PUBLICATIONS


The following numbers have appeared:*

PUBLICATIONS SCIENTIFIQUES

No. 1. S. F. GRACE:
  I. Historical review of dynamical explanations of tides in non-elongated enclosed seas and lakes.
  II. Historical review of dynamical explanations of the tides of the Mediterranean, the Baltic Sea, the Gulf of Mexico, and the Arctic Ocean (1931). Out of print.


No. 4. PHIL E. CHURCH: Temperatures of the Western North Atlantic from thermograph records. (1937). Out of print.

No. 5. Monthly and annual mean heights of sea-level, up to and including the year 1936. (1940).


No. 8. Report of the committee on the criteria and nomenclature of the major divisions of the ocean bottom. (1940).


*Available publications may be obtained from IUGG Publications Office: 394e, Rue Gay-Lussac, 75005 Paris, France.
No. 28. The theory of oceanic circulation as developed in the USSR over the past fifty years, 1967.

PROCES-VERBAUX

No. 3. General Assembly at Washington, September 1939. (1940).
No. 5. General Assembly at Brussels, August 1951. (1952).

These publications form a continuation of the Bulletins de la Section d'Océanographie de l'Union Géodésique et Géophysique Internationale, of which there were 17 numbers, No. 1 being issued in 1921 and No. 17 in 1931. Out of print.

ADDITIONAL PUBLICATIONS

Reports and Abstracts of Communications:


Extras:

Standard terminology on optics of the sea. (Published in the Chronique de l'UGGI, No. 57, 1964).

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FOREWORD

IAPSO convened its XVII General Assembly in conjunction with the XVII General Assembly of its parent organization, the International Union of Geodesy and Geophysics, at the Australian National University, Canberra, Australia, 2-15 December 1979.

Business sessions comprised both the Plenary sessions and Executive Committee meetings. Since the agenda for the Plenary and Executive were the same, minutes of only the Plenary session are here included, together with reports of other Committees and Working Groups.

The scientific program consisted of twelve symposia sponsored by IAPSO, four joint symposia for which IAPSO was the principal sponsor, and seven joint symposia of which another Association was the principal sponsor.

Abstracts of the papers presented in symposia for which IAPSO was the sole or principal sponsor are included in this 15th edition of IAPSO’s Procès-Verbaux.

Eugene C. LaFond
Secretary, IAPSO

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OBITUARIES

Professor Ilmo Hela (1915–1976)

Professor Ilmo Hela was born on 2 March 1915 in Jyväskylä, Finland. He studied at the University of Helsinki receiving his Master of Science degree in 1937. During two years he continued his studies at the Universities of Königsberg and Hamburg in Germany.

The main part of his career Ilmo Hela performed at the Institute of Marine Research in Helsinki. He joined its staff as an assistant in 1940, was appointed section chief in 1945 and director in 1955. This post he held until 1975, when he was obliged to retire for reasons of health. After a severe illness he died on 25 November 1976.

One of the characteristics of Ilmo Hela was his pronounced interest for international cooperation. He was a conspicuous figure in IAPSO, acting as its vice-president from 1960–1963 and its secretary from 1963–1967. Moreover, he was active in many other marine organizations, such as ICES, IOC, SCOR, ICES, etc. He worked also with the UNESCO and served on its Executive Board from 1966–1974.

Ilmo Hela was several times on leave of absence from the Institute of Marine Research acting during two years as a visiting professor at the University of Miami and during two years–1961–1963—in Monaco as the first director of the International Laboratory for Marine Radioactivity.

It could seem that Hela did not have much time left for scientific work. However, the number of his publications on different questions connected with oceanographic research is considerable. It is not possible to name all Hela’s papers; only a few may be mentioned. His thesis bore the heading: “Über die Schwankungen des Wasserstandes in der Ostsee mit besonderer Berücksichtigung des Wasseraustausches durch die dänischen Gewässer.” During his stay in the United States, he published a paper on the Gulf Stream. In his last years he studied the hydrography of the Åland Sea in order to obtain a value for water exchange between the Gulf of Bothnia and the northern Baltic.

The premature death of Professor Ilmo Hela was a great loss not only for his native country, but also for numerous international oceanographic organizations.

— Eugenie Lisitzin

Professor Kozo Yoshida (1922–1978)

We have learned with deepest regret of the death of Professor Kozo Yoshida on 28 January 1978 at the age of 56 from cancer after three years of illness.

Kozo Yoshida was a well-known physical oceanographer, Professor at the University of Tokyo, Chairman of the Oceanographic Committee of the Science Council of Japan, and Vice-President of IAPSO (1970–75).

