.

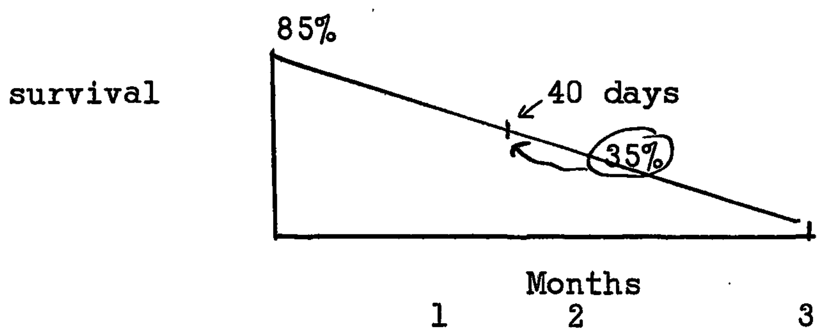
Sure there are predators too & hence risk of line being cut near float

ISAACS: Recalled yoyo buoy used in Pacific bomb tests. Haul on surface line to bring instruments up (surface buoy small) complicated to install, but instrument line stays on deck until mooring down.



CAWLEY: Buships Study (last 3 years).

1) Arthur D. Little - analysis under Trident program. Based on WHOI data and Nutmeg data. Analysis of short life times 2-3 months to 6 months. RCAF - 60 launchings, winter results poor, summer data only used in this study.



Main problem is with surface float.

2) Coastguard Station C in mid-Atlantic. Water depth 2000 f, buoy in place 6 months nylon line. Used as position fixer

for ship which is essential to trans-Atlantic jets for positioning with increased flights and narrower flight lanes.

3) Explosive anchors have been used to 3000 f (mine warefare experience).

SATHER:

Naval Weather Facility, Monterey.
3 buoys in Pacific - up to 9 months.
1 at Station Papa since July 8 - 2200 f of line.
Telemtering - no luck so far.
"Nafi" out to 400 miles. Package in Richardson torus.
"Nomad" to go out 500 miles. Mooring as follows:
1000' 5/16" stainless steel at top (insulated).
2500' 9/16" nylon spliced directly to 9/16" polypropylene for scope of 1.2 to 1.3.

Out beyond St. Nicholas Island.
No fouling on the stainless steel in 1 year (use spool fastenings, no clamps)
25' of small chain. (1-1/8" destroyer chain) - 1 shot plus danforth and 35 lbs. clump..

Q.A. FRANTZ: 304 stainless should be poor in salt water.

SATHER: Re: Nomad buoy. Plow steel ok for 6 months. 304 stainless good for years in Gulf of Mexico. Has been very compatible with aluminum hull. Hull 3/8" wall has pitted 1/8" in 3 years. Type 304 bolts in all buoys ok. No corrosion on bolts or on aluminum. Sulphur forming bacteria very bad.

RICHARDSON: High oxygen gradient believed bad.

SNODGRASS: Work hardening appears to accelerate failure. Present state of knowledge doesn't permit prediction of performance.

RICHARDSON: Stainless steel bolts in plastic sleeves corrode badly. Very important to weld in inert atmosphere. #318 (low C) stainless is better than #304. Better to stay away from high carbon. Free carbon promotes corrosion. Suitable heat treatment may remove (i.e. reabsorb) it.

MAXWELL: In October last, the Maritime Safety Committee (MSC) submitted recommendations to the International Maritime Consultation Organization (IMCO) Assembly, concerning the marking and lighting of oceanographic buoys and stations. A copy of these recommendations is attached as per Attachment I.

FOFONOFF: Proposal for first research problem for buoy (to be done in Pacific Ocean).
Buoy is in some ways analogous to ship. One can separate various processes from Navier-Stokes Equation.

Circulation Annual Cycles (& Harmonics)	Rosby Waves	Inertial Osc.	Tides (forced waves) 12-24 hrs.	Waves Internal, Surface	Turbu-lence Salt Fingers
DC			Spectrum f	cpm	cps

1) Cycles/minute; scales of cm.
   - Hi Freq. mechanism mainly turbulence several cps; scales indicate mms & less but turbulence probably not common in ocean, except near boundaries - rare in vast bulk of ocean. Mixing processes may well be largely diffusive.
   - Salt finger instability.
   - Rate of convection instability.

