UNIVERSITY - NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

RESEARCH VESSEL TECHNICAL ENHANCEMENT COMMITTEE

MEETING MINUTES

October 16, 17, 18, 1995

Monterey Convention Center
One Portola Plaza
Monterey, CA

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Introduction

The meeting was called to order by Chair Rich Findley on Monday, October 16, 1995 at the Monterey Convention Center, Monterey, CA. Dr. Gary Greene, Director, Moss Landing Marine Laboratory welcomed the group to Monterey. The agenda is included as Appendix I, and the list of attendees is Appendix II.

Charter Change

Rich Findley noted that the charter did not include any mention of term limits for officers. Rich is in the first year of his second term and Tim Pfeiffer, the current Vice Chair, is in the second year of his first term. Tim will not be able to stand for reelection. The consensus of the group was that the Chair and Vice Chair should serve no more than two consecutive terms.

RVTEC Logo

Several sketches for logo designs were presented and the group was encouraged to submit additional ideas.

UNOLS Customer Satisfaction Survey

Rich Findley introduced the subject of the UNOLS customer satisfaction survey recently carried out by FIC. Jack Bash provided additional background information and a tabulation which included all the answers to the surveys received by FIC. This tabulation is included in

Appendix III. During the discussion concern was expressed regarding the existing Chief Scientist's and Captain's cruise assessment forms.

Safety

Jack Bash provided an introduction to the discussion of safety related matters, pointing out that RVOC had produced both the UNOLS Research Vessel Safety Standards and also the RVOC Safety Training Manual. The UNOLS Council has been examining the responsibility of the Chief Scientist. By law, the Captain is responsible for all that happens on the ship. The distinction drawn on research vessels between scientific operations and safety of the ship is often easier to make in theory than in practice. Diving operations have a fairly specific hierarchy of responsibilities associated with them. In general the results of the FIC study regarding safety at sea were positive. There was discussion of the use of Chapter One of the Safety Training manual, the Research Party Supplement, and it was felt that the techs could assist in ensuring that this reaches the scientists. There is much variation between ships, and even variation on a single ship between projects, on how the coordination of allocation of responsibilities for safety related matters is handled. Given the widely varying operating profiles of the ships and requirements of the scientific parties this variation is to be expected. The consensus of the group was that although the coordination and communication take place on an ad hoc basis, they are taking place effectively. The group agreed to begin accumulating video footage with the ultimate goal of being able to produce a safety video based on actual at sea back deck operations. There was also discussion of laboratory safety, material safety data sheets, and handling of radioactive isotopes and it was agreed that the video should include lab safety as well as deck operations.

Vans

Jack Bash reported that FIC is proceeding with the study of design guidelines for shipboard vans. The report which includes input from both RVOC and RVTEC will be published soon.

Cruise Assessment Forms

The Chief Scientist and Captain's post cruise assessment forms were discussed and there was an effort to determine how the purpose and use of the forms could be better specified and how the forms could be improved. Woody Sutherland agreed to continue to work on this problem and report back to the group later in the meeting.

Future of UNOLS

Jack Bash briefed the group on discussions surrounding the subject of Don Heinrich's "modest proposal". The ship acquisition programs have been successful in recent years, but the funding for science programs has not been keeping pace. The present shortfalls in funding for the fleet may get worse and several possible alternatives to the present practice of rotating lay-ups were discussed.

Data Standards and Interchange

When the meeting was reconvened after the lunch break Marc Willis took the floor to begin the discussion of data standards. Marc presented the "Specification for Shipboard Data Logging" which is included as Appendix IV. There was some discussion of the resources necessary to implement this program in terms of the programmer time required for software development and the ease or difficulty of integrating NetCDF with existing data logging software. There was further discussion of the details of the implementation during which Eric Firing contributed several points from the point of view of a user of the data product. Lisa Rom reminded the group that there is a distinction between making the data available to embarked scientists and archiving the data. Our funding does not encompass archiving. After further discussion the following statement was adopted by the group:

> It is the consensus of RVTEC that the "Specification for Shipboard Data Logging" is endorsed. The Data Interchange Sub Committee is tasked to proceed with further development of a NetCDF extraction tool. Eric Firing has agreed to contribute guidance from the perspective of users of the data product.

Day 1 - Wrap-Up

The final discussions of the afternoon included the use of CDROMS for data storage and the use of e-mail and various electronic bulletin boards and mailing lists. Sam Neihardt and Guy Farnsworth presented the science layouts for the HEALY.

NOAA NODDS

The meeting reconvened on Tuesday, October 17, 1995 at the Monterey Convention Center. Dr. Doug McClean gave a presentation on the NOAA NODDS program. NODDS is a system which allows civilian users access to a wide variety of weather and oceanographic information produced by the Fleet Numerical Meteorology and Oceanography Center. The NODDS software runs on each user's local computer and once the user has selected which data products are of interest, the software automatically calls the NODDS computer in Monterey over standard phone lines and down loads the required data. All the background maps, captions, etc., are stored on the local computer and the data is compressed before transmission so the time spent on line is quite short. At the present time, phone lines are the only route of access to the NODDS data, but the group is working on developing an access protocol which can be used over Inmarsat C. Unfortunately, future funding for this program is uncertain. The slides for Dr. McClean's talk are included in Appendix V.

SeaNet

Andy Maffei presented an update on the status of the SeaNet project. The slides from his presentation are included in Appendix VI. SeaNet is intended to extend the Internet to ships, buoys, and other platforms throughout the ocean and will develop the infrastructure to support a collaborative effort to integrate shared network and telemetry tools for oceanography. NSF has funded SeaNet light, a pilot project to design and implement the first shipboard communications node. This node will be installed on R/V THOMPSON in support of JGOFS work and will communicate over an Inmarsat B High Speed Data link. Rex Buddenburg continued the discussion with an update on current and future communications technology.

Dissolved Oxygen Workshop

The meeting then moved to Monterey Bay Aquarium Research Institute's facility in Moss Landing where Ginot Friederich, MBARI, and Bob Williams, Scripps, presented a workshop on dissolved oxygen measurements. A copy of MBARI Technical Report No 91-6, "An Easy-to-Construct Automated Winkler Titration System", by Gernot E. Friederich, Louis A. Codispoti, and Carole M. Sakamoto, April 1991, is included in Appendix VII. The workshop and demonstration covered proper sampling techniques to avoid contamination of the sample with air and use of the automated titration equipment.

Steve Etchemendy, MBARI's operations manager, conducted tours of their facilities, including the workshops where the ROV's are built and maintained, and MBARI's vessel. Rich Muller also conducted tours of R/V POINT SUR and the Moss Landing Marine Labs facility. Moss Landing hosted a reception for the group at the end of the day.

Chirp Sonars

The meeting reconvened on Wednesday, October 18, 1995 at the Monterey Convention Center. Mike Rawson and John Freitag discussed Chirp sonars. The data tapes can be replayed through the system's deck unit without trouble but they have experienced difficulty in reading the tapes on other computers. Although both systems produce data in SEGY format that format is not completely self documenting and much additional work is necessary to be able to read the tapes off line. The majority of the use of these systems has been through the paper hard copy output on board the ships. John stated their goal is to develop the use of the system as a tool in contrast to a dedicated survey system. The work necessary to reduce the data and compare the performance of the two existing Chirp systems will continue.

Database Subcommittee

Tom Wilson presented the report from the Database Subcommittee. He traced the evolution of the data base through the two paper editions to the present World Wide Web version. the RVTEC home page can be reached through the UNOLS home page located at

http://www.gso.uri.edu/unols/unols.html

or through the Oceanic database at

http://www.cms.udel.edu.

Tom demonstrated the functioning of the WWW database and the RVTEC home page he had created. The database contains both biographical information on people associated with the tech support groups and also on equipment available from each institution.

Elections

Tim Pfeiffer, the outgoing Vice Chair, reported that John Freitag and Marc Willis had expressed a willingness to stand for election as Vice Chair and he placed their names in nomination. Rich Findley called for additional nominations from the floor. There were none and Marc Willis was elected Vice Chair.

Charter Change

The revision to the charter which had been discussed on the first day of the meeting was formally adopted. The revised section of the charter reads:

> The Chairperson and Vice Chairperson shall not serve more than two consecutive terms.

Cruise Assessment Forms (Continued)

Woody Sutherland reopened the discussion on post cruise reports and presented a draft format of a revised report which included the following questions:

1. Length of the cruise, including transit
   ( ) Less than 7 days
   ( ) 7 - 14 days
   ( ) more than 14 days

2. Did the cruise meet scientific objectives?
   No ( ) ( ) ( ) ( ) ( ) Exceeded objectives

3. How did each of the following impact the success of the cruise?

	greatly harmed--greatly helped
a) Weather	() () () () ()
b) Precruise planning with ship	() () () () ()
c) Precruise planning with techs	() () () () ()
d) Ship equipment (generators, winches)	() () () () ()
e) Scientific equipment(CTD, computers)	() () () () ()
f) Performance of Captain	() () () () ()
g) Performance of crew	() () () () ()
h) Performance of techs	() () () () ()
I) Precruise coordination of scientific party	() () () () ()
j) Instrumentation brought by scientists	() () () () ()
k) Performance of scientific party	() () () () ()

4. List any safety related problems or concerns:

5. Additional comments:

The same form could be used by the Chief Scientists, Captains and Technicians. In the following discussion there was still concern about the purpose and use of these forms.

1996 Annual Meeting

In discussing the plans for next year it was agreed that three days was sufficient for the meeting and that it would be desirable to hold it in conjunction with the MTS Conference. However, MTS 1996 will be in September and holding the meeting that early would be operationally difficult for many people The meeting was scheduled for November 11, 12, 13, 1996, at Harbor Branch Oceanographic Institution, Ft. Pierce, Florida.

Long Range Planning

After some discussion the group reached a consensus that RVTEC should begin to prepare long range plans with a focus on fundamental, enabling technology and with input from the scientific community. The need for reassessing the design of the standard UNOLS conductor cable was cited as one example of the type of planning appropriate for RVTEC.

Gyro Interface

Tom Orvosh presented a gyro interface module that they had developed at URI based on the converter chip used in the OSU SAIL modules and a 6811 processor programmed in Forth. Details on the construction and software are available from URI. Marc Willis mentioned that Furuno also has a NMEA 0183 gyro module and Tim Pfeiffer commented that there also were IBM PC bus boards available.

Auto Sal Interface and Software

Chip Maxwell discussed a new interface to the Auto Sal which uses Keithley MetraByte boards and is optically isolated at both the computer and the Auto Sal end. They have also developed software which standardizes procedures for Auto Sal measurements, including standardization, flushes, and repetitions. With this software they have found that inexperienced operators can produce standard results.

Respectfully submitted,

Timothy Pfeiffer
Vice Chair

APPENDIX I

TENTATIVE AGENDA

RESEARCH VESSEL TECHNICAL ENHANCEMENT COMMITTEE
OCTOBER 16,17,18
MONTEREY CONVENTION CENTER
MONTEREY, CALIFORNIA

Monday, October 16:

8:30 Informal Networking

9:00 Meeting Called to Order
Introductory Remarks by Chair

9:15 Participant Introductions

9:30 General Business
- Nominations and election of Vice-Chair
- Amendment of Charter
- Logo Design
- FIC survey
- Safety
- Design Criteria and Use of 20 Foot Shipping Containers as Laboratories

10:15 Break

- Review of UNOLS Forms
  - Ship Time Request
  - Chief Scientist's Cruise Assessment
  - Captain/Technician Cruise Assessment
- The Future of UNOLS
- E-mail

12:00 Lunch

1:00 Data Standards Introduction; Mark Willis
followed by Data standards Workshop

Tuesday, October 17:

8:30 Meeting Called to Order
Presentation on NOAA NODDS
Technician & Equipment Database Subcommittee Report

Continued on back...

10:15 Break

Oxygen Workshop

12:00 Lunch

1:00 Oxygen Workshop (continued)

3:00 Break

3:15 Presentation by MBARI on MBONE
Tour of MBARI Facilities

Wednesday, October 18:

8:30 CHIRP Inter-comparison Update

9:30 Show and Tell
URI Gyrocompass Interface
RSMAS Salinometer Interface
Whatever else any one wants to present

10:00 Break

Long Range Instrumentation Planning
Updating of Action Plans
Scheduling of Next Meeting
New Business

Adjournment

APPENDIX II

RVTEC - Oct. 16, 17, 18, 1995

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APPENDIX III

Customer Satisfaction Survey - Comments

Question 1

- Poor - Non-existent for all ships & cruises that I've been on...while I've had few complaints, I've never had an operator tell me what they've done to fix things!
- Satisfactory - UNOLS should make more effort to get suggestions from the community about equipping the ships, porting of ships, ship support etc, independently from cruise assessments.
- Very good - Whenever we need repairs or alterations on the AII, they are accomplished cheerfully and quickly.
- Poor - I don't believe I received any follow-up to my cruise reports.
- No comment, don't remember.
- Unknown
- Can't remember if there is any report, what it says, or if there is any follow-up at all.
- Superb - Superintendent Smith also calls and discusses cruise operations with Chief Scientist following cruise completion. Marine Tech and Captain do the same as well.
- Non-existent so far - but I only returned a short time ago.
- I don't remember the report.
- Poor - The commonest effect of my comments seems to be to outrage officials at the operating institution. I generally hear about that - I seldom hear whether constructive criticisms were followed up, so without such feedback it is hard to answer this question. I'd welcome feedback from the operators that isn't couched as denial of the perceived problem, or excuses for it, but is a simple statement of what if anything the operator intends to do about it.
- Superb - This comment is based solely on my experience with my own institutions' regard for users' comments.
- Don't know.
- Very good/satisfactory - Few significant issues. Not enough time to see if action is effective, but a good attitude.
- I'm not sure. It was submitted by the CO-chief.
- N/A
- Don't know - Few scientists go out on the same vessel frequently enough to be able to assess this.
- Don't know.
- I was not requested to provide a report.
- Fair - I have never had anyone speak with me about comments in my Post Cruise Assessment Report.
- I have no information on whether or not issues raised in the UNOLS Post Cruise assessments are followed up!
- Superb - We have not raised any issue - our cruises on the PT. SUR have been outstanding.
- All identified problems have been corrected by subsequent cruise - R/V ALPHA HELIX.
  Don't know - there are immediate and long-term issues.

Question 2

- Satisfactory - however, it should never be returned directly to the operator -- stifles truthfulness. Should be returned to UNOLS Office.
- Fair - Need improvement for quantification of results and to provide more accurate reporting of the scientists "true" feelings.
- I'm not sure the correct questions are really asked.
- A copy of the report would have helped here...
- Very good - I recall it didn't take long to fill out.
- Don't know.
- All paper work is a pain!
- Don't remember.
- I'm not sure. It was submitted by the CO-chief.
- N/A
- Satisfactory/fair - Didn't think these work very well - frequently they are not sufficiently critical. Immediately after cruise Chief Scientists rarely want to intrusive a ships operations. Only way this works is private 'one-on-one' discussions at the institutions between operations staff or chief scientist.
- Don't know about these reports.
- ROSCOP form is confusing and outdated - modern measurements often not listed.
- Not applicable.

Question 3

- This comment is in response to the word "capability" - "Availability" is poor and getting worse.
- Fair - The only estuarine vessel on the west coast of the US (the R/V BARNES) has/is; 1) insufficiently maneuverable, 2) too unstable, 3) too little lab space, 4) too few bunks, 5) too short a cruising time, 6) only one engine (a safety problem. The R/V SPROUL is almost unusable for estuane physical oceanography.
- Very good - Varies greatly. MELVILLE with excellent Seabeam, good maneuvering, 0.680" wire is ideal. T. THOMPSON with poorly operating multibeam, and poor ship design making instrument recoveries difficult (despite excellent crew work) is the other end of the pack. All the intermediate ships are very good, but (see Question 4)
- Very good - We design our science around the ship's and sub's capabilities.
- Very good - Depending on state of the vessel. My experience with the ISELIN was apparently during a "low" period. I understand that it has improved significantly since that time (i.e. 1991).
- Very good - Only problem is scheduling, when the EWING is the only MCS ship in the fleet. Not much that can be done, however.
- Superb - All ship answers went to R/V OCEANUS. Don't know about rest of fleet!
- Poor - I require a UNOLS operated icebreaker. My arctic research is limited to early fall and limited ice capability of ALPHA HELIX does not permit access to important areas. Aside from ice limitation HELIX rolls/pitches badly. Operations are often terminated in marginally rough weather due to danger to equipment/personnel. HELIX should be used in bays, lakes or subtropical (gentle) waters. It is a credit to the crew's scientists that she accomplishes as much as she does in some of the stormiest seas on earth. We can not depend on the HELIX to work in N Pacific, Bering S arctic seas. A UNOLS arctic research vessel is required. A more stable platform for the N Pacific work is required.
- Fair - Only one ship is available for serious seismic projects (R/V EWING) which can be a problem for scheduling good projects. At least one other ship (MELVILLE or REVELLE?) should be equipped to collect multi-channel seismic (maybe 60+ channels with a 3000 cu.in. air gun array). The seismic ships should be equipped with SEA BEAM 2000 or better and with P-code GPS for superior navigation.
- Superb - All except for the z-drive not working on the R/V MELVILLE on one of the thrusters. Was fixed in Valparaiso, Chile.
- Highly variable - the only ones I'd rate "very good" are those that I've put capability-enhancing effort into.
- Very good - The limited number of scientist berths on some vessels sometimes limits the number of hands available to perform the tasks required.
- Very good - for R/V COLUMBUS ISELIN, R/V SEWARD JOHNSON, R/V CAPE HATTERAS.
- Superb - I have never had a disappointing cruise on a UNOLS ship. I have also used Navy and Navy contract ships and this has not been my experience on those platforms.
- Very good - Like to work in worse weather without the hazard and discomfort.
- My only experience is with ATLANTIS II.
- Satisfactory - low cost coastal vessels are needed in Alaska.

- Very good - Cranes, winches, maneuverability and skill of officers and crew are generally excellent. Sometimes they slip a net, but rarely.
- Very good - In general, very good, but quality varies from ship to ship.
- Fair - The fact that there is only one ship (EWING) capable of firing a large tuned argus array is a major handicap to my research. The EWING's hydrosweep system, which is not state-of-the-art, is also an independent.
- We have had complete success with all projects using UNOLS R/Vs.
- There is a documented need for an Arctic research vessel with UNOLS to support US scientific objectives.
- ALPHA HELIX comes to a superb suite of equipment, a tech who knows the equipment and the ability to trouble-shoot it all at sea. The result is very little research time lost. The HELIX is small and flexible - in terms of daily scheduling. This is most useful or we modify our work as we go along.
- Fair - A vessel capable of northern North Atlantic winter, including ice strengthening, is needed.

Question 4

- Satisfactory - XBT hardware/software not always as good as it should be; mixed quality of meteorological sensors; mixed quality of depth sounders; CTD support for non-CTD cruises sometimes has problems - example, how do you get bottle salts done?
- Very good - Does vary a lot between ships though.
- Very good - Depends on the ship. Very wide range in equipment, expertise and reliability.
- Fair - The vessel (R/V/ BARNES) is set up for mooring work, but lacks an ADCP, and is less than ideal for CTD work. It is relative to have only one wire over the side at a time.
- Satisfactory - (Continued from Question 3)...but, I would like to see 0.680 conducting wire on more ships. Also, most ships need a few more MAC's and PC's - 486's, mac quadras and Mac PC's.
- Satisfactory - It would seem to me to be much more cost-effective (and fair) for NSF to equip the UNOLS vessels w/state-of-the-art equipment to be used by a broad user group (eg. Sea-Soar, ADCPs, etc) rather than funding a few individuals to obtain their own equipment. Some vessels have such equipment, though in some cases investigators are charged extra fees for the use of the equipment. Small scientific programs could benefit just as much as large problems with open access to such equipment. This is not a personal bias due to lack of access. I have successfully been funded to receive my own equipment, but I believe, especially in tight fiscal times, an equipment pool associated with UNOLS vessels would not only be cost effective, it would allow more talent access to high quality sampling equipment.
- Fair - All should have SAIL systems or similar and many smaller vessels do not.
- Very variable from ship to ship, depending on operator.
- Superb - Staff/scientists/crew work hard to maintain and upgrade HELIX equipment.
- Superb - Both in regards to SEA BEAM 2800, standard mgd, xbt's and dredging.
- Highly variable, with a very uneven opinion of what "standard oceanographic equipment" is - eg. lack of magnetometers on WHOI ships.
- Very good - Instruments (flow-through fluorometers, anemometers) occasionally go to sea functioning poorly.
- Very Good - For COLUMBUS ISELIN and CAPE HATTERAS.
- Very good - While all available equipment operated according to expectations, the lack of some equipment for use was disappointing. Specifically, I refer to CTD units. I feel there should be standard equipment, rather than prohibitively expensive gear (as a benthic ecologist, I could not afford the $2,500 to rent a CTD for any of my 3 cruises). My experience in other countries has been that even tiny research vessels have CTDs available as routine equipment.
- Very good - There is a clear need to work consistently on replacing older equipment with modern versions and to introduce entirely new instrumentation. Broad UNOLS standards for modern equipment might be set.
- Superb/very good/satisfactory/fair - Varies.
- Fair - We need to test some equipment for sampling hard rock through sediments.
- Very good - "Standard" equipment varies between large (e.g. MELVILLE) and intermediate (e.g. OCEANUS) ships.
- Generally not great on AII but understandable. Acquisition of P-code GPS was great.