He will be remembered as an honest and kind person; a true scholar with the courage of his convictions, but withal, a very modest person, beloved by his colleagues and students.

He was born in Toyonaka City (near Osaka) 17 January 1922. He worked most diligently at the University of Tokyo and was graduated in 1944. As an assistant to Professor Koji Hidaka, he served in the war-time for surveys of surf-breakers.

He was married in 1949 and led a happy married life.
In the years 1952–54 he worked at Scripps Institution of Oceanography with several distinguished oceanographers. In 1953 he received a DSc degree from the University of Tokyo; in 1954 he became Assistant Professor, and in 1964 succeeded Professor Hidaka as Professor of Geophysics. In 1968 he presented a series of lectures at Woods Hole Oceanographic Institution. For many years he helped organize and participate in international meetings.

His major scientific accomplishments include a variety of physical oceanographic studies on such topics as waves and their interaction with currents, especially the energy budget, upwelling in the California Current; circulation in the upper mixed layer; Equatorial Current and Counter Current; Subtropical Current System including the Subtropical Counter Current which he named; and the Kuroshio Current from a dynamic point of view.

He reported his work in many oceanographic publications. He served as co-editor, with Professor Stommel, of the monumental book entitled, “The Kuroshio—Its Physical Aspects”; edited “Studies in Physical Oceanography” commemorating Professor Hidaka; and contributed the introduction and a paper to “Perspective of Fisheries Oceanography” commemorating Professor Uda.

Dr. Yoshida was a great physical oceanographer possessing deep philosophical thought and a warm human mind, leaving his charming image in our hearts forever.

— M. Uda

Fredre Hermann (1917–1977)

Freder Hermann was born in North Jutland on 16 December 1917. He was educated at the local grammar school and at the University of Copenhagen where he graduated in physics in 1941. While still a student he became a part-time assistant under Professor Martin Knudsen in the Hydrographic Laboratory of the Danish Commission for Marine Research. After his graduation Hermann was appointed full-time assistant, and in 1953 he became leader of the Laboratory, a position he held until his untimely death on 21 February 1977.

Fredre Hermann carried out hydrographic investigations in regions as far apart as the Baltic, the North Sea and the North Atlantic, including Greenland waters, and he made important contributions to the study of them. Hermann’s work in Greenland waters is reflected in a number of papers presented at the meetings of the International Commission for the Northwest Atlantic Fisheries (ICNAF). Also at the meetings of the International Council for the Exploration of the Sea (ICES), where he was a member of the Hydrography Committee since 1951, Hermann presented several papers among which may be mentioned one on water mass analysis (“The T-S diagram analysis of the water masses over the Iceland-Faroe Ridge and in the Faroe Bank Channel”).

Hermann was a member of the ICES Working Group on the Coordination of Hydrographic Investigations in the Baltic, serving as its Chairman from 1970 to 1972. He was also active in the Committees of ICNAF and presented the 8th Conference in Copenhagen in 1972. For a number of years he participated in the work of the Danish-Swedish Øresund Water Committee, in which context he studied the water exchange in the Sound and the long-term fluctuations of oxygen and phosphate concentrations in the waters of the region.

These achievements, however, do not exhaust Hermann’s contributions to hydrography. Of the greatest importance is his association for more than 30 years with the Standard Seawater Service. This Service was established in the beginning of the century on the proposal of Martin Knudsen and was run under his direction from 1908 to 1948 when it, on his suggestion, was taken over by the International Association for Physical Oceanography (IAPO). From 1941 until the end of 1974 Hermann was in charge of the preparation of the Standard Seawater. After Martin Knudsen’s death in 1949, Helge Thomsen, at the request of IAPO, took over the administrative responsibilities and Hermann continued to prepare the Standard and carry out the analyses—an arrangement which lasted until 1959 when Thomsen wished to retire as Director of the Service. Upon IAPO’s request Hermann took over full responsibility for the Service in January 1960.

There was in the following years an increasing demand for standard seawater, in some years rising to more than 30,000 ampoules. Hermann coped successfully with this additional work for many years. In 1972 he felt, however, that the work began to interfere too much with his research activities and he decided to retire from the Service. At his proposal IAPO passed the responsibility for operating the Service to Fred Culkin who for several years had collaborated with Hermann in the chlorinity calibrations, and at the end of 1974 the Service was transferred to the Institute of Oceanographic Sciences at Wormley (U.K.).

A principal point in the preparation of the Standard is the high precision chlorinity determination on each batch. For use in these analyses Hermann worked out a modification of the potentiometric method to replace the time-consuming Volhard method used earlier, and he also designed a special weight burette.