2) Waves - internal waves not studied much and only coastal. Upper freq. is limited by restoring force $\tau \doteq 5$ min.

Ocean values near surface	3-7 min.
deep	½ hr.
low stratification	1 hr. plus

3) Tides - forced oscillation narrow frequency spectrum; excite internal waves and barytropic wave.

4) Inertial* - 12 hrs. 90°Lat. 24 hrs. 30° 0°

   excited by impulsive agents $\tau = \frac{12}{\text{sin latitude}}$

   *Resonates with M2 tidal component at 30° (24 hrs.) and >70° (12 hrs.) Latitude.

5) Rossby or Planetary Waves (Not yet observed)

   Because coriolis parameter changes with latitude. Induced ∴ in any rotating system. Barytropic 3-5 days. Periods up to months.

At any point in ocean, we have this array of possible processes.

Geography: Boundary conditions. Influences many of these. Equator is a special region. Seamounts, ridges, trenches, flat bottom, all have influence.

Buoys are poor for small scales. We can study turbulence near surface where sensor behaviour can be checked out but otherwise time and space efforts are hopelessly mixed.

Internal waves studies could be rewarding - presumably stronger near areas of strong meteorological activity and other generators. Tidal generated internal waves could have complex structure influenced by coast and bottom.

VST spectra and mass	)	transport could be rewarding
heat	)	well adapted to measurements
salt	)	at a fixed point
KE	)	
momentum	)	

Interaction Processes

e.g. coupling of inertial oscillation with tidal components, 24 hr. inertial comp. at 30° Latitude (Knauss).
e.g. boundary interactions - hard to study with buoy.
e.g. interaction between waves and turbulence.

Ocean - atmosphere reaction is a combination of the processes. The sequence of events following storm excitation would be interesting.

FOFONOFF is particularly interested in frequencies below inertial oscillation. Bulk of energy is in this region. One can start to ask about correlation between effects in atmosphere and effects in the ocean.

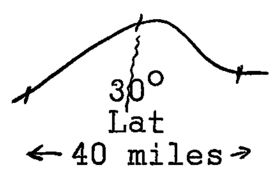
Selection of Initial Buoy Problem.

1) Evaluation to determine possible buoy performance. Location conditioned by ease of measurement. One could put buoy almost anywhere and get interesting results.

2) A year in Gulf Stream would be very good but may not be possible.

3) Next look at 30° Lat. for peak in inertial oscillation range varying with latitude. Theoretically predicted (one would do other things simultaneously).

4) Equator would permit studying undercurrent properties.



Measurement times need to be 10 times period.

3) needs approximately 1 month or more at each station.

2) and 4) need longer - annual cycles and down.

KNAUSS: Problem should depend on who is going to run program. We need an unequivocal success.

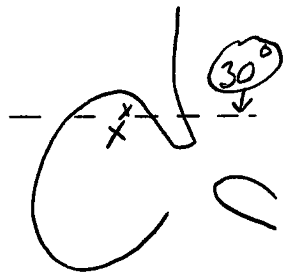
1) Feels 30° experiment is feasible. His swallow float experiments at 29° give him confidence in this. Suggest series of 4 or 5 buoy stations 22° - 38°. A month plenty at each station.

2) Equator undercurrents <u>seem</u> much more stable in space than Gulf Stream.

3) Perhaps more energy in Rossby waves towards vertical boundary. Put buoys across ocean at say 38°; well within state of art.

<u>Comments of others</u>

<u>MACLELLAN</u>: Most hope of immediate success in measuring temperature. Should also test other sensors. Associate with Roy Gaul's program in Gulf of Mexico. He has 2 towers off Panama City STV and Met. data with reduction system ashore. A buoy would give a 3rd station. Lots of internal wave action. Strong currents and depths to 3500 meters. Good place to find lost buoys. Meteorologists think of instrumenting large area for air-sea interaction. Weather mostly good but interesting extremes. Near 30° but perhaps too complex for inertial wave study.