- Very good - One problem is the constant "improvement" of the 12 Khz echo sounder that makes it less useful for acoustic tracking and telemetry.
- Superb - The PT. SUR is well equipped for our needs.
- Very good - Would like all institutions to include CTD/rosette in basic cost of ship (block funded) so PIs don't get thousands charged on one ship that would be free on another. For example, I would need to know years in advance of a cruise if it will be on a Scripps ship (charges for CTD) or PT. SUR (no charge) to properly write the grant proposal! Also - good availability of 30L bottles would help my program.
- Any problems we have had were turned around by the vessels engineering staff. All equipment has performed superbly.
- Larger selection of "back-up" sampling gear and back-up on board monitoring equipment are desirable.
- (Small size R/V) is good for inshore work, small size is a liability for open oceans in bad weather.
- Some variation between ships. Equipment charges are on some ships, and not on others. Why do we need to pay for equipment funded by NSF?
- Satisfactory - Not "standard"; always requires upgrading.
- Very good - Why do some ships charge so high a rental fee, while others have no fee for equipment rental?

Question 5

- Fair - Capstan/crane problems not uncommon; cranes on some ships impose limits on weather conditions for work.
- Very good - Depends on ship. Gear on most ships getting very old and less reliable.
- Satisfactory - Mooring deployments are often a problem. Varies with ship.
- Satisfactory - Mounting our ADCP over the side now goes reasonably well. BARNES needs a CTD winch and davit separate from the main crane.
- Satisfactory - The ships need better capstans, for extended use at high load.
- Superb - Primarily because of our "standard" needs.
- Fair - AII winch is and has been problematic.
- Very variable from ship to ship, depending on operator.
- Satisfactory - Some equipment on the EWING is marginally functional but should be upgraded before complete failure (esp. capstans).
- Superb - Note, the resident tech is an important and crucial aspect to this question.
- Very good - Mainly concerned with CTD and winches. During one cruise, a small backup CTD for the main unit would have been very helpful.
- BLUE FIN - satisfactory, CAPE HATTERAS - satisfactory, COLUMBUS ISELIN, very good.
- Very good - Usually - but some old equipment requires excess baby-sitting/repair.
- Very good/satisfactory - Varies.
- Very good - Faster winches would help.
- My only experience is with ATLANTIS II.
- Very good - Cranes are capable but not always able to reach all parts of deck - stretch problem, hopefully to be rectified in time.
- Superb - PT. SUR is well equipped, and the crew keep the gear in excellent condition.
- For mooring work, <u>variable speed</u> capstans are a necessity, some vessels may not be equipped with this item.
- Larger selection of "back-up" sampling gear and back-up on board monitoring equipment are desirable.

Very good - Winches, frames, cranes seem much improved over several years ago.

Question 6

- Fair - Some platforms have little or no computing hardware; some much better; little or no standardization across fleet; better access to underway data needed on some.
- Satisfactory - Depends on ship.
- Satisfactory - Depends on the ship. PELICAN was much better than THOMPSON.
- What data center?
- Very good - Much improved on AII from a few years ago.
- Very good - As of 1990/1991 - I do not know if standard data centers on UNOLS vessels currently have the capacity for real-time graphics displays, etc., which may be useful - designing synoptic sampling regimes.
- I don't really have much experience here.
- Satisfactory - Not a lot of contact with such centers.
- Much improved - recent additions to AII improves things significantly.
- Need to have your own in-house capability - but at least SUNS, GMT, etc. are becoming standards.
- Very good - Consistent improvements made by marine tech Steve Hartz and UA programmers.
- Satisfactory - Should have more computers and tape drives available for work during cruise.
- Satisfactory - The R/V MELVILLE would have benefited from having 1/4" in tape cartridge readers for Sun Sparcs - not everyone uses 8mm exabyte tapes.
- Satisfactory - highly variable - as good as can reasonably be expected.
- Satisfactory - The capabilities change from cruise to cruise over a several month period. These changes make each cruise a new challenge even though the same vessel is used. Ship to ship variables add to the problem.
- Not Applicable.
- Very good - This varies from ship-to-ship although I have never had a problem in adapting to the local standards. A continuing effort to standardize on commercial or public domain standards should be undertaken by UNOLS.
- Satisfactory - Incompatibility always exists somewhere in the chain - provide my own.
- Satisfactory - Out put of multibeam could be better.
- Minimal experience with data centers.
- Not sure what a "data center" is. Highly variable from vessel to vessel - cannot generalize. (Assume you mean routine data collection of nav. parameters, etc.)
- Satisfactory - Highly variable from institution to institution - with Scripps excellent.
- SAIL loop great; better networking and computer capability needed.
- Fair - Some systems are quite outdated and arcane. No uniformity among ships.
- R/V ALPHA HELIX is showing great improvement.
- Satisfactory - Not "standard".
- Satisfactory - Data output from ADCP should include other media than IBM-PC 1.4 Mbyte floppies, 8mm tape or internet access would be much more efficient.

Question 7

- Satisfactory/fair - Mixed across the fleet as to how serious and complete briefings are.
- Superb - No problems here.
- Very good/satisfactory - Crew wisely emphasizes safety of R/V BARNES. R/V SPROUL is so conservative that its capabilities are quite limited (e.g. no night-time transits on the Columbia, master must be on bridge during all transits). It is effectively impossible to use the SPROUL 24 hr./day in estuane waters, except at anchor.
- Very good - Re Chapter 1 -Does anyone ever read this?
- Very good - On several occasions, I was glad to see that suggestions for safety improvements were taken seriously and implemented.
- Satisfactory - Should be taken more seriously.
- Superb - Captain and crew take safety as their primary responsibility.
- Very good - Yes, but note that acquisition of foreign clearance could be improved by sending a copy of request to Chief Scientist before going to the country to make sure correct map is used, etc.
- I'm not sure.
- Very good - As far as I know.
- Satisfactory - This issue worries me - we need to increase pressure on this. There seems to be an increasing number of very inexperienced scientists out there who need to be watched carefully!
- Very good - I didn't know this was UNOLS, thought it was Coast Guard.
- My experience on UNOLS vessels notes extreme safety conscious officers and crew, all standards are superb and have been met.
- Crew needs to set a good example in use of vests, helmets, etc.

Question 8

- Satisfactory/fair - Mixed level of safety concern across fleet; mixed policies for crews about hard hats/steel-toed shoes/work vests.
- Very good - We cannot operate in some areas we need to, because this would violate safety standards on both BARNES and SPROUL. However, safety is fine during existing operations.
- Fair - With no overtime pay available for deck ops, I question the wisdom of putting science staff in hard hats for over-the-side ops. This is a serious safety time-bomb.
- Superb - R/V BLUE FIN - superb, others: satisfactory
- Very good/satisfactory - Some variation from inst. to inst. exists. Perhaps asking PIs on a regular basis how their cruises went would help flesh this out.
- Superb - PT. SUR is outstanding.
- Crew needs to set good example in use of vests, helmets, etc.

Question 9

- Superb/very good - The crews compensate for the platform deficiencies in most cases; resistance and lack of cooperation in the rare case.
- Very good - Highly ship dependent, but generally very good.
- Superb/very good - The Master of the R/V BARNES (Ray McQuin) is terrific. The SPROUL is very accommodating, given the limited motion required of it. We could not do physical oceanography off the SPROUL, however.
- Very good - Crew can get grumpy if they've been out too long, or if they feel that cost-cutting efforts are compromising their abilities to do a good job. Overtime concerns make scheduling difficult and often constrain science activities.
- Very good - I have always had excellent help from the deck and engineering crew. "Officers: have also been most helpful in ensuing our scientific goals are met.
- Superb - With a few exceptions.
- Very good - Usually.
- Superb - Outstanding work by AII crew, above and beyond the call of duty.
- Superb/Very good/satisfactory/fair/poor - Highly variable.
- Superb - While not so in the past recent changes have led to considerable improvement. Capt. Rook is the best UNOLS skipper I have ever had.
- Superb++ - The captain and crew always gave 110% but at the same time insisted on safety and clearly took great pride in their work.
- Superb - Highly variable - "superb" in the case of those I have worked with most.
- Superb - BLUE FIN - superb, COLUMBUS ISELIN, very good, CAPE HATTERAS, very good to satisfactory.
- Superb - They were all great; very cooperative and accommodating.
- Superb - UNOLS has the most professional crews I know of in modern oceanography.
- Superb - Always been great.
- Superb - THOMAS WASHINGTON grew was great!
- Very good - Most of crew is highly skilled and helpful. Some are skilled but not helpful. Few are not skilled. Officers are generally highly motivated and helpful.
- Satisfactory - Cooperativeness is a problem on some vessels.
- Satisfactory - Varies quite a bit among ships and personnel.
- Superb - On the PT. SUR - The PT. SUR has been an outstanding ship for our needs (midwater training). The crew work nice together, and with the scientists. The winch and crane operator make the operation run smooth and safe with their experience. The food is exceptional, an unexpected bonus! The engineers keep all their equipment in top shape and have been great helping us when we had equipment problems. I have only been on one other UNOLS R/V and it was not the same as the PT. SUR. We got the work done and it was satisfactory, but I would rate the PT. SUR superb. It would be a good model for the rest of the fleet.
- Officers and crew have always gone out of their way to accommodate us.
- Unparalleled by international standards!
- HELIX is superb this year; a great crew and very good ship handling by skipper and mate.

Question 10

- Very good/satisfactory - But, if there are layoffs and some ships are not used for periods of time - will the experience be lost?
- Very good/Fair - Depends on ship!
- Very good - Aside from Ray McQuinn, other vessel operators have to be "borrowed" from other vessels at UW.
- Very good - Submersible piloting stays good as long as turnover doesn't get too high.
- Very good - Our work has not required especially unusual equipment, plus the experience level has been fine. (eg. MOCNESS, CTD, moorings, ADCP...) Occasionally the technical support has not been adequate, but this occurred with a new technical employee.
- Superb - Outstanding work by AII crew, above and beyond the call of duty.
- Superb/Very good/Satisfactory/Fair/Poor - Highly variable.
- Very good - Most of the crew is superb. Occasional new crew without experience.
- Superb - Although some of the crew were young, they were all very mature, and responsible.
- BLUE FIN - superb, CAPE HATTERAS, COLUMBUS ISELIN - very good.
- Very good - Have run into "on-the-job" mate/crew training that hinders ideal ops.
- Superb/very good - some variability.
- Superb - Lets try to keep it this way.
- Very good - A few problems from inexperience, but rare.
- I have utilized the R/V ALPHA HELIX for the past 10 years and overall have found the crew excellent.

Question 11

- Satisfactory - Lack of pre-cruise information in timely fashion, such as specifics on ship's payload, on policy of crew helping/not helping with science deck work, sometimes occurs; better coordination of State Department/UNOLS operator/NOAA reporting needed.
- Fair - Probably the one consistent thing in the fleet - shore support is lacking (pre-cruise liaison, billing, post cruise follow-up).
- Fair - Problems include/have included: overly bureaucratic approach, lack of understanding of estuarine/coastal operations, unrealistic safety standards (restrictions on use of the R/V SPROUL in the Columbia River), and poor communication skills (U of WA).
- Satisfactory - ENDEAVOR (URI) - very good, ISELIN (Miami-1991) - fair to poor - hard to communicate with, also we were not informed of known problems with the ISELIN's ADCP.
- Poor - WHOI billing practices appear random; if not malicious; foreign port problems with unscrupulous agent; answers to questions often difficult or impossible to decipher.
- Very good/Satisfactory/Fair/Poor - Variable.
- Variable - Rawson at LDEO is superb.
- Very good - Yes, but note that acquisition of foreign clearance could be improved by sending a copy of request to Chief Scientist. Before going to the country to make sure correct map is used etc.
- Some very good/some poor - I find the ship's crew support (eg. marine superintendents, port captains, etc) very good. The ship scheduling/foreign-clearance-getting staffs unskilled and often unhelpful; these jobs should be filled by people who know something about logistics, shipping, geography and diplomacy, not just secretaries with on-the-job training.
- Satisfactory - Some of the shorebased staff was extremely competent, but others were incommunicative and less than helpful. I have no recommendations for this other than hoping it is better next time...
- Superb - Participation by RSMAS SWAB team (Ostlund, Topp, Grall) is crucial to maintaining our capability of collection samples for natural 14C &3H abundances. Their interests are important, & funding of this group essential.
- Very goods - This is more important during planning.
- Superb - Very helpful and cooperative.
- Satisfactory - Not as responsive to requests as the crews/mar techs are.
- Excellent (consistent) support.

Question 12

- Very good/satisfactory - These folks always seem over-worked but always also seem to come through. They cannot be experts on all the gear now on some ships.
- Superb/Very good/Satisfactory/Fair/Poor - Depends on the ship, obviously!
- Very good/satisfactory - Varied. PELICAN - very good. THOMPSON - marginal.
- Superb/very good - Both U of WA and Scripps have good technical people.
- Very good - Occasionally the technical support has not been adequate, but this occurred with a new technical employee. The technical staff at URI was very helpful.
- Unknown - WHOI sea-going tech support is ambiguous. Is this the DESSC tech? Deck assistance? Its very unclear.
- Very good/satisfactory - Variable.
- Variable, even within an institution
- Superb - Both marine techs go beyond their responsibilities to assist.
- Superb - Note, the resident tech is an important and crucial aspect to this question. Computer support was also superb.
- Poor - It is increasingly difficult to find first class and up-to-date electronic engineers, systems analysts, programmers etc. who are willing to go to sea. Too many people in these support groups are expensive long-servers with out-of-date skills and declining motivation.
- Very good - This varies with the experience of the technical staff. It always has been very good and occasionally superb.
- Superb - CAPE HATTERAS, Tim Boynton, satisfactory - COLUMBUS ISELIN.
- Superb - They were all great; Very cooperative and accommodating.
- Very good - Usually not required, but...
- Considerable variability.
- Very good - Mostly expert at what I want, occasionally expert only at something I don't care about and not too good at what I need.
- Satisfactory - Highly variable - some are superb and some fair.
- Very good - This form does not address cooperativeness of marine techs. On some vessels this is clearly an issue.
- Satisfactory - Varies greatly among institutions.
- Steve Hartz is excellent in all ways - hard working, competent, and forward thinking.

Question 13

- Very good/satisfactory - The refit Oceanus class with new limitations due to heavy cranes and the large AGOR 25 ships indicate a trend toward ships that may prove to be less useful. There is need for low cost (small science party), weather-capable, vessel that could carry a large deck payload. The refit has lowered pay load and weather capacity. The big ships are very expensive.
- Satisfactory - As an overall comment, each R/V is an independent operation and there is little consistency between operations (although this is slowly changing). This is a particular problem when you are forced to use a ship other than the one you requested.
- Fair - The only facilities on the R/V BARNES are a bare, overly small lab. However, the navigation equipment (GPS and gyrocompass) is functional.
- Satisfactory - AII a bit cramped, but adequate.
- Very good/satisfactory/fair - Variable.
- Mostly good.
- Very good - Always willing to adapt to contingencies.
- Very good - (When they are available) Long delays for cruise scheduling are the biggest problems. If the availability is taken into account, the rating would be "fair".
- AII has problems doing ancillary work at night because can't use main A-frame and lacks conduction .68" coaxial.
- Very good - Some docks, receiving departments, and shipping support are better than others. Mostly they are very good or superb.
- In the specific instance of northern North Atlantic winter work, the UNOLS fleet is lacking.

Question 14

- No basis for comment.
- None exist for estuarine work.
- Very good - FLIP deserves wider support from UNOLS.
- No experience.
- No contact.
- Fair - ALVIN - inattention to upgrades; poor navigation; pilot retention; all issues we're addressing on DESSC.
- No experience with these.
- Very good - When using equipment from the Alvin group for a French Nautile Dive, I was given excellent instructions, and the equipment was fully tested, etc.
- Satisfactory - I haven't used Alvin for several years; then it was ok.
- No opinion.
- Not applicable.
- Superb - My experience is solely with Alvin.
- Alvin is ok, but not exactly the best in the world anymore.
- Not sure.
- Satisfactory - Alvin facility needs improvement in way of support personnel and the reliability of some of the instrumentation.
- Haven't used them in a long time.
- No experience.
- Not applicable.
- Don't know.
- We do not use such vessels.
- Generally not applicable to our cruises, but others I have been on.
- Not relevant in my work.

Comments

I think this sort of survey is useful. However, an evaluation of chief scientists, their preparations for a cruise, and their attitudes, by R/V operators would also be useful! I've seen too many who came half-prepared, with mickey-mouse equipment, trying to do crazy things. Then, if it doesn't work, you'll probably see "unsuccessful" in the chief scientist's cruise evaluation. That sort of think is just as wasteful of time and money as inadequacy of ship's equipment, etc. - yet we don't seem to have a mechanism to correct such occurrences.

This questionnaire is well-intended, but is far to general on the one hand, and far too detailed on the other!

New Question:
The adequacy of this questionnaire as a constructive guide to user's opinions.
Poor - I think you should have made a distinction (or had 2 separate questionnaires) between comments applicable to the chief scientist's own institution's hip, and those of other operators. When we use our own ships, then any deficiencies are to some degree our own fault.

Also, the only rational answer to most of your questions, to people who have used several ships from several operators, is "highly variable" - sometimes very good, sometimes inadequate.

APPENDIX IV

Specification for Shipboard Data Logging

UNOLS-RVTEC
Data Interchange Subcommittee
Marc Willis, OSU-COAS, Chair

The opinions and recommendations expressed here are those of the Chair, and do not necessarily reflect those of anyone else.

Background

- 1993 - Rich Findley initiates discussion of common data formats, DIsC is formed (Willis, Polous (UHI), Nelson (URI), Mulhern (NOAA). DIsC charge is to evaluate various data formats and recommend one.

- 1994 - DIsC recommends use of netCDF as standard logging format, RVTEC adopts netCDF. DIsC is charged with developing a specification for logged data.

- 1995 - DIsC submits long overdue draft specification for shipboard data logging.

The Specification is intended to provide a common base which can be adapted or added to depending on the needs and desires of an individual institution.

The Specification deals with:

- Shipboard logged data files, their format and types of information they contain.

- Information which is associated with the data files, and information associated with the data items within logged files.

- A recommended sensor suite common to all UNOLS vessels.

- Recommendations for standard identifiers for data items in the "standard" shipboard sensor suite.

- A recommended data distribution specification for onboard, (near) real-time use.

The Specification does NOT deal with:

- Format of data actually delivered to the user, or the medium used for delivery.

- Any aspect of hardware or software other than those pertaining to netCDF.

- Any other product (data or display) delivered to the user.

Recommendations for Logged Data Files

- netCDF has been adopted as the standard logging format for shipboard data.

- Logged data files should contain raw, untransformed data.

- Data files should have headers which identify the file as to ship or system which generated the file, and some indication of file or software version.

- Data files should always be accompanied by descriptor files (at least one is mandatory).
  - Descriptor files can include sensor identification references, calibration information, etc.

Recommendations for Data Items

- Sensors should be identified within the netCDF file, or cross-referenced to the descriptor file(s) so that the serial number and other relevant information can be determined.

- Sensor ID should include information on the location of the sensor on the ship.

- Sensor data should include calibration equations, constants and factors, and other relevant calibration information.

Recommendations for “Standard” Parameters

- Time Information
  - Date
  - Time
  - Consecutive Sample Number

- Navigation Information
  - GPS
  - SavNav (?)
  - Loran-C (?)

- Sea Surface Information
  - Temperature (multiple?)
  - Conductivity (at least one with T)

- Meteorological
  - Wind Speed
  - Wind Direction
    [Wind Vector]
  - Barometric Pressure
  - Humidity
  - Air Temperature

Identification of Standard Parameters

- Standard Parameters should carry standard identifiers

Onboard Data Distribution

- Data delivered in real-time should conform to the NMEA-0183 standard. NMEA-0183 includes specifications for electrical interface, data format, etc.