Fredre Hermann’s expertise in salinity determination was drawn upon also outside the Service. He became Chairman of the ICES Sub-Committee for Considering Standard Methods for Salinity Determination in 1954. He was an ICES representative on the UNESCO/ICS/SCOR/IAPO Joint Panel on the Equation of State of Sea Water from its establishment in 1962 and on its successor, the Joint Panel on Oceanographic Tables and Standards, until 1973, serving as Chairman from 1967 to 1969.

For his many contributions to oceanography, especially those related to the determination of salinity, Hermann was in 1975 awarded the Prince Albert I Medal by the Institut Oceanographique (Paris).

Fredre Hermann was a person of friendly and unpretending manners. He will be missed by his many friends the world over. The deepest sympathy will go to his widow, Grethe Hermann, and their three children.

— Jens Smed
PAST AND PRESENT OFFICERS OF THE ASSOCIATION

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- Prof. S. H. Sharaf-El-Din
  Oceanography Department, Faculty of Science, Alexandria University, Alexandria, Egypt

PRESIDENTIAL ADDRESS

Presidential Address to the First IAPSO Plenary Session
3 December 1979 in Canberra

PHYSICAL SCIENCES OF THE OCEANS OVER THE PAST FIFTEEN YEARS

In any rapidly advancing science (or any other area of endeavour), most of the time you look immediately in front of you. Some of the time you look some way in front in order to chart your path in the future. However, I think that it is worthwhile every few years, perhaps every four years, to look back to see where you’ve come from and see what has happened in getting you where you are now. I want to do a little of that—surely a fitting thing to do under the title of Presidential Address.

Having of course tried to look back myself, I have come to a realization that I suspect has not been as widespread as it might be: in the last dozen to fifteen years we have been through what must be described as a revolution. If you live through a political revolution: in Paris in 1789, Petrograd in 1917 or Tehran in 1979 you know you’re in a revolution. There is never any doubt about it. But the kind of revolution we’ve been through has taken just enough longer that it may not be so evident.

Nevertheless, there has been a revolution in our understanding of the things that go on in our science, in the techniques of our science, and also in the motivation of our science. The way in which we describe oceanography is really almost entirely unlike that of fifteen years ago.

With respect to understanding: in Geophysics for example there have been the huge changes which have taken place because of the advent of plate tectonics and the understanding of spreading zones and subduction regions. Fifteen years ago it was speculation. I remember that only about eighteen years ago the new evidence for spreading, in what we now call spreading zones, was being seriously interpreted in good places like Lamont as indicating an expansion of the earth. Now the behaviour of the moving plates has become doctrine. I am told that, at a meeting just last July, an almost completely successful reification of Gondwana was attempted successfully. I think that similar attempts for Laurasia are under way. Beyond that perhaps Pangea. At the same time the distribution of masculial versus placental animals is now almost universally described in terms of plate tectonics. Similarly, I have seen a recent article describing the distribution of crinoids (a small sessile animal that lives on the bottom) in a similar way.

In not a dozen years this new description of the world has become accepted and used ubiquitously.

Chemistry, I suppose, is the IAPSO field that I know least about. I find it difficult to have the same kind of confidence in making statements. I will be corrected, I'm sure. But in particular, in Chemistry the thing that struck me has been the realization of the tremendous importance of surfaces in the chemical behaviour of the ocean. Not just the surface on the top of the ocean but surfaces on particulates and the bottom. The importance of these surfaces for the chemical reactions that take place in the ocean has been one of the big changes in thinking that I have become aware of. This has changed our attitudes towards all the geochemical balances of the whole earth-atmosphere-ocean system.
Physics is the field I know most about, and I suppose that I could go on about longest, but the advances there have been perhaps not so revolutionary as those in geophysics. Still, they are such that most of the modern literature would have been quite unrecognizable fifteen years ago. The literature on waves, for example, now is completely unlike the literature of a decade-and-a-half ago. What we know about the eddies in the ocean, whether you call them synoptic eddies or mesoscale eddies, is now a huge field where almost all of the literature has appeared in this last decade. If you talked about fronts in the ocean before the last dozen years you would know that you were using some kind of analogy, with what goes on in the atmosphere, but they would not have any idea what they were like in the ocean. There have been intense studies of the upwelling which have changed our attitudes towards upwelling completely. We have recognized that it is a phenomenon which is extremely spotty in both time and space. Those long, slow, even things we used to talk about don’t happen very often. The emphasis on edge influences on the propagation of various kinds of waves and, another kind of an edge, the emphasis on equatorial phenomena, has brought our understanding to a level quite beyond what it used to be. And in this I have talked only about things in the deep ocean, not things in the estuarine and coastal regions where the advances and changes have been every bit as great.