<u>MAXWELL</u>: Our 5 year program will probably give us 6-12 plus buoys. First buoy next year. We should consider: energy distribution in ocean; data collection needs; groups interested in most "important" area. He personally favoured 30° latitude experiment in the Pacific. Geophysical experiments were a possibility but had not been much considered.

<u>RICHARDSON</u>: Suggested location off University of Miami.

5 miles off x water 50-100 f   1 knot current

15 miles off x water 250 f   4.5 knot current

Hi-Fix being installed. Easy telemetry 23 miles to shore direct path, overwater paths 500, 800, 1100 (WHOI) 1500 (NS) available for capability tests.

<u>KNAUSS</u>: "Ideal Buoy Project" was suggested some time ago. Array 10-15 buoys each with 5-10 current meters, 10-100 Km apart anywhere in ocean.

Technology can't do this program yet. We <u>have</u> to solve mooring noise and other problems. Fofonoff is working on it. Hopes it can be a long range objective.

Must 1) good current measurements; 2) deep ocean; 3) separate out buoy "mooring" noise.

<u>FOFONOFF</u>: Distortion from averaging out of buoy motion is real problem. They had tried a small experiment off Bermuda where they could see buoys at 17 miles from so far towers and detect movements of 10 feet. They got speeds up to 7 cm/sec. They plan to do this again and to see if they can reconstruct observed motion from buoy records (motions of tidal period). In a linear system this tidal motion would integrate out - does it? This must be checked during trials.

<u>MAXWELL</u>: ONR has a parallel program on mooring problems - need information for engineering targets.

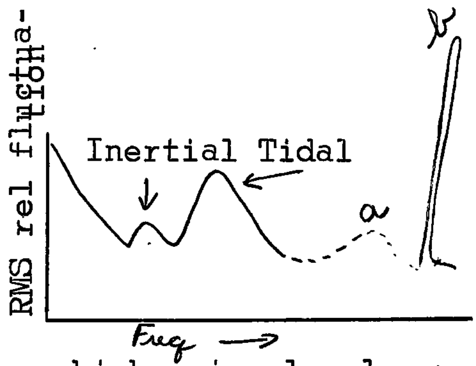
<u>JENNINGS</u>: First phase must be engineering studies.

<u>FOFONOFF</u> ET AL: There is no conflict here. We want "engineered" buoys.

<u>REID</u>: We thought we understood the general circulation in the tropical Pacific but recently Flip moved 60 miles in 25 days at right angles to predicted direction. Can we get at this with the buoy? Need 30 days or 6 months or a year's data.

<u>FOFONOFF</u>: Sampling Rate.

Guessed power spectrum. Bulk of energy in vlf end
a) internal waves - not yet studied
b) mooring noise



Either we filter out HF noise or see it as high noise level. But if read out has lower frequency cut off than sensor, we get aliased data, e.g. for classical statistics random walk type problem looking direction only $\sigma = \frac{1}{\sqrt{n}}$ say 10,000 readings taken, same accuracy unaliased requires only 100 readings.

Thus we <u>must</u> sample above principal noise peak seen by the sensor, unless we are willing to take tremendous number of readings. A filtering sensor works as $\frac{1}{n}$, multiple sampling as $\frac{1}{\sqrt{n}}$ in this case.

Current meters integrate out (filter) well for velocity but <u>not</u> for direction. We're often limited by memory capacity. This can be helped by sampling in bursts. Length of record: perhaps like swell measurements 200 x period required. Can be less for stronger peaks say 10 x period. To avoid aliasing, sample at 2x highest frequency seen by sensor.

<u>RICHARDSON</u>: Aliasing throws energy into low frequency and makes spectrum look like usual standard geophysical data which has more energy in l.f. end. A filter program can take care of this - if filter is right.

"Always start with sampling rate fast enough to handle anything the sensor can see". He lost 2 years on this - later, one can reduce sampling rate, using filtering to take out HF noise.

<u>FOFONOFF</u>: Would like instrument time constant of 24 hrs. for examining Rossby. Servonius rotor is non-linear which complicates filtering. Time constant of 30 sec. would be nice for general use.