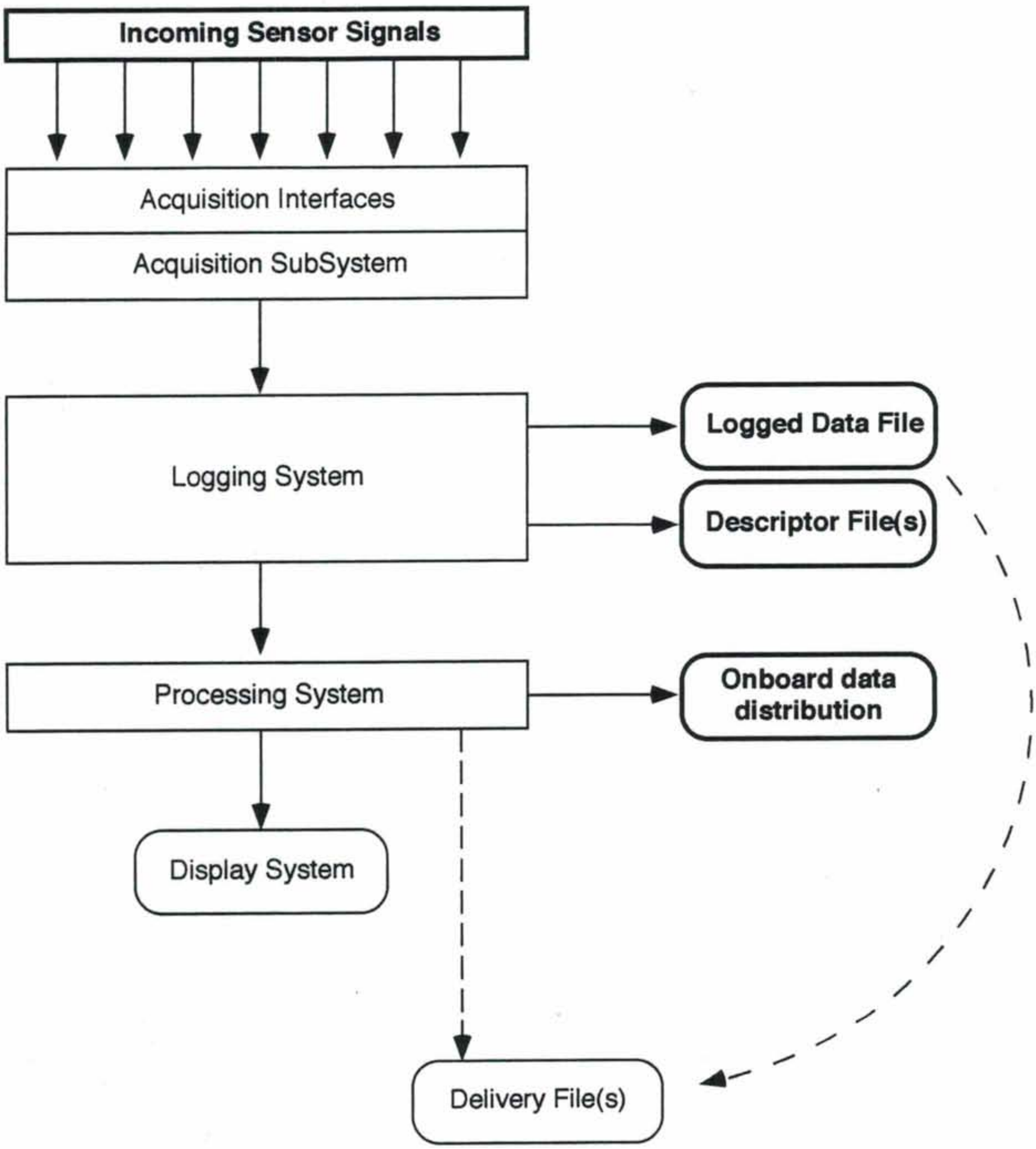
- Data delivered in real-time should be transformed, "calibrated" values rather than raw values.

Unresolved Issues

- Decomposition of combination data items?
- Derived variables?
- Multiple real-time streams?
- Is the specification detailed enough?
- Implementation?
- Others

Schematic of Typical Shipboard Data Acquisition and Logging System

Bold Items are those addressed in Shipboard Data Logging Specification



********DRAFT********

A Specification For Shipboard Data Logging

UNOLS-RVTEC Data Interchange Subcommittee
Marc Willis, OSU-COAS (chair)
Draft 24 March 1995, rev 15 June 95, 21 Sep 95

Disclaimer: 1) The recommendations and opinions expressed in this document reflect those of the subcommittee chair, and do not necessarily reflect those of anyone else. 2) Throughout the document, examples from the Acquisition and Logging system in use on WECOMA are used to illustrate certain points and recommendations. These have been included only as examples, and are not meant to imply that they should be adopted. They are far from perfect. In some cases, the WECOMA examples given do not meet the specification.

Editorial Comment: Standards established in UNOLS, particularly those dealing with technical services, computing, or data acquisition, have largely been a failure. The establishment of standards tends to stifle innovation, and predetermine the direction of development. Developments in the technical services area should be unfettered, with wide latitude for experimentation, innovation and creativity. This document approaches the problem of shipboard data logging from the standpoint of performance rather than specifics. That is, to establish the outcome of the effort, rather than the route by which an individual institution might arrive there. This specification has been written in hopes that it can easily be implemented on shipboard systems from the simplest to the most complex. The specification leaves wide leeway for institutions to pursue a range of development without violating the basic specifications. The specification is intended to provide a background against which development can take place. The specification should not drive new developments, nor determine their direction. The rich variety of shipboard computing efforts now seen in the fleet should not be diminished by this specification. That is not its intention.

Summary of Recommendations:

- **At the 1994 RVTEC meeting held in Miami, netCDF was adopted as the standard data format for shipboard data logging.**

- **Data files should always be accompanied by descriptor files. Logged data files in netCDF format require a *.cdl file. Each physical data storage unit which contains a data file (or files) should also contain a copy of any descriptor files.**

- **Data files should have headers which identify the file as to ship or system generating the file, and file version in use.**

- **Raw, untransformed data should be logged in the data files. Transformed data in engineering or scientific units may be added to the file, but should be in addition to the primary raw data.**

- **All data records should include information on time of collection, and averaging information if any. If averaging is used, at least the** number of samples, maximum value, minimum value and mean should be recorded.

• Sensors should be identified within the data file or cross-referenced to the descriptor file so that the serial number and other relevant information for each sensor can be easily determined.

• Sensor identification should include information on the location of the sensor on the ship. This is important when a calculated parameter (e.g., sea surface salinity) requires two measurements from the same location.

• Sensor data should include calibration equation(s), constants and factors, date of last calibration, where calibrated, and any other calibration-related information which might assist with interpretation of the data.

• A Basic Shipboard Sensor Suite should consist of the following: Date, Time, Sample Number, GPS, SatNav(?), Loran-C(?), Ship Heading, Ship Speed, Sea Surface Temperature, Sea Surface Conductivity, Wind Speed and Direction, Barometric Pressure, Humidity, Air Temperature.

• Standard Shipboard Sensor data items in logged files should be identified in a standard way from ship to ship.

• Onboard real-time data products should conform to the NMEA-0183 standard. The NMEA standard specifies electrical interface, data format, standard sentence formats, and allows addition of user-specific data sentences as "proprietary." The use of "proprietary" sentences should be kept to a minimum. [Where possible, transformed and "calibrated" numbers should be output in the onboard real-time stream, to maximize its usefulness.]

1. Basic Assumptions and Parameters

1.1. There is a recognized need for a common data format for UNOLS vessels.

1.2. The data format recognized as best for this purpose is netCDF (UCAR network Common Data Form.
[There is no discussion of netCDF itself in this document]

1.3. The convention is to be established as a minimum set of specifications and parameters. This will not preclude a particular institution from implementing a superset of these specifications.

1.4. The specification will contain not only the standard format (netCDF), but recommendations for information to be included in the data file.

1.5. There is to be wide latitude for individual institutions to adapt these specifications to their particular needs and capabilities.

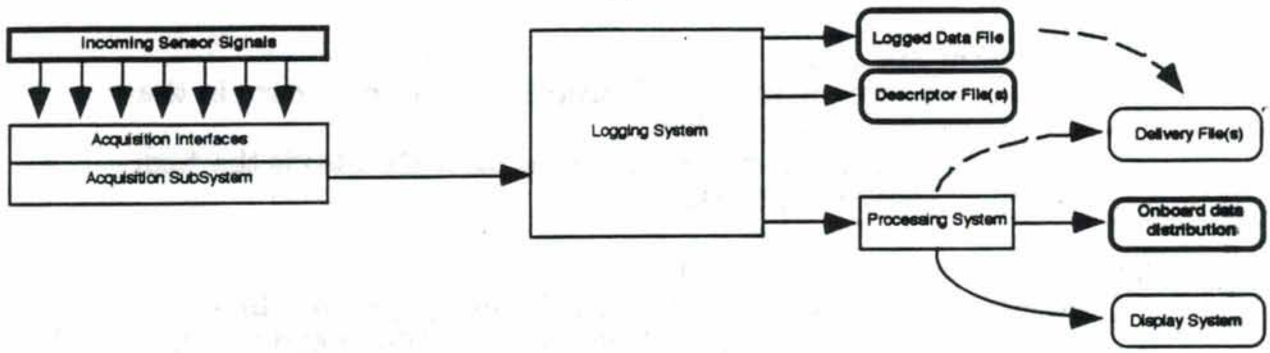
1.6. **No attempt was made to integrate data from other sources (CTD, ADCP, Bathy systems, etc) into this specification**

2. Definitions

These definitions apply to the discussion which follows. They are not meant to imply any particular arrangement of components or any particular topology of shipboard data acquisition. ITEMS MARKED WITH AN ASTERISK (*) ARE NOT PART OF THE SPECIFICATION.

Schematic of Typical Shipboard Data Acquisition
and
Logging System

Bold Items are those addressed in
Shipboard Data Logging Specification



2.1. Data Format

The standard logical format for data storage. This refers only to the logical format (netCDF), not the medium or system on which the data is stored. It can be used onboard in user processing and display functions, but is generally not considered available (or useful) as a real-time data transfer format. It is intended to function as an archiving and logging format for post-cruise use.

Data File: File of data in **data format.**

2.2. *Delivery Format

The format (logical and physical) in which the data is delivered to the user. This may include flat ASCII files in various forms (comma-separated, tab-separated, flat tables), particular database formats, and may include real-time serial ASCII output from acquisition systems, network access to data in (near) real-time, etc. **Delivery formatted** data is that delivered to the user in the most useful format. Data in the **delivery format** may be in any form (i.e., processed, averaged, engineering units, raw data, etc.). This may also include physical media such as floppy disks, removable media, rewriteable optical disk, and CD-ROM. Individual institutions should decide what **delivery format** they wish to use; this specification does not address **delivery format**. The most logical **delivery format** may or may not correspond to the **data format**.

Delivery File: Files of data in **delivery format.**

2.3. Logged Data Form

The form (raw, processed, engineering units) in which the data is stored in the logged **data format**.

2.4. *Sensor

Any point source of data. Includes analog and digital sensors, direct ascii and binary sources of data.

2.5. Sensor Information

Information associated with each sensor. Can include type, calibration constants and equations, identifiers, and any other information significant to use of the **sensor**. **Sensor information** may be included in the logged data file, or may be contained in one or more **descriptor files**.

Descriptor file

File or files containing information describing data in the **data** or **delivery files.**
A mandatory **descriptor file** for netCDF files is the *.cdl file for each **data file**.

2.6. *Acquisition Interface

Interface point between **sensor** and **logging system**. Most common types include serial interfaces and buffers and analog-to-digital converters.

2.7. *Acquisition Subsystem

Computer or other system which concentrates data from suites of **sensors** for transmission to the **logging system**. An example is a meteorological subsystem. May be integrated with the **logging system**.

2.8. *Logging System

Computer system integrating and processing incoming **sensor** data from **acquisition interfaces** and logging it in the **data format**. This system may also produce data in the **delivery format**.

2.9. *Processing system

Computer system or part of **logging system** which converts **sensor** data into meaningful units for use onboard ship in (near) real-time.

2.10. *Display System

Separate computer system or part of **logging system** which displays data for ship users in (near) real-time.

2.11. Onboard Data Distribution System

Hardware/software system which allows users real-time access to data streams.

3. RVTEC Specification for Shipboard Data Formats

3.1. Data Format

RECOMMENDATION 1: At the 1994 RVTEC meeting held in Miami, netCDF was adopted as the standard data format for shipboard data logging.

3.1.1. Data Files

Data files should be of a size appropriate to the system on which they are written, media available, etc.
Each disk or other storage unit should contain not only the appropriate data file, but a copy of any other **descriptor file** necessary to interpreting the **data file** on that disk or storage unit.

RECOMMENDATION 2: Data files should always be accompanied by descriptor files. Logged data files in netCDF format require a *.cdl file. Each physical data storage unit which contains a data file (or files) should also contain a copy of any descriptor files.

Attachment 1 gives an example of a data and descriptor file system as used on WECOMA. This is only an example, and does not imply adoption of this system by anyone else.

3.1.2 Header Information

Each netCDF file should include information identifying the file as to which ship or system generated the file, and what file version is in use. This will be necessary because while the basic format (netCDF) will not change in the short term, the information in the files will change as sensors are added or changed.

RECOMMENDATION 3: Data files should have headers which identify the file as to ship or system generating the file, and file version in use.

3.2. Logged Data Form

It is important that the data logged on shipboard be in a form which is most useful for post-cruise processing by scientific parties. Basically, there are two choices: To log raw data, or to log fully transformed and calibrated data. The best choice from our perspective is to log raw data, and include in the data file all relevant sensor information, so that the end-user can easily locate information for calibration and transformation of the data. By logging raw values, any post-cruise calibrations, sensor difficulties, etc., can be incorporated into post-cruise processing with a minimum of difficulty. This does not preclude logging of calibrated data in the logged file, but such logging should be in addition to the raw data.

The **logged data form** should take into consideration the suite of sensors to be logged, and how they are identified. There are advantages to establishing a list of basic sensors which all ships should have: commonality of data sets between ships, and a basic data set which investigators can count on from ship to ship. This does not preclude a particular institution adding additional sensors to this basic suite. A suggested basic suite is listed below (Section 3.4).

RECOMMENDATION 4: Raw, untransformed data should be logged in the data files. Transformed data in engineering or scientific units may be added to the file, but should be in addition to the primary raw data.

RECOMMENDATION 5: All data records should include information on time of collection, and averaging information if any. If averaging is used, at least the number of samples, maximum value, minimum value and mean should be recorded.

3.3. Sensor Information

Following from recommendation 4, it is necessary to include information in the **data file**, or in the **descriptor file(s)** which will allow the user to 1) identify the sensor associated with a particular value, 2) identify the location of the sensor on the ship (where important), 3) identify the calibration constants and other calibration information for a particular sensor, 4) identify the calibration type or equation for conversion of the raw data, and 5) produce calibrated values from the raw data logged in the data file. The information in the *.cdl file will only allow the user to extract the actual raw values from the *.cdf data file. *.cdl files do not include specific information about data values.

Attachment 2 shows an example of the sensor and location identification system used on WECOMA. This is only an example, and does not imply adoption of this system by anyone else.

RECOMMENDATION 6: Sensors should be identified within the data file or cross-referenced to the descriptor file so that the serial number and other relevant information for each sensor can be easily determined.

RECOMMENDATION 7: Sensor identification should include information on the location of the sensor on the ship. This is important when a calculated parameter (e.g., sea surface salinity) requires two measurements from the same location.

RECOMMENDATION 8: Sensor data should include calibration equation(s), constants and factors, date of last

calibration, where calibrated, and any other calibration-related information which might assist with interpretation of the data.

3.4 RECOMMENDATION 9: A Basic Shipboard Sensor Suite

The sensor suite listed below is intended as an initial starting point for discussion. It is based on limited knowledge of the sensors routinely available on UNOLS ships. There may be more than one source for each data item.

3.4.1. Time

Date
Time
Sample Number

3.4.2. Navigation

GPS (possible multiple sources)
SatNav (not universal)
Loran-C (not universal)
Ship Heading
Ship Speed

3.4.3. Sea Surface (direct, flow-through and/or towed)

Temperature (may be more than 1)
Conductivity (at least one associated with a temperature for calculation of salinity)

3.4.4. Meteorological

- Wind Speed
- Wind Direction

The following sensors can be basic, or part of an extended suite. Each additional meteorological sensor added also adds to the work load of the technicians, and to the complexity of the system.

- Barometric Pressure
- Humidity
- Air Temperature

3.5. RECOMMENDATION 10: Identification of Standard Parameters

To aid in the interpretation of data in netCDF files, and to make the vessel-to-vessel transition as painless as possible for scientific users, it may be necessary to adopt a standard list of ascii identifiers for variables in the netCDF files. These identifiers would appear only in the netCDF file, as a variable associated with a data value.

An example of such a variable identification scheme can be found in Attachment 4. This attachment describes the EPIC convention as registered with UNIDATA. This may serve as an example of a more rigorous convention, such as that required for standard parameters in this specification.

3.6. Onboard Data Distribution

One of the most frequent comments heard on WECOMA is: "Why can't I get [some data item] in real time like they have on the [some other ship] ?", and its converse "I sure wish I'd had access to [some WECOMA data item] when I was on the [some other ship] ." This experience is not unique to WECOMA, and points to the need for a common onboard data distribution specification for the fleet. As above, this is not meant to preclude any development beyond the basic specification, but as a basic service which can be improved on. The goal is to provide science parties with a "standard" service which can be counted on from cruise to cruise and ship to ship; that they will be able to go to any ship and find a plug which says "Real-time data," and have confidence that the data they got last time will be there this time.

An example of the real-time, NMEA-formatted stream used on WECOMA is shown in attachment 3. This is only an example, and does not imply adoption of this system by anyone else.

RECOMMENDATION 11: Onboard real-time data products should conform to the NMEA-0183 standard. The NMEA standard specifies electrical interface, data format, standard sentence formats, and allows addition of user-specific data sentences as "proprietary." The use of "proprietary" sentences should be kept to a minimum. [Where possible, transformed and "calibrated" numbers should be output in the onboard real-time stream, to maximize its usefulness.]

4.0. Some Unresolved Issues (large and small):

4.1. Decomposition of combination data items?

Some data items found commonly on UNOLS vessels are actually combinations of several discrete data items. The prime example of this is GPS data acquired via serial interface from a receiver or navigator. Each GPS "record" may contain multiple data items (for example, position, time, satellites tracked, DOPs, etc). Should this be treated as a single data item, or a number of data items which are logged separately? If they are treated separately, which items should be included in the standard suite, and which optional?

4.2. Variables derived from other variables?

Certain data items are best dealt with as a value derived from two or more other variables. In the case of measured winds, it is better to average the wind vectors, rather than to average wind speed and direction separately. Which data items are to be accepted as combinations, and which separately?

4.3. Multiple Real-Time Streams allowed?

Many devices transmitting data to shipboard acquisition systems send data already formatted in NMEA-0183 format, notably navigation receivers. Should the specification allow multiple real-time streams that, in combination, conform to the specification? Must each vessel supply all data in a single stream, or is a combination of several navigation streams and one analog data stream acceptable?

4.4. How much farther do we want to go?

This specification is very general. Is there merit in establishing a more rigorous convention, such as that described in Attachment 4? Does this specification go too far?

4.5. How should the specification be implemented?

Attachment 1

R/V WECOMA Logged Data File System (*SLOGGER*)

File Type	Format	Description	Name
Raw Data file	netCDF	Main data file	*MMDDHHmm.cdf*
cdf "list" file	ascii 'C'	cdf descriptor file	*midas.cdl*
instrument configuration	ascii	instrument ID and calibration info.	*inst.cfg*

SLOGGER data disks are 3.5", 1.44 MB PC-formatted floppy disks. Each disk has a copy of *midas.cdl*, *inst.cfg*, and a single data file.

Data file naming:
2 digits - month
2 digits - day
2 digits - hour
2 digits - minute

Time indicated is that for the first data record in the file. First data record after program is started begins on the minute.

Attachment 2

R/V WECOMA Instrument Type Codes
[rev. 12/94]

AD Air Temp, Dew Point
AO Air Temp, OSU
AR Air Temp, Rotronics
AV Air Temp, Vaisala
AZ Air Temp, Other

BA Barometer, A.I.R.
BZ Barometer, Other

CS Cond, SeaBird
CZ Cond, Other

DE Down-welling, Shortwave (Eppley 8-48)
DL Down-welling, Longwave (PIR)
DP Down-welling, PAR
DS Down-welling, Shortwave (PSP)

FL Flow Rate
FR Fluorometer Range
FV Fluorometer Value

HR Humidity, Rotronics
HV Humidity, Vaisala
HZ Humidity, Other

PH Heave
PP Pitch
PR Roll

RO Rain Gauge, ORG 100
RB Rain Gauge, ORG 700
RS Rain Gauge, Siphoning
RZ Rain Gauge, Other

SA Salinity, Computed

TS Water Temp, Seabird
TZ Water Temp, Other

UL Upwelling, Longwave
US Upwelling, Shortwave
UZ Upwelling, Other

WH Wind Heading
WS Wind Speed
WV Wind Vector

R/V WECOMA Instrument Location Codes
[rev 12/94]

A = met 1
B = met 2
C = met 3
D = Dog house (non met)
E = Engine room
F = Flow thru
G = Bow mast (non met)
H = Bow, in water
I = Trailed to port
J = Trailed to stbd
K = Trailed aft
L = Transducer well
M = Main Mast (platform)
N = future
O = future
P = Port (main mast)
Q = future
R = CTD package
S = Starboard (main mast)
T = Towed vehicle
U = future
V = future
W = future
X = future
Y = future
Z = No where/off line/in a box somewhere/etc.

Example Code

TSL001 = SeaBird Temperature, Transducer well, Sensor ID#001.

Attachment 3

Slogger Raw Data NMEA 0183 Format

This page defines the format of the serial data stream sent by the WECOMA Slogger system. The data is in the National Marine Electronics Association's NMEA 0183 Standard for Interfacing Marine Electronic Navigational Devices. $P type proprietary sentences are used to transfer data which does not fall within the scope of approved NMEA 0183 sentences.

Transmission Specs

Source: Slogger
Format: ASCII NMEA 0183 data
Serial Configuration:
- 4800 Baud
- No Parity
- 8 Data Bits
- 1 Stop Bit

Data Interval: 1 minute

Record Format

The Slogger system acquires data from serial, analog, and frequency devices, computing a mean, minimum, and maximum sample value for each input over the period of a minute. It then broadcasts this data out a serial port in the herein defined format. Below is a sample slogger data stream. As can be seen, each data record is bound with the proprietary coded items $PSTA and $PEND. All data in these bounds was acquired during the same time interval.

```
$PSTA, <'record count'>   /* Start of Slogger record */
$ZCZDA, <'data'>          /* sample time and date */
$TRGLL, <'data'>          /* SatNav Data */
$TRVTG, <'data'>
$TRTRF, <'data'>
$LCGLL, <'data'>          /* LORAN-C Data */
$LCGTD, <'data'>
$LCSBK, <'data'>
$LCSCY, <'data'>
$LCSNU, <'data'>
$LCVTG, <'data'>
$LCZLZ, <'data'>
$GPGGA, <'data'>          /* GPS Data */
$GPVTG, <'data'>
$GPGLL, <'data'>          /* GPS 10 scan average */
$GPGFF, <'data'>          /* GPS crystal clock */
$WISTN, 01                /* Start of MET A */
<'data'>                  /* Raw data from MET A Computer */
```

```
$WISTN, 99                /* End of MET A */
$WISTN, 02                /* Start of MET B */
<'data'>               /* Raw data from MET B Computer */
$WISTN, 99                /* End of MET B */
$WISTN, 03                /* Start of MET C */
<'data'>               /* Raw data from MET C Computer */
$WISTN, 99                /* End of MET C */
$HEHDT, <'data'>            /* Gyro Data */
$VDVBW, <'data'>            /* Speed Log Data */
$PRAWA2D, W011, <'data'>   /* Port wind speed data */
$PRAWA2D, W012, <'data'>   /* Port wind heading data */
$PRAWA2D, W021, <'data'>   /* Stbd wind speed data */
$PRAWA2D, W022, <'data'>   /* Stbd wind heading data */
$PRAWA2D, F011, <'data'>   /* Fluorometer Signal Data */
$PRAWA2D, F012, <'data'>   /* Fluorometer Range Data */
$PRAWFREQ, L011, <'data'>  /* SST Data */
$PRAWFREQ, T011, <'data'>  /* Flow Thru SST Data */
$PRAWFREQ, C011, <'data'>  /* Flow Thru Conductivity Data */
$PEND, <'record number'>   /* End of Slogger Data Set */
```

Note: The output from the MET systems is expected to already be in NMEA-0183 format.

Attachment 4

Unidata Registration
of
PMEL-EPIC netCDF Conventions

NOAA
Pacific Marine Environmental Laboratory
Seattle, WA

24 November, 1993

This document describes the netCDF implementation utilized by NOAA's Pacific Marine Environmental Laboratory (PMEL) for use with the EPIC software package for oceanographic data. PMEL has developed the EPIC system library (EPS library), which is layered on top of the netCDF input/output library, to write netCDF files with the conventions described here. This library is not intended to provide the complete functionality which is available with the netCDF library, but rather to simplify production of a standardized implementation of netCDF for oceanographic data. It transparently provides support for some commonly used variations on the recommended standard implementation, and could be modified to provide support for others. With the use of this library, all application programs are independent of data file format, and formats other than the Unidata netCDF format can be supported by the addition of a set of "format dependent" routines to the "format dependent" layer of the library. At present, one other format is supported in addition to the netCDF format. Both EPIC and the EPS library, are available via anonymous ftp. Data files with the PMEL-EPIC conventions are compatible with the netCDF calculator function which PMEL uses in conjunction with the PPLUS graphics package. Simple examples including C and Fortran programs to read and write EPIC netCDF files, PPLUS scripts to read, plot, calculate and make animations from netCDF files, information about the interactions of PPLUS, the EPS library, EPIC and the TOGA-TAO Display software, and information about the commercially available PPLUS graphics package, are all included in the anonymous ftp directories. In addition, PMEL-EPIC netCDF files are compatible with the MATLAB netCDF interface (mexcdf) developed by USGS/WHOI, and available from USGS or from PMEL.

```
HOST:       csg.pmel.noaa.gov (192.68.161.12)
DIRECTORY:  anonymous/epic
            anonymous/eps
            anonymous/eps/examples
            anonymous/eps/pplus
            anonymous/tao/matlab

HOST:       crusty.er.usgs.gov (128.128.19.19)
DIRECTORY:  /pub/mexcdf
```

This document (from the Unidata /pub/netcdf/Conventions/PMEL-EPIC directory on unidata.ucar.edu) describes the Conventions common to all PMEL-EPIC style netCDF data files. Please see the accompanying documents describing Conventions specific to specific data types:

/pub/netcdf/Conventions/PMEL-EPIC/CTD/Conventions.CTD
/pub/netcdf/Conventions/PMEL-EPIC/Time_Series/Conventions.Time_series

===================
General Conventions
===================

The EPIC system library is intended for reading and writing geophysical data, and assumes this data is represented by three spatial axes and one time axis. Each data file has dimensions, or axes, of longitude, latitude, depth and time. One or more of these axes may be collapsed to a single point, but four axes are always present. For example, data files containing oceanographic observational data, such as time series data or CTD profile data, may have latitude and longitude axes each consisting of a single point. Although we provide the ability to read netCDF files with fewer than four axes, we do not recommend this practice. Our underlying philosophy is that all geophysical data is located by longitude, latitude, depth and time, and if this information is not included as an axis, it must be included elsewhere within the data file, if the file is to be self-describing.

====
AXES
====

EPIC axis conventions are described here. These conventions are compatible with the netCDF calculator function which PMEL uses in conjunction with the PPLUS scientific graphics package.

Geographic axes in a PMEL-EPIC netCDF file are, at present, described by a numeric variable code included as an attribute in the data file. There is a disk file named "epic.key" which contains all EPIC variable codes with other related information. The numeric variable code is a unique identifier for the variable or axis, and is described more fully in the section below on "VARIABLES". The use of the numeric variable code to define the axis is necessary for EPS libary V2.1 and earlier, and for PPLUS V1.2c and earlier. In future releases of both the EPS libarary and PPLUS, the use of an axis variable code may be replaced by the use of units from UDUNITS, and may no longer be required.

Longitude axis

Many longitude representations are possible, however, for compatability with the netCDF calculator function of PPLUS V1.2c (and earlier versions), use of the the West longitude convention is required. The West longitude convention, described in detail below, defines the numeric representation of the longitude axis in the netCDF file, with positive values for west longitudes. In future releases of the netCDF calculator function of PPLUS and also of the EPS library, both East and West longitude conventions will be supported. The recommended West longitude convention is described in the following paragraphs.

We recommend that users represent the longitude axis with the West longitude convention. This means that western longitudes are positive numbers, for example, 170W is +170.0. Eastern longitudes can have either of two representations, both of which are supported by the EPS library, EPIC system application programs, and the PPLUS graphics system:

1. If the data being represented would best be described as continuous across the dateline, then east longitudes are written as (360.-long). EXAMPLE: 170E is written as 190.0.

2. If the data being represented would best be described as continuous across the Greenwich meridian, then east longitudes are written as (-long). EXAMPLE: 170E is written as -170.

The units of the longitude axis in the EPIC system library routine call should be selected either from the Unidata netCDF's udunits.dat file, or the EPIC system key file (see the EPS manual). The default spatial axis data type is real number. The recommended units are degree_west (epic variable code 501).

Latitude axis

The recommended latitude convention is for north latitudes to be represented by positive numbers (e.g., 10N is +10.0), and south latitudes by negative numbers (e.g., 10S is -10.0). The units of the axis should be compatible with UDUNITS. The default spatial axis data type is real number. The recommended units are degree_north (epic variable code 500).

Depth axis

The depth axis should be given with the oceanographic convention of depth as a positive number, increasing downwards from the surface of the water towards the bottom of the ocean. The units of the axis should be compatible with UDUNITS. The default spatial axis data type is real number. Recommended units include dbar (pressure axis with epic variable code 1) or meters (depth axis with epic variable code 3).

Although the EPS library and PPLUS will support depth as a negative number, decreasing from the surface towards the bottom of the ocean, EPIC system application programs do not support this convention.

At present, only surface atmospheric data is being written to EPIC style netCDF data files. Conventions could be expanded to include this axis type, if desired, e.g., if upper air data is written in future, this axis could have the name "Height", with a corresponding epic variable code created to identify it uniquely.

Time axis

The EPIC system library routines return the time axis from a data file to the calling routine in the form of a two-integer array, in which the first integer is the "True Julian Day Number" with units of days, and the second integer is the number of milliseconds since 0000 GMT of the True Julian Day. The True Julian Day (eg, May 23, 1968 is 2,400,000), used by astronomers, should not be confused with the "year-day" (eg, Feb 2 is year-day 33). The "year-day" is frequently called julian day (incorrectly) by oceanographers and meteorologists. Our double-dimensioned integer time word (word1=True Julian Day, word2=milliseconds since 0000 GMT of the True Julian Day) allows millisecond accuracy for time periods extending over centuries. There is a complete set of EPS routines for manipulation, calculation, and character string representation of this standard representation of time. The representation of the time axis within the data file can be of several types, for both read and write, including the UDUNITS standard, the two-integer array which is used internally by the EPS routines, and some other time representations which are supported for compatibility with other in-house software packages. Time axes can be written or read in either real or integer format. Note that, regardless of the format of the time axis in the netCDF data file itself, the values used internally by the EPIC system library will be the two-integer array.

VARIABLES

Each variable in an EPIC data file is described by a numeric variable code in the data file. There is a disk file named "epic.key" which contains the variable code and other related information about the variable. The numeric variable code is a unique identifier for the variable. Although the idea of a numeric code identifying the variable may seem at first unnecessary for netCDF files, there are several advantages to having a dependable variable identifier associated with the variables in the file. One reason is that it is unlikely that all the information about the variable will actually be included in the netCDF file (for example, exactly what algorithm was used to calculate salinity). Another reason is that it is difficult to build tools that will do complex tasks based on generic netCDF files. For example, salinity calculated by two different methods could be identified with two different numeric variable codes, but application software can be written to recognize both of these codes as a "salinity" value for use in the calculation of density. Therefore, we recommend that the variable codes be used to identify variables in the data file. Although the EPS library will write netCDF files which omit the numeric code entirely, this omission will result in a lack of information available to EPIC or other application programs.

ATTRIBUTES

There are standard attributes created by the EPS library for EPS files, as described in the following table, and additional attributes may be defined by the user as desired.

Standard Attributes Automatically Written for EPS Files

Category	Attribute Name	Type	Comments
global	CREATION_DATE	c	File creation date and time
	Conventions	c	** Name of Conventions used by the file,(eg. PMEL-EPIC/CTD)

variable	name	c	variable name
	long_name	c	variable long name
	generic_name	c	variable generic name
	FORTRAN_format	c	data Fortran format
	units	c	variable unit
	epic_code	i	variable code; write only when it is defined in epic.key file
axis	FORTRAN_format	c	axis data Fortran format
	units	c	axis unit
	type	c	axis data type
	epic_code	i	axis variable code; write only when it is defined in epic.key file

NOTES: "i" is integer
"c" is character
** The global attribute "Conventions" is not automatically written by EPS libary V2.1, or earlier, but will be written automatically by later releases of EPS.

Similarly, standard global attributes are created for EPS data files containing specific types of oceanographic data (e.g., PMEL-EPIC/CTD and PMEL-EPIC/Time_Series). Additional global and variable attributes may be defined by the user as desired. The standard global attributes for each specific data type are described in the Conventions documents in those subdirectories of pub/netcdf/Conventions (eg, pub/netcdf/Conventions/PMEL-EPIC/CTD).

APPENDIX V

End-to-End Data Management

Planning a cruise
- SHIP ROUTE — Enter and plot the planned LLT positions

Make the cruise
- SEAS — Use GPS for actual LLT positions
  - Encode a SHIP report of weather obs
  - Digitize an XBT cast in BATHY code
  - Make an AMVER report to Coast Guard
  - Transmit the reports to shore
    - GOES, INMARSAT A and C
- SEASPLOT — Plot the observations

Generate real-time products
- NMC, FNMOC, ECMWF, etc.

Send products back to observers
- NODDS — Download and display products
  - 80 users receive 50,000 products by modem.
  - On all NOAA RVs and RV Alpha Helix.

Standard Oceanographic Software

IODE software for oceanographic laboratories

BILKO	Display and analyze satellite images
OCEAN-PC	Enter, process, and display oceanographic data

IGOSS software for ships of opportunity

SHIPROUTE	FNMOC Ship Routing Program
SEAS	NOS Shipboard Environmental data Acquisition System
NODDS	Navy/NOAA Oceanographic Data Distribution System

INTERNATIONAL OCEAN DATA EXCHANGE PROGRAMS

IGOSS Integrated Global Ocean Services System
BATHY, TESAC, BUFR, etc.

IODE International Ocean Data Exchange
ROSCOP, CSR, GF-3, ICES, ad infinitum.

IGOSS and IODE will merge and adopt common data formats:

BUFR Binary Universal Format for Observations
GRIB GRIdded Binary for gridded fields

GLOBAL ENVIRONMENTAL OBSERVING PROGRAMS

WWW	World Weather Watch
GCOS	Global Climate Observing System
GOOS	Global Ocean Observing System
GTOS	Global Terrestrial Observing System

Objective: Monitor the global environment in real-time to support interdisiplinary studies and simulations.

The four programs must adopt common data management so that data can be shared globally between programs in real-time.

GOOS will integrate data from research vessels, ships of opportunity, satellites, and buoys in real-time to generate products for millions of users.

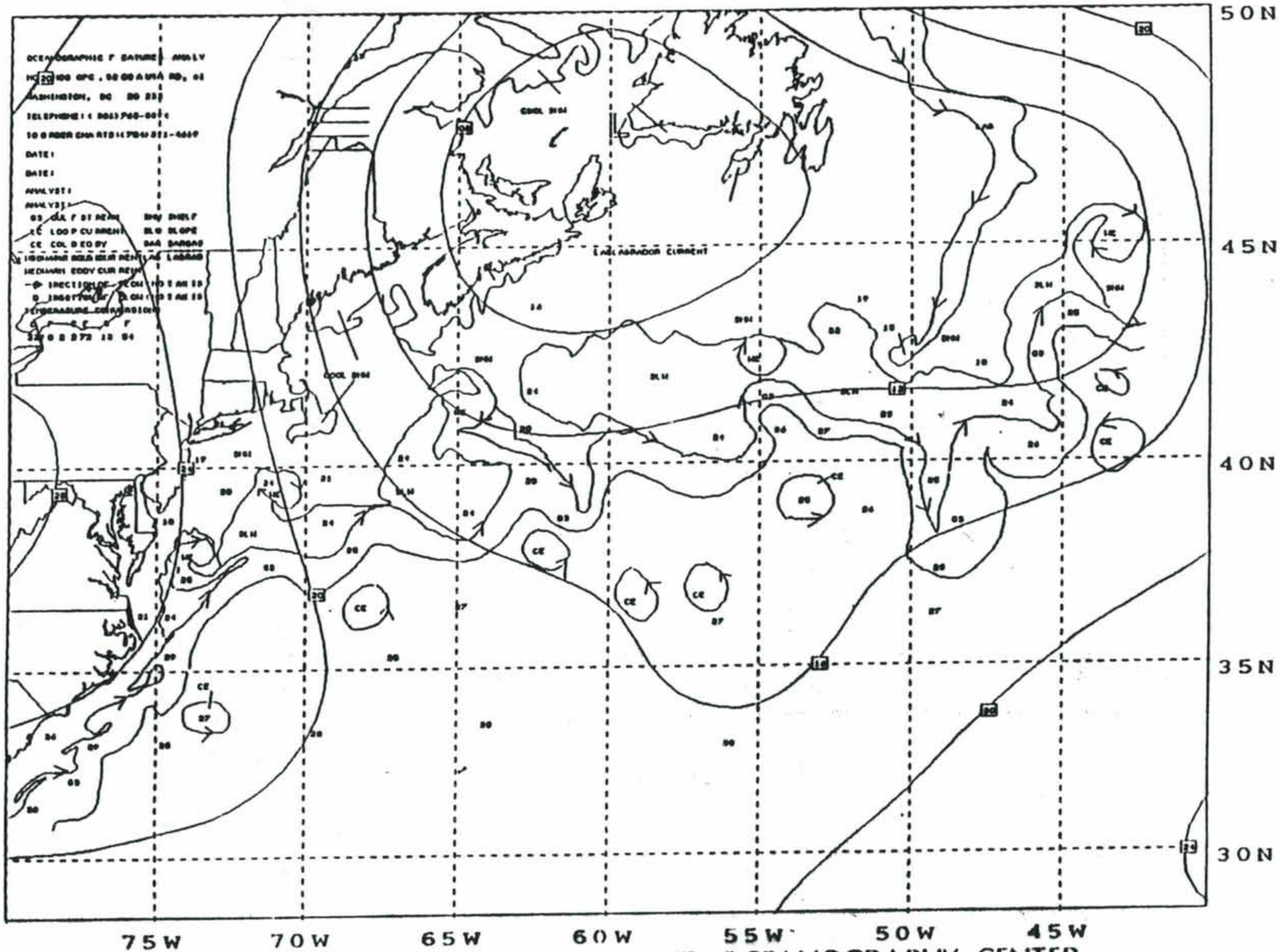
United States VOS/Met Summary					
	1991	1992	1993	1994	1995 est.
No. of Ships	131	130	148	160	155
No. of Obs.	60.6 K	66.3 K	79.7 K	78.1 K	70.3 K
No. Obs/Ship/Yr.	463	510	538	488	454

United States VOS/XBT Summary						
	1990	1991	1992	1993	1994	1995 est.
No. of Ships	79	80	76	71	78	70
No. of Routes	27	26	29	28	24	24
No. of XBT's	10.9K	19.3K	15.6K	15.0K	16.3K	15.0K
% R-T Global	34%	58%	42%	44%	41%	?

UPPER TABLE SUMMARIZES THE PRODUCTION OF THE SEAS VOS PROGRAM SINCE 1991 REGARDING THE NUMBER OF SEA SURFACE METEOROLOGICAL OBSERVATIONS TRANSMITTED IN REAL TIME.

LOWER TABLE SUMMARIZES THE PRODUCTION OF THE SEAS VOS PROGRAM SINCE 1990 REGARDING THE NUMBER OF SUB SURFACE XBT OBSERVATIONS TRANSMITTED IN REAL TIME AND THE NUMBER OF ROUTES SUPPORTED.