<u>MILLER</u>: Anti-fouling, Anti-corrosion Techniques.
All organisms attach as larvae or spores. Growth rates up to 1 lb/sq. ft./month affect weight, function, deterioration. Fouling not serious below 600 feet.

Control: 1) poison 2) mechanical removal. Ultrasonics, radioactive rays don't give general control. Electric currents work only by producing chlorine and power needed is large. Mechanical devices themselves foul. Anti-fouling paints best for suffaces - Cu or Hg in resinous binder slowly soluble in seawater. Navy gets 9-12 months per mil. of anti-fouling. For steel or Al. hulls, have to use isolating paint underneath. 10 mils total gives 1 year's protection. New-organotin compounds - may inhibit corrosion too - are lighter, require no primer.

His new devices are porous, release anti-foulant (organic) near surface. Anti-foulant also prevents corrosion of the stainless steel. Uses 20% pore volume materials. These would have 80% tensile strength. (sintered metals, ceramic, sintered teflon.)

<u>MURDOCK</u>: Convair - Sensors General (couldn't read diagrams).

Long period phenomena demand high stability in carrier multiplex system. DC system is complex. Digital - expensive, aliasing is a problem. Convair proposes a new "clamp-on" inductive coupled device. No direct connection; could make it ride up cable and profile. Pressure, velocity; temperature salinity generalization. Current measurement down to 0.05 knot direction plus or minus 1 degree.

BROWN: Convair - New Sensors (couldn't see diagrams).

1) Paraloc Osc; frequency locked to parameter. Phase shift and osc. frequency is very sensitive to sensor.

4/10% sensor change can give 100% frequency change. Makes strain gauges and resistance thermometers directly usable. Good with Special differential transformers and with toroidal seawater transformer. Volume 6 cu. in. power 300 milliwatts. Can work with sensitivity 1/10 that of platinum thermometer.

2) Has made Pt thermometer with 1/4 sec. response - pressure protected.

3) Vibrating wire pressure transducer (constant tension) like Vibratron but constant tension so that creep is not important. (Gravity meters measure 1 in 10^5 on similar system). Vibratron - stiff diagram; His transducer - flexible bellows. Less attractive at high pressures; 500 psi limit.

4) Straight tube "bourdon" with elongation measured by differential transformer. .02% scatter in lab., detect 1 part in 10^5, measure tsunamis in open ocean with bottom installation.

5) Salinity (Conductivity) - corrected for P & T, for .02 ppk salinity plus or minus .01% conductivity, plus or minus .01°C. temperature, plus or minus 50' depth. Network subtracts out P & T leaving S. Uses platinum resistance thermometer so correction stable. Open ocean salinity variations 5 ppk in plus or minus .02 = plus or minus .4%. Instrument uses toroidal transformer and pyrex glass (stable). Is sensitive to fouling - there is no way yet of measuring specific conductivity. Time constant limited by temperature element is .2 to .3 sec. Salinity part very fast, temp compensation is slower. Pressure compensation for salinity is very temperature dependent., Flushing not yet investigated but should be good.

A Way Out Current Meter - Tagging system.

Hot blobs: too slow with temperature sensor. Conductivity can be used to detect hot blob might make a sing around current meter.

Current Direction

Fluxgate compass, 1 part in 100 very low power, should be pursued.

Clamp-on Sensor is not highly sensitive to pin holes - can stand quite a few.

Self-healing cables have been made (Al 0). Cable can short to sea at both ends without impairing performance.

HOROWITZ: Sampling rate and accuracy.

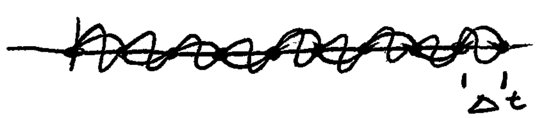
Some analysis done for Apollo project, possibly applicable to oceanographic information. He assumes random white noise.

Auto correlation fcn = av $x(t)\ x\ (t + n)$
Cross correlation fcn = av $x\ (t)\ y\ (t + n)$

Spectral Density = power in some bandwidth = fourier transform of autocorrelation.