NOAA OPC GULF STREAM NORTH WALL FOR 06SEP94 0000Z
FNMOC SURFACE PRESSURE (MB) 12 HR FCST VALID 12SEP94 1200Z



FLEET NUMERICAL METEOROLOGY AND OCEANOGRAPHY CENTER

APPENDIX VI

SeaNet Status Report

RVTEC Meeting

October 17, 1995

Andrew Maffei

Woods Hole Oceanographic Institution

SeaNet – Big Ideas

- **Extend the existing Internet on, over and through the oceans.**
- **Start to develop an infrastructure that supports a collaborative effort to integrate shared network and telemetry tools for oceanography.**
- **Promote development of network applications that enhance the capabilities of remote research platforms.**

SeaNet Components

- Communications Nodes (SCN, BCN, End nodes, Gateways)
- Communications Links (as available)
- Interface Specifications (link, SNMP, SMTP, HTTP)
- Network Management (still to be fully defined)
- Application Layer Services (to help remote science)

Examples of SeaNet Nodes

- Shipboard Communications Node
- Buoy Communications Node
- IP-savvy End Nodes
- Gateway/Proxy Nodes

Potential SeaNet Platforms

- Shore station/Laboratory
- Coastal Monitoring Station
- Drifter, various
- Seafloor Observatory
- Buoys
- Aircraft
- Satellite, various
- Ship
- Manned submersible, submarine
- Towed Vehicles
- Remotely-operated vehicles
- Autonomous underwater vehicles
- Rain Forest Camps
- Ice Camps

Available Communications Channels

- Direct (verbal, hardcopy, etc.)
- Underwater Acoustic Modem (AUV application)
- Packet Radio (HF, VHF)
- Cellular Telephone (coastal buoy applications)
- RF, various (RF-LAN, RF-Serial)
- Satellite, shared channel, various (INMARSAT-B)
- Microwave (Point-to-point)
- Satellite, dedicated channel, various (ATS, SATCOM for Oceanography?)
- Shipboard Ethernet
- Fiber Optic (Seafloor observatories, towed vehicles)
- Shipboard Power LAN (?)
- Aircraft SeaPhone/RF-Link bridge(?)
- TDRSS (?)

SeaNet Interfaces

- Data Link (TCP/IP or proprietary)
- Human Interaction (HTTP)
- Near-RT or software based Command and Mgmt. (SNMP & MIB)
- Store and Forward Command and Mgmt. (SMTP)

SeaNet Network Management (Still Fuzzy)

- Monitoring SeaNet nodes with SNMP Network Management Station
- Accounting (currently integrated into SCN)
- Installation of SCN and BCN Systems

SeaNet–Lite Effort

- Design and Implementation of first Shipboard Communications Node (SCN)
- Implement one of first Maritime INMARSAT-B HSD Data Links for TCP/IP.
- Demonstrate prototype on R/V Thompson in support of JGOFS science.
- Answer "Can we make INMARSAT affordable for use in ongoing oceanographic science?"

SCN Design

- Portable UNIX
- Perl 5 Modules as glue
- Modular and Extendable
- WWW front end (SNMP,SMTP planned)
- PPP for Satellite Communications
- Incorporate components developed by others
- UNIX freeware where possible

SCN v1.0.1 Parts

- Core

SCN v1.0.1 Distribution
Solaris 2.4 on SPARC
Perl 5
MorningStar PPP
NCSA HTTPD
Netscape client

- UNIX Utilities

gcc, gzip, watch,

- Applications

Harvest Cache
Mirrord
WHOI/MIS UNIX Sysadmin code
WHOI/DSL serial port logging code

Potential SeaNet–Lite Applications

- Less costly email delivery
- INMARSAT-B accounting
- Proxy HTTP URL Caching (File Transfer)
- Remote cruise participation
- Directory mirroring
- Data Logging and Internet Multicast Delivery
- Video-conferencing

Collaborators

- **Participating Oceanographic Organizations**

  Joint Oceanographic Institutions Inc (JOI) - Project coordination

  WHOI - SCN and BCN core design development

  LDEO - INMARSAT-B SES component development

  NPS - SeaNet component testing, SATCOM forward-looking

  UWashington - JGOFS pilot project support

  JGOFS - JGOFS pilot project support

  UNOLS - RVTEC - Technical review - shipboard systems

- **Funding**

  NSF - SeaNet-Lite Pilot

  ONR - SeaNet for AUVs (proposal submitted)

  NATO/SACLANT - Interested in clone of SCN/SES

Shipboard Communications Node Top-Level Design

S. Lerner - April 3, 1995
Woods Hole Oceanographic Institution

Overview

This document describes the top-level design specification for the prototype Shipboard Communications Node (SCN). The SCN is a component of the SeaNet infrastructure and its purpose is to provide services for off-ship inter network services.

The first use of the SCN will be to interface a shipboard LAN to the INMARSAT DHSD SeaNet component. The SCN and INMARSAT DHSD components will be integrated into a portable system scheduled to be installed on the Thompson in the summer of 1995.

The inter network services provided by the SCN include: IP packet routing, link management, accounting, shipboard LAN support, application-layer services, and incorporation of standard SeaNet interfaces for realtime and store/forward variable query.

The design of the SCN will not only meet the minimum requirements for this prototype, but also includes an infrastructure to allow the SCN to grow and incorporate new technologies as they become available. One goal of the design is to integrate off-the-shelf products and to minimize custom development. This will allow shorter development time, greater reliability, and enhanced compatibility between multiple platforms.

SCN Architecture

The prototype SCN will be developed and deployed on a SPARC workstation running Solaris 2.4. The initial supported communication interfaces will be a high speed synchronous Morning Star snap-link interface to the INMARSAT HSD and a world blazer modem for use as a backup system. The goal of the SCN architecture is to address additional communications interfaces as they become available, cost effective, etc. without having to redesign the SCN. As shown below, the SCN modules are isolated via a multi-layer approach, and only the network interface layer deals directly with the communications interface (See figure below). Note: The bold communication interfaces are to be implemented for the prototype.

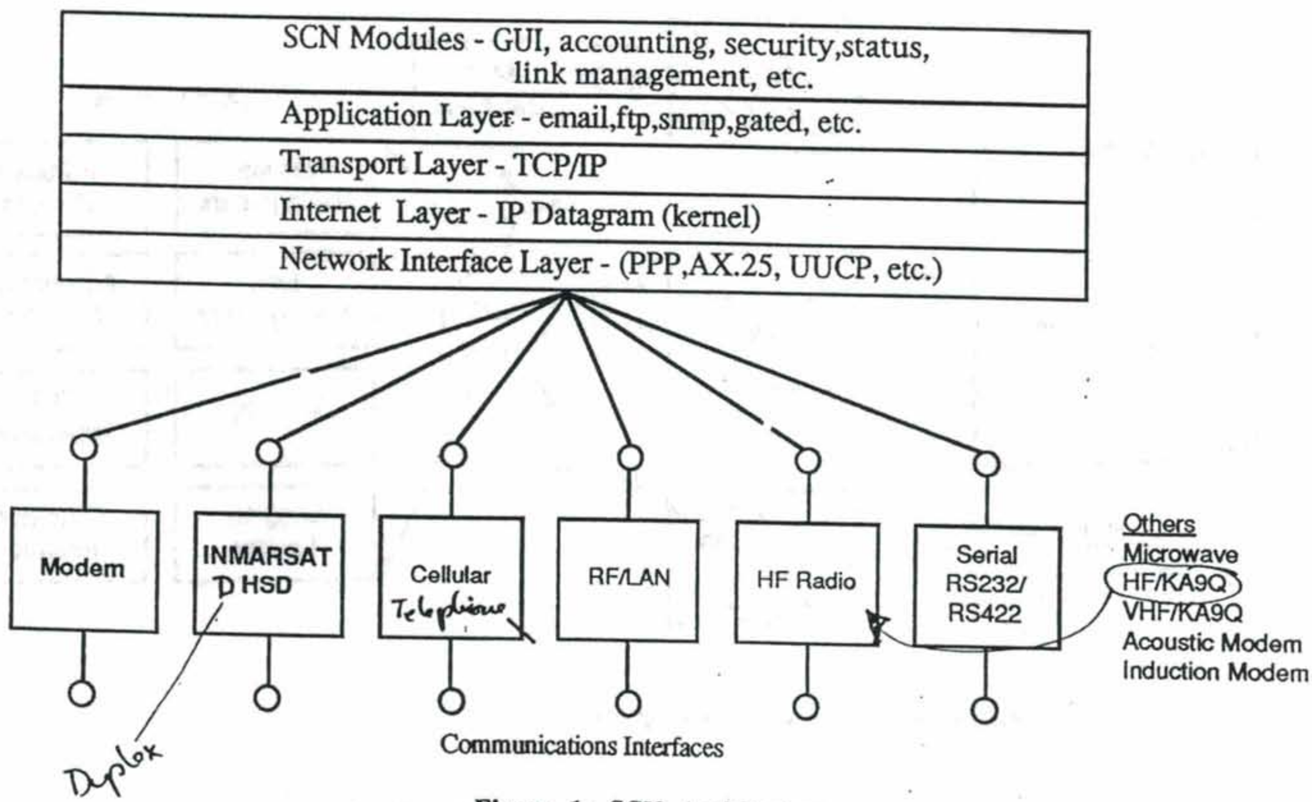
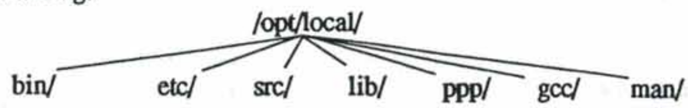


Figure 1: SCN Architecture

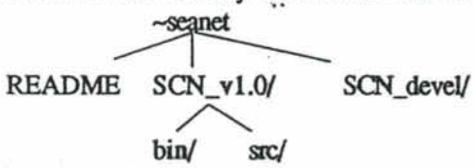
SCN Software

The SCN software will be a modular design using many off-the-shelf software packages. For the prototype system, there will be the following directory structure in order to keep both off-the-shelf software packages and custom software organized. Since the prototype system is a Sparc running Solaris2, the recommended place for installing optional software packages is /opt/local. Therefore, all non-custom SCN software packages will reside in that directory. Where appropriate, sub-directories will be created. By convention, packages which are standalone typically will have their own sub-directory. Thus the directory tree will look something like the following:

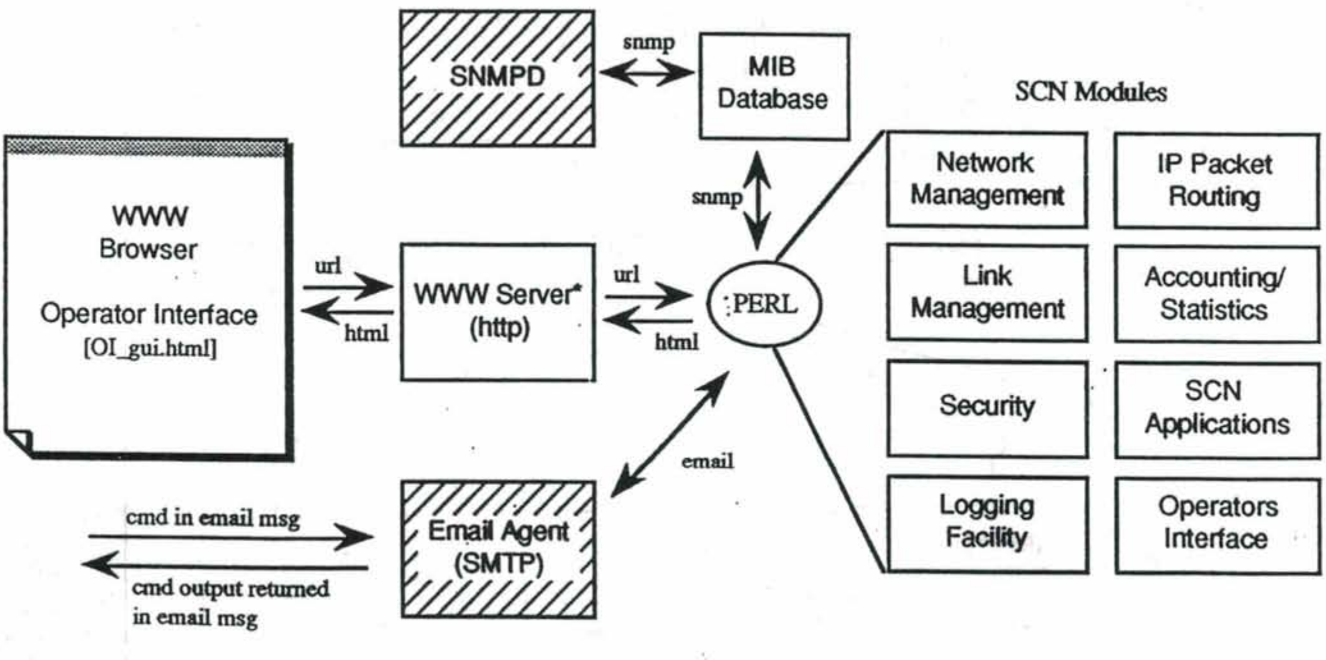


Note: Since many software packages still refer to /usr/local/..., there is a symbolic link from /usr/local to /opt/local. Additionally, several packages will want to modify or add files to /etc. By convention, there will be a sub-directory /opt/local/etc and any new files which should be added to /etc will actually reside in /opt/local/etc and be connected via a symbolic link. Any of these files which require modification, the original will be saved as filename.orig, the new one placed in /opt/local/..., and a symbolic link created.

All custom SCN software will reside in the home directory of the seanet account. Since the software configuration management tools used for SeaNet have not been established yet, as a minimum, there will be individual sub-directories indicating the latest version. The SCN custom software directory tree will look something like the following:

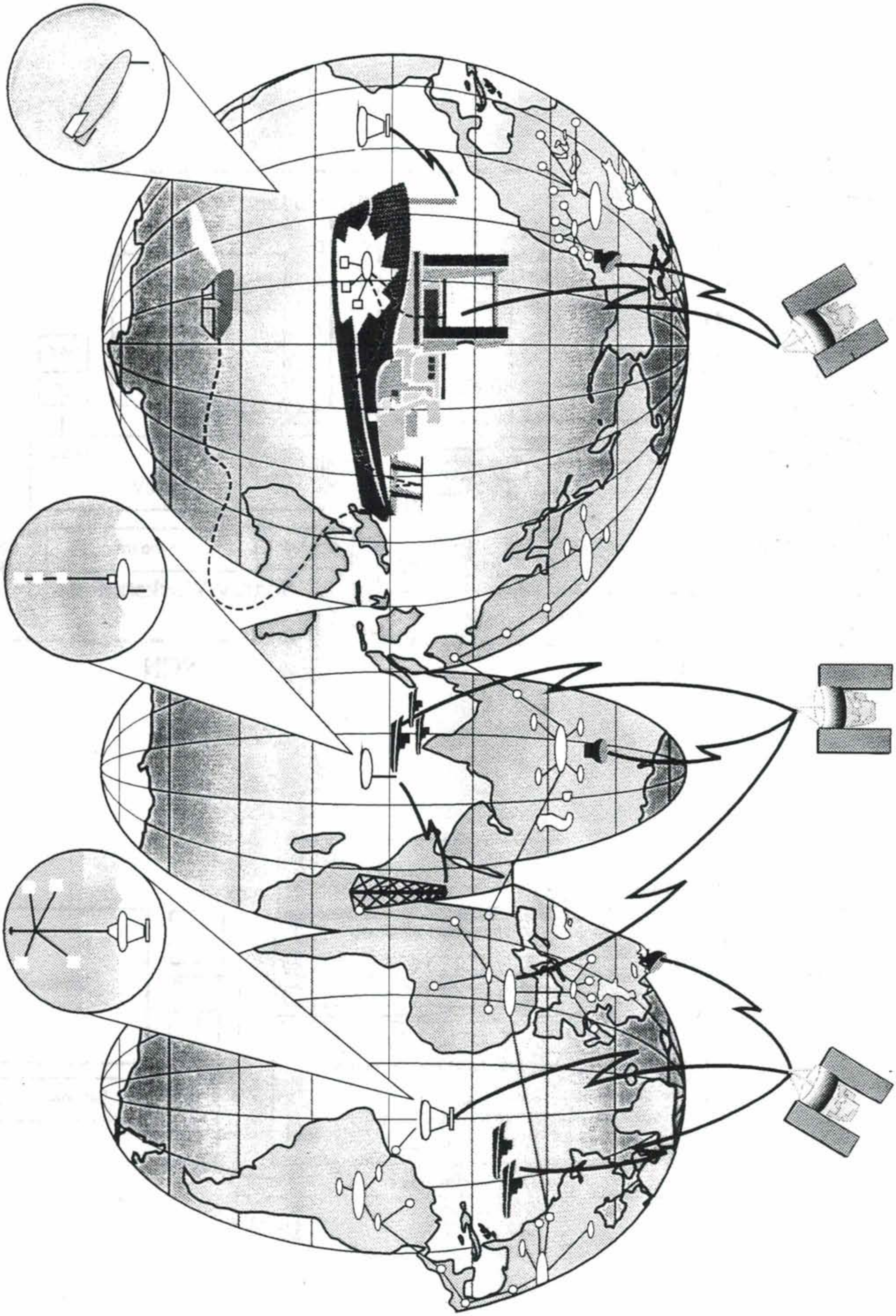


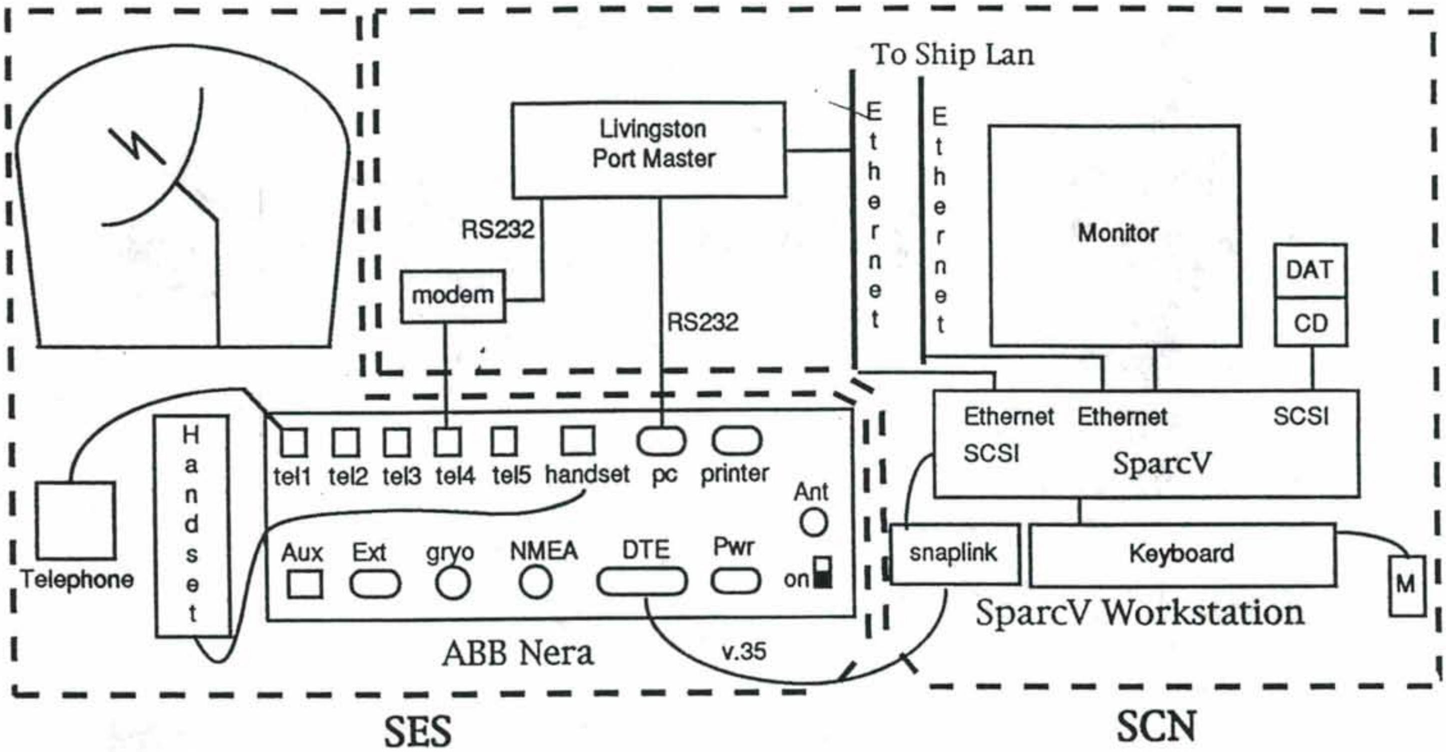
There will be a seanet account setup for the operator's use. This account will have all required symbols, aliases, privileges, etc. defined appropriately for running the SCN software. File protections will be covered under the SCN software module Security.