"Solving Navier-Stokes eqn. is a hell of a job because it is desperately non-linear". He assumes a trigonometric series soln plus noise.

Sampling theorem says highest resolvable freq. $\sim \dfrac{1}{2\Delta t}$

e.g. 

looks like DC for all freq. above $\dfrac{1}{2\Delta t}$

Central limit theorem allows us to assume gaussian dist. if we make enough observations (CLT say dist of averages of a subsets of samples is more nearly normal than original distribution).

On December 12, a closed meeting of the Guidance Committee for the ONR program was held. An extract from the minutes of this meeting is attached (Attachment 2).

ATTACHMENT 1

NS/IOC/B-9
Annex IV

ANNEX IV

Extract from the Supplementary Report
of the MSC to the IMCO Assembly

COUNCIL IX/12

Marking of Oceanographic Stations - Problems Raised by the Intergovernmental Oceanographic Commission of UNESCO (IOC)

17. Paragraphs 88 and 89 of COUNCIL VIII/8, attached to A.III/12, record that the Maritime Safety Committee had been invited by the IOC to study certain problems concerning the safety of navigation arising out of the use and operation of various types of oceanographic buoys and stations and to express its views.

18. In the light of further information made available by the IOC and other interested bodies, the Maritime Safety Committee considered this matter further at its seventh session. After full discussion in which the representatives of UNESCO, WMO, IOC, IHB, and IANA participated, the Committee reached certain conclusions which are set out in Annex IV. The Committee authorized the Secretary-General formally to communicate those conclusions to the IOC and to other interested organizations, pending approval by the Assembly.

19. The Committee also took note of information relating to the requirements of the IOC for the use of radio frequencies within the bands allocated to the maritime mobile service. The Committee decided to resume consideration of this matter at its next session in April 1964.

Action by the Assembly

20. The Assembly is invited to approve the above action of the Maritime Safety Committee.

ANNEX IV

CONCLUSIONS ON THE MARKING OF OCEANOGRAPHIC STATIONS

1. Growing use by oceanographers and meteorologists of various types of oceanographic stations presents the following problems:

(a) Avoidance of collision between vessels and stations;

(b) Easy identificattion and recovery of the stations by the owner and protection of the stations from being tampered with;

(c) Avoidance of confusion due to similarities between oceanographic stations and navigational buoys or other aids to navigation.

2. As a basis for the solution of these problems the following classification of existing types of oceanographic stations was adopted by the Committee:

(a) Craft which, owing to their size, material and construction, can cause and/or receive damage through collision. Such craft carry personnel and may have moderately heavy equipment on board. They may be operating at any distance from the coast, either anchored or not;

(b) Permanent structures embedded in the sea-floor and rising above the sea surface (masts and platforms), manned and unmanned, generally within a short distance of the coast;

(c) Equipment which, owing to size, material and construction, is less likely to cause damage through a collision. However, it may receive damage or can foul a propellor or rudder or fishing gear. Such equipment is not expected to carry personnel and it may be anchored at any distance from the coast;

(d) Free floating equipment generally small in size and operating either independently or in the proximity of research vessels or craft of the type 2(a). Such equipment can be carried away for long distances, drifting with the currents.

3. The Maritime Safety Committee concludes that:

(a) Craft of type 2(a), since they appear to satisfy the requirements of the definition of "vessel" should be treated as vessels and comply with the appropriate Rules of the International Regulations for preventing Collisions at Sea in force;

(b) Permanent structures of the type 2(b) should be considered generally as aids to navigation. Their light characteristics and other navigational aids should be adopted in consultation with the country, or countries, most concerned. Their position should be marked on the charts and information should be promulgated as required in paragraph 3 (g) below;

(c) Oceanographic stations of the types 2(c) and 2(d) should carry at night identification lights of a flashing type clearly distinct from those used on navigational buoys and other aids to navigation. The following specifications should be recommended:

(i) Color: white-bluish, high intensity, corresponding to the light of xenon discharge tube;

(ii) Repetition rate: short period of quick flashes of a few seconds duration (2-5 seconds) followed by a longer period of darkness (15-18 seconds), the whole cycle being no less than 20 seconds.