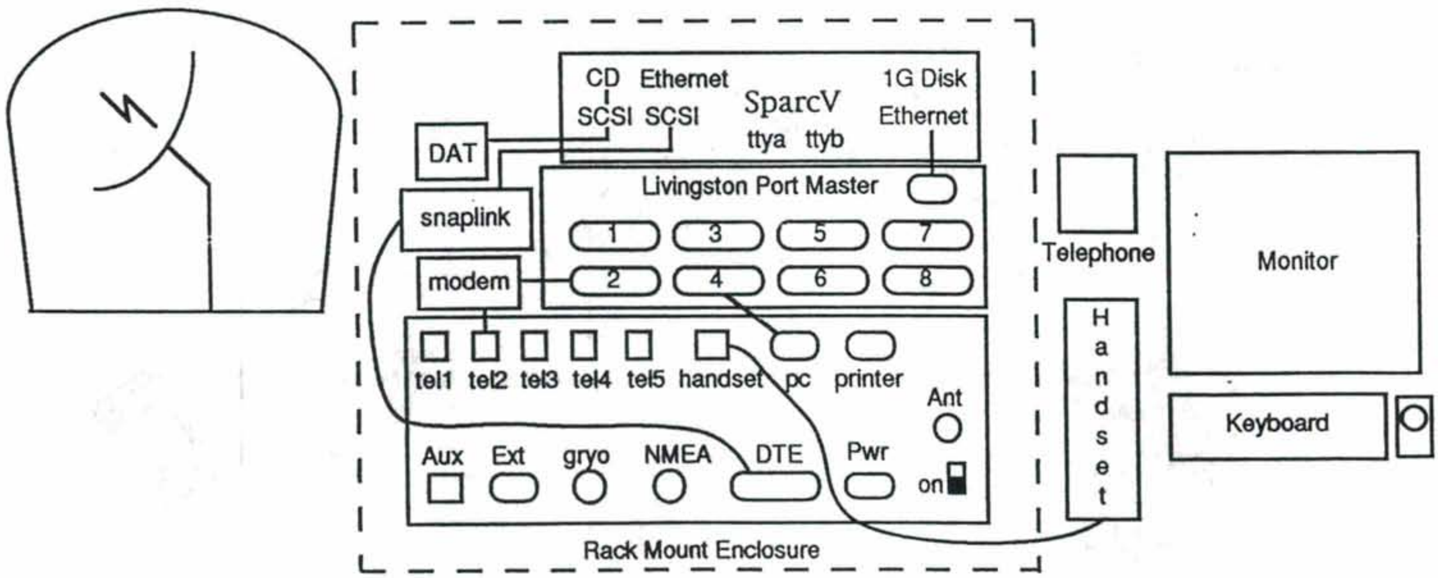


Notes: *WWW server not required for standalone installation
Future

Figure 2: SCN Software Architecture



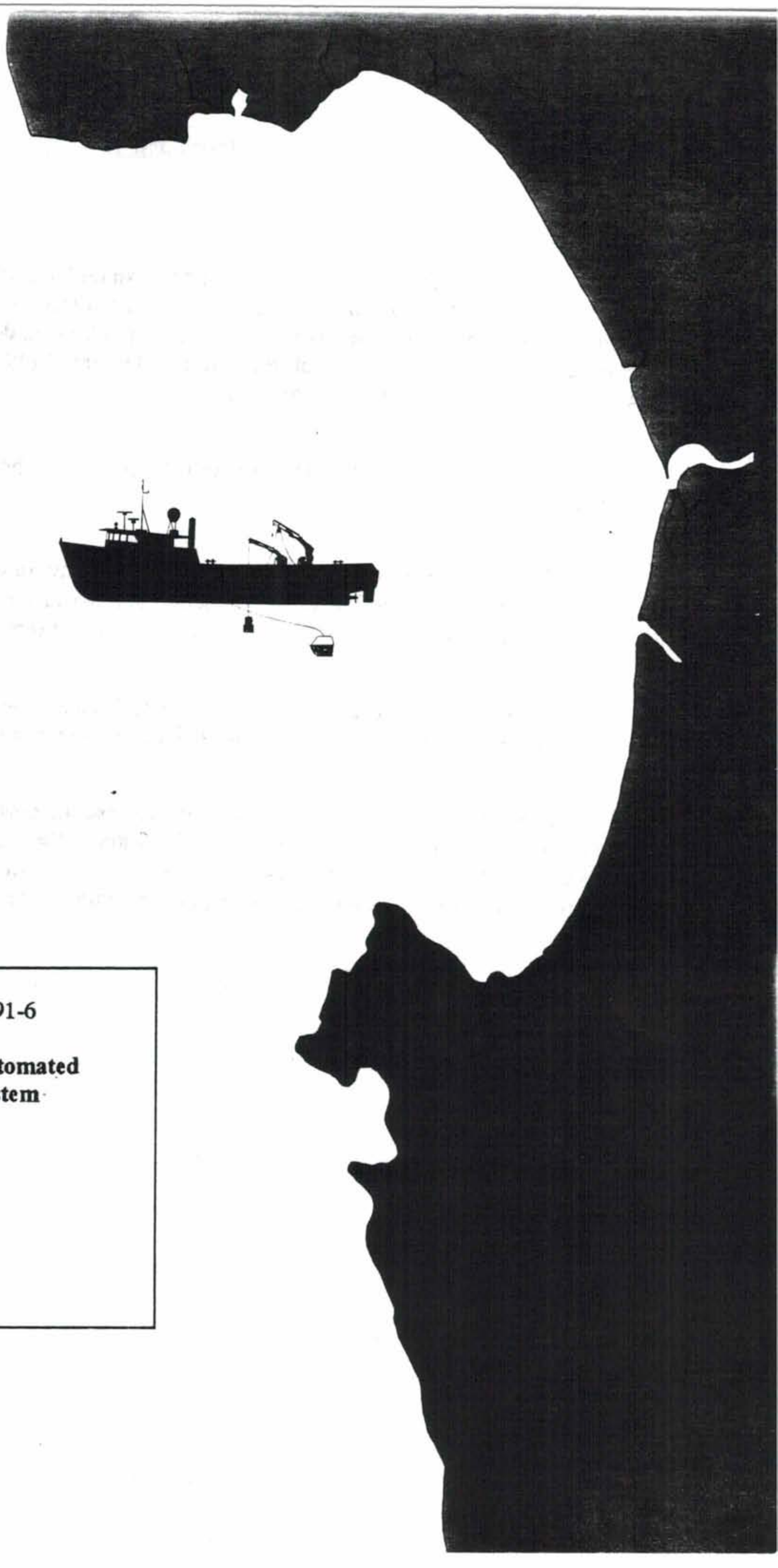

To Ship Lan
Livingston Port Master
Ethernet
Ethernet
RS232
RS232
modem
Monitor
DAT
CD
Ethernet
Ethernet
SCSI
SCSI
SparcV
H a n d s e t
tel1 tel2 tel3 tel4 tel5 handset pc printer
Ant
Aux Ext gryo NMEA DTE Pwr
on
Telephone
snaplink
Keyboard
M
SparcV Workstation
ABB Nera
v.35
SES
SCN


CD Ethernet
SCSI SCSI
SparcV
ttya ttyb
1G Disk
Ethernet
DAT
Livingston Port Master
1 3 5 7
2 4 6 8
snaplink
modem
tel1 tel2 tel3 tel4 tel5 handset pc printer
Ant
Aux Ext gryo NMEA DTE Pwr
on
Rack Mount Enclosure
Telephone
H a n d s e t
Monitor
Keyboard

APPENDIX VII

M B A R I

MONTEREY
BAY
AQUARIUM
RESEARCH
INSTITUTE



Technical Report No. 91-6

An Easy-to-Construct Automated Winkler Titration System

by

Gernot E. Friederich
Louis A. Codispoti
Carole M. Sakamoto

August 1991

Introduction

The instrument described in this report is an updated version of the high precision, automated Winkler titration system described by Friederich *et al.* (1984). The original instrument was based on the work of Bryan *et al.* (1976) who developed a colorimetric end-point detector and on the work of Williams and Jenkinson (1982) who produced an automated system that used this detector.

The goals of our updated version of the device described by Friederich *et al.* (1984) were as follows:

1) Move control of the system to the MS-DOS environment because HP-85 computers are no longer in production and because more user-friendly programs could be written using the IBM XT or AT computers that control the new device.

2) Use more "off the shelf" components and reduce the parts count in the new system so that it could be easily constructed and maintained.

This report describes how to construct and use the new automated Winkler titration device. It also includes information on the chemistry of the Winkler titration, and detailed instructions on how to prepare reagents, collect samples, standardize and perform the titrations (Appendix I). A disk containing the program needed to operate the new device is also included.

Hardware Description

The titration and end-point detection apparatus consists of three interactive components:

1) IBM-PC/AT or IBM-PC/XT compatible computer
2) 665 Dosimat dispenser
3) Light source/ detector module

Items 1&2 are unmodified commercial devices and item 3 can be easily built from a few readily available components. The details of the configuration are given below.

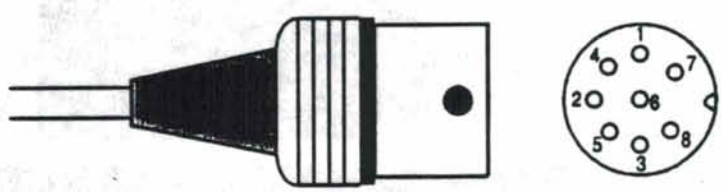
Computer

The system should have at least 512K of RAM available, otherwise problems may be encountered when manipulating large data files. Support of either CGA or EGA graphics are also necessary. Communications to the Dosimat and light detector are via a RS232 interface operating at 9600 baud, even parity, 7 data bits, 1 stop bit. During serial communications a line feed character is sent after a carriage return. The Data Carrier Detect line (DCD), the Clear To Send line (CTS) and the Data Set Ready line (DSR) are ignored.

665 Dosimat

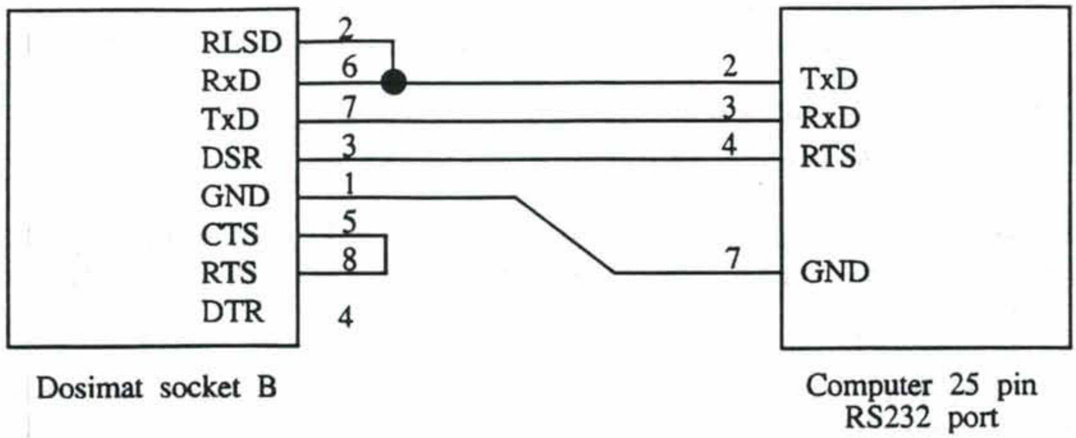
A 5ml dispensing unit was used while developing the current software. Using a 1ml unit with more concentrated thiosulfate would decrease precision slightly while a 10 ml unit with more dilute thiosulfate may exceed the capacity of the titration flasks. The software recognizes the particular dispensing unit and loads an appropriate set of default parameters. Dispensing units should not be changed while the program is in the Titrate option since the configuration of the Dosimat is only checked upon entering this mode. The diagram for the Dosimat RS232 connection is given below.

Contact location at the plug for Dosimat socket B:



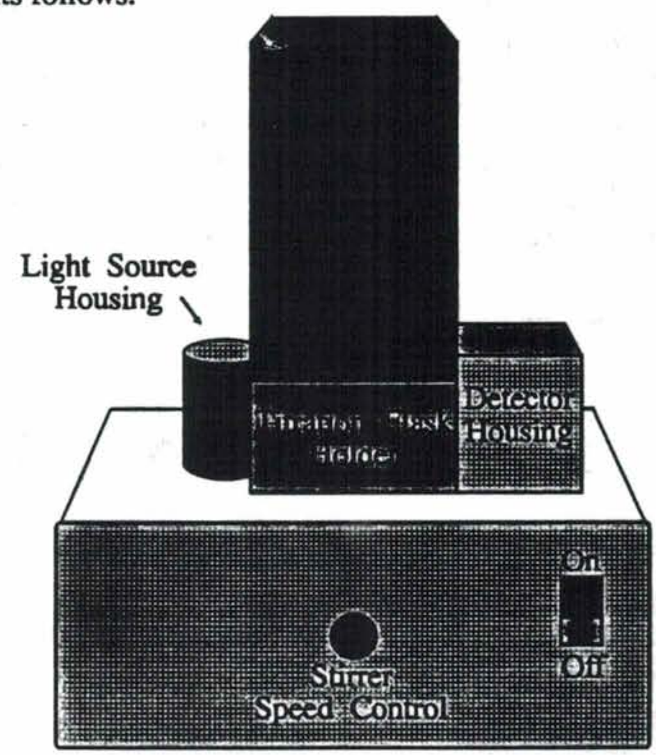
1) Signal ground
2) Received Line Signal Detector (RLSD)
3) Data Set Ready (DSR)
4) Data Terminal Ready (DTR)
5) Clear To Send (CTS)
6) Received Data (RxD)
7) Transmitted Data (TxD)
8) Request To Send (RTS)

The connection between the Dosimat and a standard 25 pin RS232 computer port is:

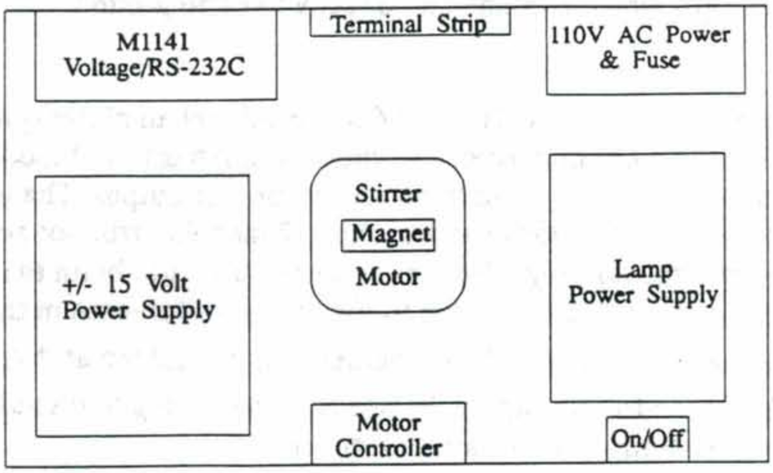


<u>Light source\detector unit</u>

The light source, light detector, analog to digital converter\RS232 interface, titration flask holder, magnetic stirrer and all associated power supplies are housed in a single unit. This unit has a footprint of 26 by 16 cm , an overall height of 30 cm and weighs about 5 kg. An approximate layout is given below and detailed descriptions of the individual components follows.



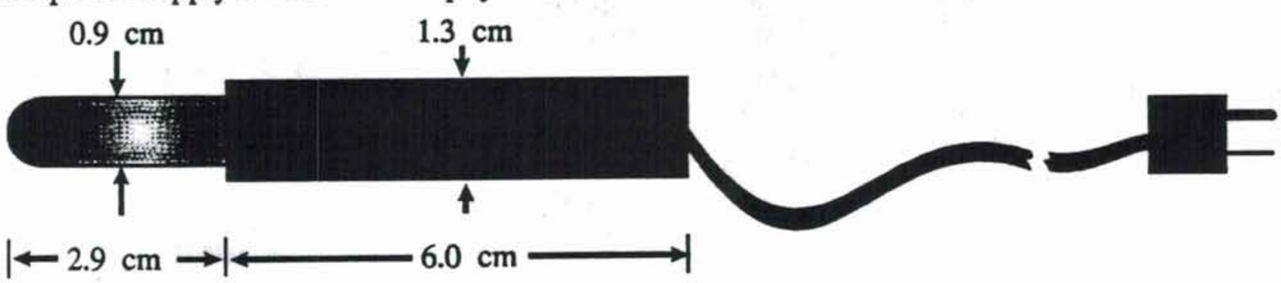
A top view of the internal layout of the base unit :



Note: The lamp power supply in this diagram consists only of the transformer. Electrical connections should be made identical to those in the original controller box supplied by the manufacturer.

Light Source:

The light source is an Analamp Model 80-1025-01\351 low pressure mercury vapor lamp with a phosphor coating. The lamp has an emission peak at 351 nm with a band width of 41 nm, thus closely matching the tri-iodate absorbance peak at 352 nm. The lamp has a starting voltage of 800 V and requires a current of 18 ma. The actual supply voltage from the power supply is 1600 V. The physical dimensions are shown below.



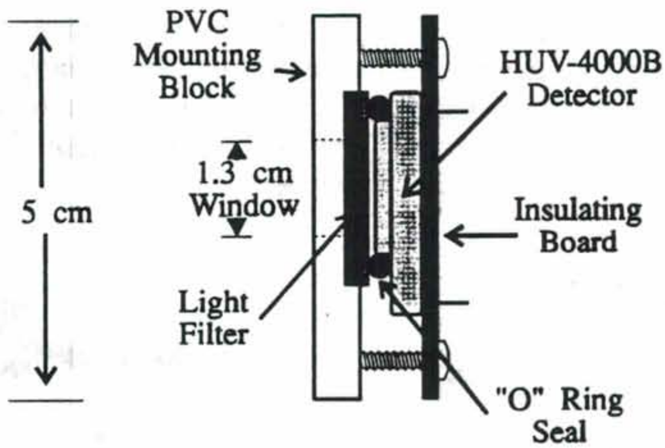
This lamp is mounted upright in the apparatus so that the center of the light emitting region is located at a level that is approximately 3 cm above the bottom of the titration flasks. A housing is used in order to shield the light from air currents that might cause rapid temperature excursions and to prevent excessive UV radiation from escaping. The side of the housing that is directly in line with the titration flask and the detector has a 1.3 cm diameter open window. The mounting and housing are made of PVC.

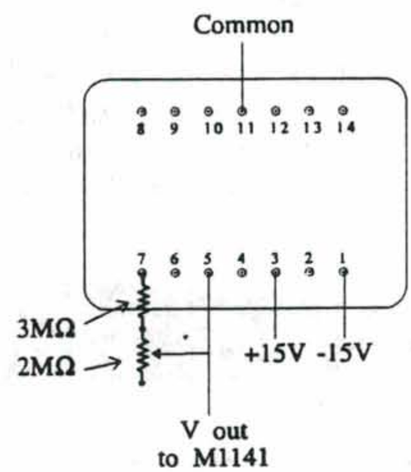
Caution should be used with these lamps. Although they are shielded and do not produce ozone they do produce radiation at 254 nm. In order to eliminate the 254 nm radiation a piece of Pyrex glass tubing must be placed over the light emitting portion of the lamp.

Note: The handle of the lamp is made of steel and is connected to the neutral line of the high voltage power supply which is connected directly to earth ground.

Light Detector:

The detector is an EG&G model HUV-4000B operational amplifier\photodiode combination mounted behind a Corning type 7-37 glass filter. An external feedback resistance of about 4.5 megohms is required to obtain the proper output. The gain of the detector is adjusted using a fixed resistor in series with a 2 megohm trimpot accessible from the outside of the detector housing. The resistance required to obtain the proper gain may be different from the values given here due to changes or differences in the physical parameters of this unit. Power requirements for the detector are 2.2 ma at $^{+}/_{-}$ 15 V. A power supply should be chosen to also supply the needs of the analog to digital converter(50 ma at 15V). Mounting details are shown below.

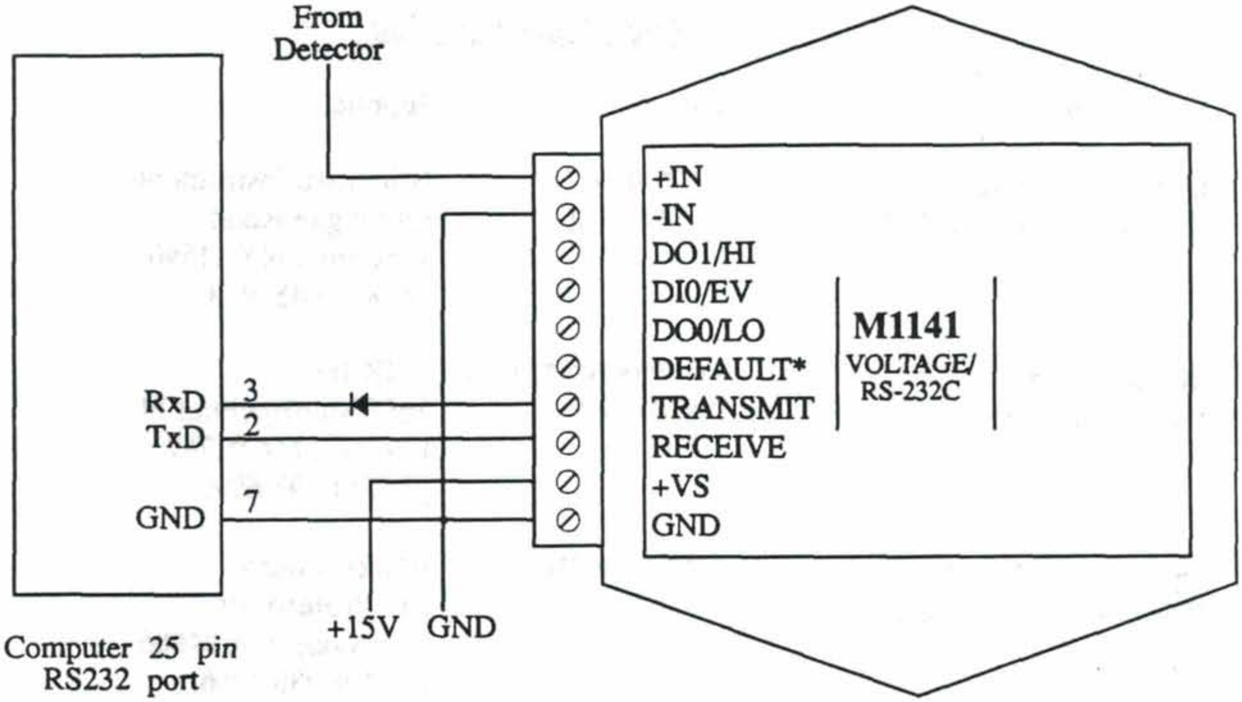




The above unit is mounted in such a way that the center of the window is at a level that is 3 cm above the bottom of the titration flask on the opposite side and directly in line with the light source.

Analog to Digital Converter:

The output from the detector is sent to the computer via a MetraByte Model M1141 RS232 compatible digital converter. The converter receives its power from the same supply as the detector and should require less than 50 ma of current at 15 V. In order to be able to communicate with this device and the Dosimat on a single RS232 port, the Transmit line of the converter must be equipped with a diode in order to allow the Dosimat to transmit. A connection diagram is given below.



These modules contain an EEPROM that stores all setup information. When shipped from the factory the setup includes a channel address of 1, 300 baud rate, no linefeeds, no parity, alarms off, no echo, 2 character delay, no large filter, 0.5 second small filter. To match communications protocol with the Dosimat the setup needs to be changed to 9600 baud, linefeed, and even parity. The remaining parameters do not need to be changed. The following series of commands need to sent to the module at 300 baud before it can be used in the titrator:

$1WE	(write enable)
$1SU31A201C2	(setup string)
$1WE	(write enable)
$1RR	(remote reset)

For details on this procedure refer to chapters 1 and 5 in the M1000/M2000 User Guide that is shipped with the module.

Stirring Motor:

The stirring motor can be any small motor whose speed can be controlled in the 600 to 1000 RPM range and has a magnet mounted on its shaft. In the titrator currently in use, the motor is a Bodine KCI-26 with a 1.8K 25W resistor in series with a 5K rheostat for speed control.

Major Components List

Description	Part no.	Supplier
Dosimat 665 Digital Buret 5ml Buret Unit 552-5BC	20 75 010-3 20 68 941-2	Brinkman Instruments Cantiague Road Westbury, NY 11590 ph: 800-645-3050
Mercury Lamp Lamp Power Supply	80-1025-01/351 90-0001-01	BHK Inc. 2855 Metropolitan Pl. Pomona, CA 91767 ph: 714-593-6590
Operational Amplifier/ Photodiode Combination	HUV-4000B	EG&G Judson 345 Protero Av. Sunnyvale, CA 94086 ph: 408 738 4266
Analog to Digital Converter 10V Input/ RS232 Output	M1141	Keithley Metrabyte 440 Myles Standish Blvd. Taunton, MA 02780 ph: 508-880-3000
+/-15 Volt 75 ma Dual Output Power Supply		Any manufacturer

Note: Any dual output power supply with an output between +/- 12 Volt and +/-18 Volt can be used.

Light Filter — Corning 7-37 glass

Note: Glass filters of this type can be obtained from various manufacturers as 2.54 cm diameter disks. If a filter other than Corning type 7-37 glass is used, it should have the following properties:

1) Maximum transmission at 350 nm
2) Near zero transmission between 450 nm and 1100 nm
3) Greater than 30% transmission at 350 nm

Software Information

The operations manual describes how to use the oxygen titration software; this section merely gives technical information about the software. A complete source code listing is given on the enclosed disc. The program was written in Microsoft BASIC version 7.1 and compiled to be used under MS-DOS. The libraries and tools that are utilized are combined in the file OXY.LIB and are listed blow.

Date/Time Functions	DTFMER.LIB
Format Functions	DTFMTER.LIB
User Interface Toolbox	MENU.BAS, MENU.BI
	WINDOW.BAS, WINDOW.BI
	MOUSE.BAS, MOUSE.BI
	GENERAL.BAS, GENERAL.BI
	UISAM.LIB

Details on these procedures can be found in the Microsoft BASIC Language Reference Version 7.0. The oxygen titration program consists of four modules listed below.

OXY1.BAS	Setup, file creation, file finding
OXY2.BAS	Data listing and data export
OXY3.BAS	Data editing
OXY4.BAS	Titrations
OXYGEN.BI	Variable declarations

All data files are stored in binary random access format and can be printed or exported as standard ASCII text files using the routines included in the program.

Operations Manual

The general sample collection and preparation techniques are based on those of Carpenter (1965). Details of these procedures are given in Appendix I, which also applies to manual methods and should be read by anyone not thoroughly familiar with this method. The information below with the exception of the recipes for the pickling reagents is specific for the hardware and software in this report.

Bottles

Although the titration system will work with various bottles, it is optimized for 125 ml Pyrex brand iodine determination flasks (Corning 5400). Each flask must be gravimetrically calibrated with its stopper. First record the empty dry weight of each flask to the nearest 0.01 gm then fill the flasks with room temperature deionized water that is free of any bubbles. Replace the stopper. Remove any moisture from the outside of the flask including the area around the stopper. Now record the full weight to the nearest 0.01 gm and the temperature to the nearest degree Celsius. When these values are entered in the bottle volume files, the volume is calculated according to the equations of Kell 1967. The uncertainty of the bottle volumes is about 0.02%.

Note: If other types of bottles are used, nonuniformity in optical characteristics may require the following procedure. Place a bottle filled with deionized water in the light path and rotate it until a region is found in which the light transmission is reasonably stable. Using the gain adjustment set the light transmission to ~90%. Place each bottle in the light path and rotate it until a light transmission of about 90% is obtained and place some type of line-up mark on each bottle. This mark can then be used in subsequent titrations to position the bottles.

Reagents

Manganous Chloride: Dissolve 600 gm of reagent grade $Mn\ Cl_2 \cdot 4H_2O$ in deionized water. Adjust the final volume to 1 liter. Manganous sulfate may be substituted for the chloride, but the chloride is suggested because of its solubility and its freedom from higher valence manganese compounds. This reagent should be delivered by a 1ml repeating dispenser that has a precision of about 1% and has been gravimetrically calibrated.

Alkaline Sodium Iodide: Dissolve 320 gm of reagent grade NaOH and 600 gm of reagent grade NaI in deionized water. Dilute to 1 liter. In order to prevent photochemical reactions, this reagent should be kept in dark bottle. This reagent should be delivered by a 1ml repeating dispenser that has a precision of about 1% and has been gravimetrically calibrated.

Sulfuric Acid: Slowly add 280 ml of concentrated reagent grade H_2SO_4 to about 700 ml of deionized water. Make up to 1 liter with deionized water. USE CAUTION AS A GREAT DEAL OF HEAT IS LIBERATED! This reagent should be delivered by an adjustable 1 ml dispenser. Adjust the volume of acid dispensed such that the final pH of the sample is between 2 and 2.5.

Sodium Thiosulfate: Dissolve 10 gm of reagent grade $Na_2S_2O_3 \cdot 5H_2O$ in 1 liter of deionized water. Add 1 pellet of NaOH and 2 drops of chloroform. Let stand (preferably for a few days) before using.
Note: When using bottles that have a significantly different volume or a Dosimat with a 1 ml or a 10 ml dispensing unit, the thiosulfate concentration should be adjusted accordingly.

Primary Standard: Dissolve 0.3567 gm of oven dried (105-110 ^{o}C) KIO_3 or 0.3250 gm of $KH(IO_3)_2$ dried in a vacuum desiccator in deionized water. Make up to exactly 1 liter. This solution is 0.01000N. KIO_3 is preferred because of its stability during drying. $KH(IO_3)_2$ (potassium bi-iodate) decomposes at temperatures above $100^{o}C$. It may be more convenient to weigh out standards that are not exactly 0.01000 N.

Standardization

The thiosulfate solution should be standardized under the same conditions as the actual procedure for the determination of dissolved oxygen. To about 40 ml of deionized water add 1 ml of the H_2SO_4 reagent. Mix thoroughly. Add 1 ml of the NaOH·NaI solution. Mix thoroughly. The solution should be distinctly acid, clear and colorless. If any basic microenvironments exist at this point due to insufficient washing of the reagent into the bottle and insufficient stirring, poor results will be obtained. Add 1 ml of $MnSO_4$ reagent and mix. Pipet a precisely known quantity of the standard iodate solution into the above flask. Fill the flask to the neck with deionzed water and titrate. Repeat this proceedure using a range of standard volumes. The slope of the relationship between the standard volume and the thiosulfate volume will be used as the calibration factor and the intercept will be the blank. Two independent standards should be used. One may be kept in a 10 ml Repipet and the other in a 1 ml Repipet. The Repipets need to be gravimetrically calibrated and have to be recalibrated periodically to ascertain that their settings have not changed.

Titration and Data Manipulation

Turn on the computer, the Dosimat, and the light source\detector unit. The light source requires an initial warm-up time of about 15 minutes. Since the computer's clock will be used to timestamp all titration data, it should be set to the correct date and time. Load the program called OXYGEN.EXE. When not using a mouse use the keystrokes given in the following table

Alt	Activates the menu bar. Press the highlighted characters in the menu names to open menus and to choose commands from a menu. Or use the Left Arrow and Right Arrow keys to highlight a menu title, and then press the Up Arrow and Down Arrow keys to choose a command.
Enter	Accepts a menu choice Accepts a dialog box choice During data and standard editing displays a plot of the endpoint During bottle volume editing moves to the next field (same as Tab)
Esc	Closes menus and dialog boxes, cancelling any entries.
Tab	Moves between choices in a dialog box. Moves between edit fields during data editing.

In order to start, existing files must be chosen or new ones created. Three types of files are used:

1) Data files (filename.oxy) are used to store titration end point information for each titration. They also contain a header that holds information about reagent volumes, standard factors and blanks that will be used when this data is calculated. Therefore only data that will share this information can be included in a given file. Choose or create one of these files if you are going to titrate samples, edit data, list data or export data.
2) Standard files (filename.std) are used to store endpoint information for standards. The header in these files contains only comments. Choose or create one of these files if you are going titrate standards, edit standards, calculate factors or export standards.
3) Bottle volume files (filename.vol) are used to store bottle calibration data. Choose or create one of these files if you are going to enter bottle calibrations or wish to list calculated data.

To select a file:

1) Press [F2] or enter the File menu and choose Select File.
2) Enter a disc drive name or press Enter to choose the current drive.
3) Enter a valid path or press Enter to choose the default.
4) Enter a file selection argument or accept the default (note: you must change the file extension to find the standard and bottle volume files).
5) Select a file.

This file now remains the default of its type until you exit the program or it is changed using the above procedure. Repeat for each type of file that you need. An example of each file type is included on the program disc.

To create a file:

1) Press [F1] or enter the File menu and choose Create File.
2) Enter a disc drive name or press Enter to choose the current drive.
3) Enter a valid path or press Enter to choose the default.
4) Enter a file name making certain to use the proper extension.
5) Enter any available header data when it is requested. The headers can be edited at a later date if the information is not available. A newly created file becomes the selected file.

Titrations

If samples will be titrated press [F9] or select via the menu. For standards use [F10] or select via the menu. At this point, the computer attempts to establish communications with the Dosimat. Up to three attempts are made if it is not successful initially. The type of dispenser unit found and the default titration parameters for that unit are displayed. The titration parameters can be edited at this point.

1) Dispensing Rate (ml/min) is the rate at which continuous dispensing of thiosulfate occurs during the initial part of the titration.
2) Switch to Incremental Addition (%) is the light level above which dispensing of thiosulfate becomes incremental.
3) Incremental Rate is a factor applied to the size of the incremental additions of thiosulfate. Note: The increments become smaller as the light level increases and regardless of the rate factor take on the smallest possible value when the light level is 90% or greater. At light levels below 90% the volume of the increment that the Dosimat delivers is given by the relationships below:

$$X=(9000\text{-detector output in mv})\cdot(\text{Incremental Rate})$$

$$\text{Volume in ml}=(X+X^{1.3}/2000)\cdot(0.0001\cdot\text{volume of Dosimat unit})$$

4) Maximum Slope at Endpoint is the slope (change in light/change in volume) that is considered acceptable due to noise once the endpoint has been reached. If there were no instrumental noise this value would zero.

You may now enter the appropriate identification parameters for the first sample or standard. Before titrating the first sample check the following:

1) Place a titration flask filled with deionized water free of bubbles in the light path and adjust the light transmission output to read about 90% using the potentiometer on the detector housing. (The reading should now be about 40% when the bottle is removed.)
2) Press R to enter the rinse mode. Enter the desired number of rinses for the dispenser.
3) Adjust the stirring rate. While rapid stirring is desirable, a deep vortex or a central column of bubbles must be avoided.
4) Press the Spacebar to clear the pipet tip before inserting it into the sample. Be sure to remove any pendant drops.

To titrate a sample:

1) Remove the stopper from the flask and add the acid.
2) Add a magnetic stirring bar to the flask and place it in the titration stand.
3) Clear the pipet tip by pressing the Spacebar and remove any pendant drops.
4) Place the pipet tip in the flask and press Ctrl + Enter to start the titration.

The progress of the titration is displayed graphically and numerically. When the endpoint is reached, the data can be accepted by pressing Enter or it can be edited using the cursor keys. Except for the addition of acid, a standard is run in the same manner. If Esc is pressed, the data is also saved but the program returns to the main menu rather than to the titration routine.

Notes:

1) If the light transmission at the endpoint is low then precision is decreased since the size of the incremental thiosulfate additions is controlled by light intensity. A warning message is displayed if the endpoint is found at a transmission value less than 80%.
2) If the light transmission at the endpoint is 100% then the actual endpoint was probably not reached and the oxygen concentration may be underestimated. Since the endpoint is determined by a low slope in the volume versus light relationship and value of 100% is the maximum output of the detector, a slope of 0 results once the light transmission reaches 100%. If this occurs then the gain of the detector must be reduced using the potentiometer on the detector housing.

Data Manipulation

Editing Data and Standards: Besides the sample identification and the endpoint, the last portion of the titration curve is also saved in the data and standard files. When entering the edit mode either via the menu or [F6] (data) or [F7] (standards), the current file becomes available for editing. Choose an editing field using the Tab key to move horizontally and the Up Arrow and Down Arrow keys to move vertically; if using a mouse you can use the scroll bar. The Station and Bottle fields are alphanumeric and the Depth field is a single precision number. To edit the endpoint, press Enter to display a plot of the titration. Use the cursor keys to choose a different endpoint. The date and time of titration can not be edited. In order to exclude a standard from the determination of the calibration factor; place a * in front of its ID. Upon exiting the edit mode, you have the choice of accepting the changes or discarding them.

Editing Headers: The headers of the above files can accessed via the menu and [F5] (data header). Besides identifying information the data header also contains the thiosulfate calibration factor and the reagent volumes, both of which must be present in order to view or export calculated data. Choose an edit field using the Up Arrow and Down Arrow keys. The baud rate cannot be edited in this version since the baud rate of the Dosimat cannot be changed.

Editing and Adding Bottle Volumes: Use the menu or [F8] to edit the current bottle volume file. Choose an editing field using the Tab or Enter keys to move horizontally and the Up Arrow and Down Arrow keys to move vertically; if using a mouse you can use the scroll bar. If the Empty Weight, the Full Weight or the Temperature are modified and none of these fields is zero, then the volume is automatically updated. If the volume of a bottle is known and there is no calibration data, it can be entered. To add new bottles move to the bottom of the listing and enter new data. The bottle identifier can consist of numbers and letters. To remove a bottle delete its name. When exiting the edit mode you have the choice of accepting the changes or discarding them. When the data is saved, it is sorted numerically and alphabetically by bottle name or number.

Calculating Calibration Factors and Blanks: Thiosulfate calibration factors are calculated by choosing Standards in the Results menu. A list of all standards in the current standards file is displayed. When Enter is pressed a least squares linear regression of standard volume versus thiosulfate volume is calculated and a plot of the data is shown. Any standards that have an ID starting with * are ignored during the calculation. The Factor (slope) and Blank (intercept) are recorded in the header of the standard file. When acceptable values are obtained they should be entered into the headers of all the associated data files.

Displaying Results: To display calculated results, choose Data from the Results menu. The current bottle volume file will be searched for matches by bottle name and the data will be calculated with the factor, blank and reagent volumes in the data file header. Data will be displayed but not calculated if any of the above are missing.

Exporting and Printing Files: To export or print any file use File menu or [F3] (export) or [F4] (print). Then select which type of file. Files are sent as standard unformatted ASCII text files. Printing uses the LPT1 port. Exporting requests a destination directory that cannot be the same as the the directory containing the original data. If the bottle and calibration information is available, this information is combined with the data files to calculate oxygen concentrations before the information is exported or printed.

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APPENDIX I

ON THE DETERMINATION OF DISSOLVED OXYGEN IN SEA WATER

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INTRODUCTION

With the exception of salinity determinations, dissolved oxygen is probably the most commonly measured chemical oceanographic variable. Historically, dissolved oxygen has been determined by some modification of the classic Winkler (1888) method. Increasingly, electrodes are being used to measure dissolved oxygen, but even when this is the case, the electrodes are often calibrated with Winkler titrations.

RANGE OF OCEANIC DISSOLVED OXYGEN CONCENTRATIONS

Dissolved oxygen concentrations are generally expressed in millimolar, mMoles/kg, mg-atoms/liter or ml/liter (mg-atoms of O_2/liter = 0.08931 x ml/liter). Values from 0 to 13 ml/liter are encountered in the ocean. The equilibrium solubility values for dissolved oxygen increase with decreasing temperature, and salinity, and they range from about 4 to 9 ml/liter throughout most of the ocean. Generally, biological processes are responsible for the wide range of values which are encountered. Phytoplankton growth, for example, can cause oxygen supersaturations while respiratory processes can remove all of the oxygen originally present in some regions.

CHEMISTRY OF THE WINKLER METHOD

Manganous sulfate (or chloride) solution is added to a known quantity of sea water and is immediately followed by the addition of an alkaline sodium hydroxide-sodium iodide solution. Manganous hydroxide precipitates and reacts with the dissolved oxygen in the water with the formation of a hydrated tetravalent oxide of manganese.

$$Mn^{++} + 2OH^- \longrightarrow Mn(OH)_2\,(S)$$

$$2Mn(OH)_2 + O_2 \longrightarrow 2MnO(OH)_2\,(S)$$

Upon acidification, the manganese hydroxides dissolve. In the acid solution, the tetravalent manganese in $MnO(OH)_2$ acts as an oxidizing agent and liberates free iodine from the iodide ions.

$$Mn(OH)_2 + 2H^+ \longrightarrow Mn^{++} + 2H_2O$$

$$MnO(OH)_2 + 4H^+ + 2I^- \longrightarrow Mn^{++} + I_2 + 3H_2O$$

The liberated iodine, equivalent to the dissolved oxygen present in the water, is then titrated with a standardized sodium thiosulfate solution and the dissolved oxygen present in the sample is calculated. The reaction involved is as follows:

$$\underset{\text{(thiosulfate)}}{I_2 + 2S_2O_3^{=}} \longrightarrow \underset{\text{(tetrathionate)}}{2I^- + S_4O_6^{=}}$$

ACCURACY OF THE WINKLER METHOD

Under ideal conditions, the Winkler method is quite accurate. Carpenter (1965a), for example, has described one modification which has an accuracy of 0.1% at concentrations of ~5 ml/l, and using the Winkler method he (Carpenter, 1966) has produced a set of oxygen solubility tables which appear to be accurate within ~0.01 ml/liter (Murray and Riley, 1969). The field adaptation of Carpenter's technique (1965b) should have an accuracy of better than 0.05 ml/liter when carefully performed. (This estimate includes standardization, and "pickling" errors. Precision should be better than 0.05 ml/l). Automated titrating systems that will be described later on have the potential to attain precisions of ~$\pm$0.1% in the field (at concentrations of ~ 5 ml/l, page12).