Note: The possibility of using a constant white light on floating buoys of experimental or short duration nature should not be excluded provided that those buoys are small and do not represent any danger to navigation.

(d) For easy identification, oceanographic stations of the types 2(c) and 2(d) should be painted in standard colors presenting the least danger of confusion with the markings being used for the various aids to navigation or other purposes. Fluorescent yellow and red in wide stripes (vertical for anchored stations and horizontal for free-floating ones) should be recommended;

(e) The following equipment should be fitted on the 2(c) and 2(d) type stations as far as practicable:

(i) Radar Reflectors: unless buoys are of such size and configuration as to be good radar targets. If fitted, radar reflectors should be as high above the sea surface as possible;

(ii) Fog bells or fog horns: when fitted care should be taken to ensure that the sound emitted is not such as to be confused with the sound emitted by similar navigational warning devices;

(f) The requirements specified above should not exclude the possibility of installing on these stations special radio-transmitters for direction-finding purposes;

(g) Information concerning oceanographic stations which represent a danger to or an aid to navigation (position, size, safe distances to be observed and other important characteristics) should be promulgated to mariners through the usual channels (notices to mariners, radio warnings, etc.). The IOC might also use other means to ensure the widest possible promulgation of such information especially to fishing interests of the countries concerned;

(h) The IOC could, at its discretion, use numbers or other inscriptions on the stations to facilitate identification and to discourage unauthorized handling of such stations;

(i) Care should be taken by authorities operating such stations to avoid obstructing fairways used by shipping.

ATTACHMENT 2

MINUTES OF GUIDANCE COMMITTEE CLOSED SESSION

On 12 December 1963 the Guidance Committee met in closed session. Certain decisions were made regarding the future of the Oceanographic Buoy Program. They were: (1) that the most pressing problems now at hand are moorings and underwater sensors; (2) that an Ad Hoc Committee study these two problems, and (3) that the responsibility for the entire buoy system now being developed be centralized, remaining with the present prime contractor, General Dynamics/Convair.

It was made clear that details of funding of research and development in both moorings and sensors should properly be the concern of ONR, who might decide to award separate contracts for this work, or on the other hand might decide to permit awards of subcontracts in order to afford Convair sufficient control to meet its responsibilities.

The Ad Hoc Committee on Moorings and Underwater Sensors is composed of the following: Dr. William Richardson, University of Miami Marine Laboratory, Chairman; Mr. Howard French, NAVOCEANO, voting member; Mr. Roy Gaul, T. A. M. Department of Oceanography, voting member; Mr. James Snodgrass, Scripps Institution of Oceanography, voting member; Mr. Robert Snyder, Ocean Science and Engineering, voting member; Mr. Robert Devereux, General Dynamics/Convair, recorder and non-voting member. Mr. Feenan Jennings, ONR, will attend and possibly vote. Dr. Richardson set the last week of January 1964 as the tentative period for the first meeting of the Ad Hoc Committee at Miami, Florida.

It was recommended that the program at Convair proceed as rapidly as possible, the details of future work to be determined by the principal investigator and to be set forth in proposals to be submitted to ONR.

An important reservation was that the design philosophy of the data acquisition system in the buoy itself be restricted to digital format if possible, and that the actual design be reviewed by a future meeting of the Guidance Committee prior to ordering major items of hardware for the prototype buoys.

It was agreed that sea tests of one of the two prototypes should be conducted by Convair in the vicinity of San Diego. Several members of the Committee urged that the other prototype be tested by Convair in the vicinity of their own laboratories. Devereux, who wishes to conduct full-scale tests in very severe conditions where precision radio navigation equipment will be available, agreed with Dr. Richardson that tests should be conducted in the Florida Straits, in the Florida Current, and in the vicinity of the Bahamas, hopefully in hurricane conditions. It was agreed that this would be done.

In addition to these sea tests, strain cycling tests on mooring lines will be carried out by Convair, as well as time compressed cycling trials on the eight engine/generator sets and the two battery banks for the two buoys.