Unfortunately, much of the historical oxygen data has been obtained using unsuitable variations of the Winkler method and/or by unskilled analysts. A study conducted several years ago indicated that errors approaching 0.5 ml/liter may be common in the historical data (Carritt and Carpenter, 1966). Such errors sometimes make it impossible for oceanographers to use existing oxygen data. Wüst (1964), for example, could not compare oxygen data from different cruises in his study of the Caribbean Sea.

THE CARPENTER MODIFICATION OF THE WINKLER METHOD

Carpenter's (1965b) modification of the Winkler method was designed to reduce the following errors:

1. Iodine Volatilization. Loss of the iodine produced after the sample has been acidified has been shown to be significant in some previous techniques. One way in which Carpenter's method reduces this error is by eliminating sample transfers which could contribute to iodine losses. Because the entire sample is titrated in the original collection flask, no transfers are necessary. The collection flasks can easily be calibrated for volume to $\pm$ 0.02%.

In Carpenter's method, loss of iodine during exposure to the atmosphere is also minimized by encouraging the formation of the less volatile complex (I_3^-). This is done by using a high concentration of sodium iodide which encourages the formation of the complex according to the following formula:

$$I_2 + I^- \rightleftharpoons I_3$$

Comparison experiments indicate that the error introduced by not using the glassware necessary to eliminate transfers is less than 0.05 ml/liter if aliquots are drawn with care and the Carpenter reagents are employed. Knapp et al. (1991) discuss an aliquot technique in which the error due to iodine loss may be negligible.

2. Air Oxidation of Iodide. Iodide reacts with oxygen in acidic solution:

$$4I^- + 4H^+ + O_2 \longrightarrow 2I_2 + 2H_2O$$

To minimize this source of error the optimum pH to permit the proper reaction between thiosulfate and iodine and prevent the above reaction was determined. The optimum pH range was found to be 2.0-2.5 and the reagent concentrations were adjusted to attain a final pH in the appropriate range.

3. Improper Blank Determinations. In most previous methods, allowance was made only for positive blanks, but negative blanks caused by reducing impurities are also possible. Consequently, a method for determining positive and negative blanks was devised.

4. Improper Standards. It was found that potassium dichromate which had been used in some methods was not a suitable standard. The best standard is potassium iodate but potassium biiodate can also be used if it is dried by vacuum dessication. Potassium iodate can be dried in an oven at -110°C, potassium biiodate decomposes at these temperatures.

Preparation of Reagents:

Reagent Bottles. The reagent bottles used for the manganous sulfate (or chloride), potassium hydroxide-iodide, and sulfuric acid should be such that automatic filling of the pipets is possible. In order to prevent photochemical reactions, the alkaline iodide reagent bottles should be of brown glass.

Manganous Chloride. Dissolve 600g of reagent grade $MnCl_2 \cdot 4H_2O$ in distilled water. Adjust final volume to 1 liter. Manganous sulfate may be substituted for the chloride, but the chloride is suggested because of its solubility and its freedom from higher valence manganese compounds. When substituting Manganous sulfate or a form of MnCl with more or fewer waters of hydration than in $MnCl_2.4H_20$ adjust for differences in formula weight.

Alkaline Sodium Iodide. Dissolve 320g of reagent grade NaOH and 600 g of reagent grade NaI in distilled water. Dilute to 1 liter.

Sulfuric Acid. Slowly add 280 ml of concentrated reagent grade H_2SO_4 to about 700 ml of deionized water. Make up to 1 liter with deionized water. USE CAUTION AS A GREAT DEAL OF HEAT IS LIBERATED!

Starch Solution. Dissolve 1-2 g of starch indicator in 100 ml of distilled water, or boil a similar amount of potato starch in distilled water for about 5 minutes. The indicator should be made up fresh every day if possible since bacterial action degrades it. One sign of a degraded indicator is a reddish tinge to the normally blue color when the starch is added to the sample. It is permissible to "play around" with the starch concentration a little bit to produce an indicator color intensity that meets your personal preferences! **NOTE that some of the automated techniques discussed later on do not require a starch indicator solution.**

Sodium Thiosulfate Solution. Dissolve 1.6 g for the Aliquot method described here or 35 g for the Carpenter method, of reagent grade $Na_2S_2O_3{\cdot}5H_2O$ in 1 liter of distilled water. Add 1 pellet of NaOH and 2 drops of chloroform.

NOTES:

a. The sodium hydroxide is added to negate the influence of any dissolved CO_2 as the presence of carbonic acid causes the following reaction:

$$S_2O_3^{=} + 2H^+ \longrightarrow S + SO_2 + H_2O$$

b. Sodium thiosulfate is degraded by the action of bacteria. Chloroform is added to inhibit bacterial growth.

Primary Standard. Dissolve 0.3567 g of oven dried (~105-110^{o}C) KIO_3 or 0.3250g of $KH(IO_3)_2$ dried in a vacuum desiccator in distilled water. Make up to exactly 1 liter. This solution is 0.01000N.

STANDARDIZATION OF THE THIOSULFATE

The thiosulfate solution should be standardized under the same conditions as the actual procedure for the determination of dissolved oxygen. By so doing, possible errors are compensated. The best practice is to run standards and blanks before and after every sample run until you are sure that the interval between standard runs can be extended.

To about 40 ml of distilled water add 1 ml of the H_2SO_4 reagent. Mix thoroughly. Add 1 ml of the NaOH-NAI solution. Mix and wash down the sides of the flask thoroughly. The solution should be distinctly acid, clear and colorless. If any basic microenvironments exist at this point due to insufficient washing of the reagents into the bottle and insufficient stirring, you will obtain poor results. Make good use of your wash bottle and stirring motion before going on! Add 1 ml $MnCl_2$ reagent and after mixing, pipet into the flask 10 ml of the standard Iodate solution. Stir for ~5 sec. Then, titrate with thiosulfate in the same manner described below for samples.

$$IO_3^- + 5I^- + 6H^+ \longrightarrow 3I_2 + 3H_2O$$

$$\frac{10\text{ml } KIO_3 \times 0.010000N}{[\text{ml } Na_2S_2O_3 - B]} = \text{Normality of } Na_2S_2O_3$$

Where 0.010000 is the normality of the iodate solution, and B = Blank. Often it is preferable to weigh out standards that are not exactly 0.01000 N because striving for an exact weight takes extra time and tends to make the weighing process less exact. It is, of course, a simple matter to substitute a different normality when performing your calculations.

NOTE: An alternate method for obtaining a standardization and blank reading that we prefer is to construct a standard "curve" by dispensing different amounts of standard from a calibrated (glass) Re-pipet with a nominal dispensing volume of ~1 ml. These re-pipets when properly used and calibrated appear to be capable of accuracies of about ± 0.1%. Typically, we pipet volumes of standard ranging from ~1 to 12 ml (e.g., 1,2,3,5,8, and 10 mls), and obtain R^2's of 0.9999 or better with the automated system described in Friederich and Codispoti (1991). With this method the intercept corresponding to 0 standard addition is the blank. Each standard must, of course, be made up separately "from scratch" since pipetting more standard into an already titrated standard as done for the blank described by Carpenter (1965b) will invalidate this technique. Typically, we accumulate sufficient data for constructing the curve over ~day, and have found that the curve does not vary significantly over several day periods. We employ a ~10 ml re-pipet for the ~10 ml standard addition and for "running" checks between calibration curves. We fill this repipet with a totally independent (different lot) primary standard to guard against systematic errors.

Blank Determination. The Carpenter (1965b) procedure is the same as the standardization procedure except that exactly 1 ml of the standard KIO_3 is added instead of 10 ml, and, after the first titration, another 1 ml of standard is added to the same sample and the solution is titrated again. The blank is equal to the ml of thiosulfate needed for the first titration minus the ml of thiosulfate needed for the second titration. The blank may be either positive or negative.

SAMPLE COLLECTION AND TREATMENT

Samples for the determination of dissolved oxygen should be taken from the water sampling bottle immediately upon its arrival on deck. The sample should be collected in a calibrated, ground glass-stoppered container. Two types may be used - brown glass bottles approximating 250 ml and clear flasks or bottles approximating 125 ml. In the case of the latter, the entire content of the flask is used for titration while with the former, an aliquot is taken. We use 125 ml (approx.) clear borosilicate (Pyrex) glass bottles or flasks that are calibrated to contain with an accuracy of $\pm$ 0.03 ml and titrate the entire bottle as suggested by Carpenter (1965b).

To fill the oxygen bottle from the oceanographic sampling bottle (e.g. a Niskin bottle), you will need a length of amber surgical tubing (or similar material) with an inside diameter of approximately 1/4". The length of this tubing should be approximately 12", but keep the length as short as you can without sacrificing ease of movement while filling the oxygen bottle. To one end of this tubing attach a length of stiff plastic tubing or glass tubing that is a bit longer than the oxygen bottle. You are now ready to begin the challenging task of drawing a high quality oxygen sample without contamination while bathed in an atmosphere that is about 21% oxygen!! Believe it or not it can be done, and with a bit of practice you can do it!

A method that works well will be described next, but remember the principal which is to minimize contact of the seawater sample with the atmosphere. With this basic principle in mind, you can modify the technique to fit your particular blend of motor skills. Proceed as follows:

1) Attach the soft tubing to the spigot of the Niskin (or other type of bottle), and open the air vent on the Niskin bottle. If an appreciable amount of water comes out before opening the spigot, the bottle leaks! Make sure you note leaky bottles in the log sheet! Now open the air vent.

2) Flush the sampling tubing so that all air bubbles are removed. The easiest way to do this is to hold the tubing in a straight line (more or less) and point the tubing downward while letting water flow through the tubing at

maximum velocity for a brief period. At this point, you control the velocity of flow by pinching the soft tubing with your fingers. If the tubing is not completely free of bubbles after the first brief period of maximum velocity, repeat the process one or more times by turning the flow on and off by pinching and unpinching the rubber tubing. Some investigators prefer to try to remove the bubbles from the tubing by holding it in a "U" shape with the open end up and letting the water flow gently through the tubing. Any method or combination of methods that removes all of the bubbles from the tubing is okay Pre-wetting the tubing in a weak detergent may help to reduce the presence of "sticky" bubbles.

3) The next step is to rinse the oxygen bottle/flask, while minimizing contact with the atmosphere. You can do it by allowing the water to flow at a moderate pace out of the bubble-free tubing, inserting the tubing so that the stiff portion touches the bottom of the bottle, and then inverting the bottle. While in the inverted position, move the stiff part of the tubing around so that a moderate "sheet flow" rinses the entire bottle with minimal turbulence.

4) Next, momentarily stop the flow by pinching the tubing and invert the bottle quickly. Then, start a moderate flow again and let the bottle fill as quickly as possible without forming a lot of turbulence while keeping the stiff part of the tubing near the bottom of the bottle. As the bottle begins to overflow, let the overflow water rinse the ground glass stopper. After about one and a half bottle volumes has overflowed, begin to withdraw the tubing from the bottle by steadily raising while allowing another bottle volume (approx.) to overflow and continue to rinse the stopper. Let two to three volumes overflow before raising when taking samples from low oxygen (<~2 ml/l) water.

5) Now, immediately add 1 ± 5% ml of the manganous reagent by placing the tip of the delivery pipet just below the surface of the sample in the oxygen bottle. This step is immediately followed by the addition (in like manner) of the alkaline-iodide reagent. Both reagents are very much denser than sea-water, and they sink to the bottom and displace the upper ~2 ml of sea-water in the bottle which is helpful since the upper water has been in contact with the atmosphere. It is best not to immerse more than about 1/8" of the tips of the delivery pipets since this should help to cut down on contamination. Not immersing the tips at all increases the possibility of contamination from the atmosphere.

6) Now place the stopper in the bottle without trapping bubbles. The easiest way is also the way that works the best. Just drop the stopper into the bottle from a height of about one inch! If you place the stopper in the bottle slowly and carefully, you are more likely to trap a bubble. The stopper displaces the upper few ml of liquid in the neck of the bottle

thereby removing most of the atmospheric contamination that may have accumulated.

7) Now push down on the stopper to make sure that it is tight, and closely inspect the bottle to make sure that it is free of bubbles. A bubble the size of a pencil eraser will completely invalidate any sample, and much smaller bubbles can also totally ruin a sample depending on ambient concentrations and the accuracy that you desire. The best rule of thumb is to start over again if you can see a bubble in your sample even though there exist exceptional situations in which heating or the addition of the first two reagents can cause bubbles to form within the sample.

8) Now invert the bottle several times to mix the first two reagents with the sample. A precipitate will form. Allow the precipitate to settle, and repeat the mixing process one time. Shake vigorously during the second mixing to help break-up precipitate. Wait at least 15 minutes before repeating this mixing process. If you are using the Carpenter method (which we prefer), your sampling bottle will be a calibrated (for volume) bottle/flask made out of clear glass. Because of the possibility of undesirable photochemical reactions, it is important that you keep the bottle in the dark as much as possible. You can accomplish this by placing the bottles in a carrying case (which is painted black on the inside) in between manipulations. Also keep the samples cool (i.e., in the shade).

9) The next step is to add the acidic reagent. Some prefer to do this immediately after the precipitate in the oxygen bottle has settled for the second time, and others prefer to do it just before beginning the oxygen titration. No convincing evidence favors one technique over the other. In the Carpenter version of the Winkler method, the reagents are adjusted so that the final pH is between 2 and 2.5. This range of pH minimizes unwanted side reactions, but is just barely acid enough to dissolve the precipitate. If the precipitate is not dissolved when you are about to start your titration, add another drop of acid.

<u>NOTES</u>:

a. Occasionally after the addition of sulfuric acid, a gas bubble will appear. This bubble is composed largely of carbon dioxide and a little nitrogen which may have been liberated from the solution. The former results from changes in the carbonate system from the low pH. The presence of the nitrogen is accounted for by the reduced solubility of this gas upon the addition of the reagents and the possible increased temperature of the sample.

b. In running determinations of dissolved oxygen on fresh or slightly brackish waters, considerable difficulty may be experienced in obtaining complete solution of precipitate. Solution may readily be affected by the addition of a few crystals of sodium chloride to the acid solution.

c. In fresh water studies the use of hydrochloric acid may be substituted for the sulfuric acid. (Concentrated HCL is 12N and concentrated H_2SO_4 is 36N.)

TITRATION OF SAMPLES

A measured volume or an entire flask is titrated with the standardized thiosulfate solution. Thiosulfate is added until the solution sample is a pale yellow color. Then ~1 ml of the starch indicator is added. This produces a blue color that is detected well by the human eye.

It is difficult to describe how to detect the visual end-point on the printed page, and the best way is to have an experienced analyst demonstrate this for you. In case you cannot find an experienced and competent analyst, here is a method that should work. 1) As the blue color begins to disappear, start to add the thiosulfate in small increments and begin to record the buret readings. 2) If your eyes are like mine, you will not see too much color change near the end-point. Instead the solution will become progressively clearer and/or brighter. 3) Keep on adding thisulfate until you no longer see changes in clarity and/or brightness upon the addition of more thiosulfate. 4) The reading that corresponds to the last thiosulfate addition that caused a visible change is the end-point! 5) Do not let your desire to obtain the best end-point cause the titration to take too much time! See note "b" below.

With the Aliquot method, a sample or samples of known volume are drawn from the brown glass bottle. The dissolved oxygen concentration may be calculated from the following equation:

$$DO = \frac{[R - R_{blk}]V_{IO_3} \times N_{IO_3} \times E}{[R_{std} - R_{blk}]\left[V_s - V_{reg} \times \frac{V_s}{V_b}\right]} - DO_{reg} \times \frac{140\text{ml}}{V_b}$$

where

DO = dissolved oxygen (ml/liter)

R = sample titration burette reading

R_{blk} = difference between blank titration burette readings (i.e. the blank value)

R_{std} = standardization burette reading

V_{IO_3} = volume of primary standard (ml)

V_b = volume of sample bottle (ml)

V_s = volume of titration aliquot (ml)

V_{reg} = volume of sample displaced by reagents (~2 ml for this method)

N_{IO_3} = normality of primary standard

E = 5,598 ml O_2 /equivalent

DO_{reg} = 0.018 ml/liter, the amount of oxygen added with the reagents if you were using the 125 ml flasks recommended by Carpenter (1965b) that actually contain ~140 ml.

<u>NOTES</u>:

a. Since the precipitate containing the dissolved oxygen has settled before the addition of the H_2SO_4, only ~2 ml of sample are displaced by reagent additions.

b. After completing the titration, if the solution is permitted to stand for a period of time, the blue starch-iodine color may again become evident. <u>This should be ignored</u>. Titrations should be carried out as quickly as possible consistent with accuracy.

If the entire sample is to be titrated, the amount of dissolved oxygen may be calculated from the following equation which applies to the "no-transfer" Carpenter method that we prefer.

$$DO = \frac{[R - R_{blk}]V_{IO_3} \times N_{IO_3} \times E}{[R_{std} - R_{blk}][V_b - V_{reg}]} - DO_{reg}$$

where

DO	=	dissolved oxygen (ml/liter)
R	=	sample titration burette reading
R_{blk}	=	blank value
R_{std}	=	standardization burette reading
V_{IO_3}	=	volume of KIO_3 standard (ml)
V_b	=	volume of sample bottle (ml)
V_{reg}	=	volume of sample displaced by reagents (ml)
N_{IO_3}	=	normality of KIO_3 standard (equivalents/liter)
E	=	5,598 ml O_2 /equivalent, and
DO_{reg}	=	oxygen added with reagents when 1 ml of Manganous and 1 ml of alkaline iodide reagents are added to a 140 ml bottle/flask.

For the procedure described by Carpenter (1965b) in which 10.00 ml of 0.01000 N standard are employed,

$$DO = \frac{[R - R_{blk}]559.8}{[R_{std} - R_{blk}][V_b - 2]} - 0.018 \text{ ml/l}$$

NOTES: **a) As methods for the determination of dissolved oxygen become increasingly accurate, the nominal value of 0.018 ml/l for the oxygen added with reagents should receive more scrutiny.** Obviously, this value can change with factors such as temperature and the exact composition of the pickling reagents. It might be wise to do some experiments with reagents that have been purged with pure nitrogen to check this value for your particular experimental conditions. It may also eventually prove desirable to determine "Blanks" on sea-water samples that are treated like the blanks described in Carpenter's (1965) paper. Finally, calibrating the delivery of the devices that dispense the first two pickling reagents (Mn^{++} and alkaline NaI) becomes more and more important. Errors of ~5% in the volume of pickling reagents dispensed can cause errors of 0.1% in the final dissolved oxygen concentration and some of the new automated methods (see below) may have precisions of better than 0.1 %.

b. If you prefer to use the standard curve method for calibrating that we prefer, substitute the slope of the linear regression for:

$$\frac{V_{IO_3} \times N_{IO_3}}{[R_{std} - R_{blk}]}$$

SOURCES OF ERROR IN THE WINKLER DETERMINATION CAUSED BY SUBSTANCES FOUND ONLY OCCASIONALLY IN SEA WATER

a. If nitrite is present, high values for oxygen may be obtained because of the following chemical reaction:

$$2NO_2^- + 2I^- + 4H^+ \longrightarrow 2NO + I_2 + 2H_2O$$

With the exception of oxygen deficient regions where O_2 is less than ~ 0.1 ml/l the concentrations of nitrites in sea water are usually< 1 μg-atom/l.

b. If hydrogen sulfide is present, the Winkler method for determining oxygen is not applicable. Hydrogen sulfide will react with the dissolved oxygen and with iodine.

c. In waters polluted by industrial waste or containing relatively large concentrations of reducing material, Winkler's method is not applicable because any iodine liberated may react with the reducing substances or produced by oxidants.

LOW CONCENTRATION DISSOLVED OXYGEN METHOD

Broenkow and Cline (1969) have described a colorimetric dissolved oxygen method which is more suited to low concentrations (< 0.4 ml/liter) than the more normal methods described above. The normal Winkler methods described above cannot resolve the 0 to ~ 0.15 ml/l dissolved oxygen range, and high nitrite levels often occur in low oxygen waters.

AUTOMATED METHODS

A number of investigators (Williams and Jenkinson, 1982; Friederich, Sherman and Codispoti, 1984; Culberson and Huang, 1987; Friederich and Codispoti, 1991) have automated the dissolved oxygen titration. These methods reduce eye-strain, improve precision and allow the data to be directly acquired by computer. They do not require the addition of starch since the yellow iodine color that is poorly perceived by the human eye can be detected with great precision electronically.

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