On techniques: in Geophysics I suppose that the outstanding thing has been the use of the deep-sea drilling technique, yielding information quite beyond anything thought of before that technique was put in place. Of course seismics and magnetics and heat flow measurements have continued. One of the striking things in the last few years is the way the deep-diving submersible, as a real scientific tool, has come into its own in Geophysics: the examination of certain kinds of surfaces, and some of the exciting things, including biology, that have been found in spreading zones.

In Chemistry, the things that struck me most has been the increased precision for most things one has added a couple more decimal places and in some things much more than that. And the number of things that can be measured with useful precision has expanded greatly. Whether you call the work with isotopes ratios physics or chemistry is a matter of ancient debate; I think in our science we should call it chemistry—because it is done by chemists. Isotopic ratios, whether they are radio isotopes or not, have provided an enormous amount of information about the behaviour both of the present and the past ocean. The information that has come out of the Climap program, for example, on the past oceans has given us insights that we had no hint of before this last decade. In Physics, one of the really striking things is the way in which new techniques force us, maybe to change the definition of oceanography. Oceanography has always been hard to define. The most useful definition up to a few years ago, that many of us used, was that oceanography is that science which is done at sea from ships. That was the only thing that included it all. But now it doesn’t. Now a great deal of physical oceanography is done in laboratories using computers. Perhaps because of our close association with meteorologists, oceanographers have had access to the biggest and fastest computers available to a particular country. That does not mean that everybody has access to those, of course, but within a country it is usually possible to find oceanographers working with the most powerful machines that there are. And then there are the satellites, which already are giving us enormously useful information. We see on the horizon the advent of quantities of satellite data such that one of our prime difficulties is going to be able to deal with it. The simple quantity of data that the satellites are capable of delivering to us is going to be one of our major problems in the next decade, and one that is going to take a lot of our attention. We have buoys now, particularly drifting buoys. There is a whole fleet of satellite interrogated buoys in the southern ocean now around this continent and the other Southern Hemisphere continents, including Antarctica; a few in the northern oceans. Those buoys were mostly conceived and put in place by the oceanographic community despite the fact that much of the motivation for them was meteorological. I have been told by the people running the Global Weather Experiment that it is those buoys, with their pressure-sensors and the sea-surface temperature sensors, which have to be regarded as the heroes of that experiment. The data from them has been perhaps the most important advance in the meteorological information gained during this Global Experiment finished just two days ago.

By the way, as of two days ago, we ran into a problem with the financing of the treatment of the data from those buoys. I think this will have to be a matter for us to discuss, because I think some sort of international position on the question of financing of the buoy data is something that we should try to generate. But of course we have not only surface buoys now. We have submerged buoys in numbers that greatly exceed those that we used to have when it was mostly done by John Swallow. We have the SOFAR floats that can report their position across the whole ocean and can be followed across a whole ocean for many months. That, with other data, has completely changed our notions of what is going on in the interior of the ocean. And then of course there are other things on the horizon like acoustic tomography. There are great enthusiasts of acoustic tomography, who feel that we are going to be able to learn an enormous amount about both the temperature structure and the velocity structure of the ocean by acoustic measurements over very long ranges from the edges of the ocean. Frankly, I am myself a bit from Missouri—using that American idiom which means that I have to be shown—that this will in fact be successful. My attitude is that I am terribly glad somebody is working on it and I am terribly glad that it is not me! But, if it works the rate at which we will get information about both the temperature structure and velocity structure in the ocean from remote techniques will change by orders of magnitude. And then there are lots of other new things that one can do from ships and from aircraft. There is an increasing number of things that one can do from ships of opportunity so that our ability to collect data over the great ocean now is at a much higher level within feasible cost than it was even a few years ago. Also there have been great advances in deep tide gauges, to mention but one of a host of others.

The motivation has changed too, I think hardly less importantly than the other things. There is still the motivation to understand. For the scientist I don’t think there is ever a greater motivation than that and for the scientist it is probably irreplaceable. There can be additional motives, but he must have that. But now there are other motives for oceanography. In Geophysics for example, if you go to any kind of discussion about the location of hydrocarbon reserves you will find that that subject is always discussed in terms of plate tectonics. If you want to talk about mineralization you find increasingly that the subject is discussed in terms of spreading zones and the concentrations of minerals that occur in those hotspots of the earth’s crust.
Remember it wasn’t very long ago that we had that first excitement about the hot brines on the bottom of the Red Sea! In Chemistry there has of course been this great push to understand the routes and rates associated with various pollutants. They’ve driven many branches of chemistry in recent years. None perhaps more important now than carbon dioxide, because the behaviour of the carbon dioxide concentration in the atmosphere is thought to be very largely influenced by the ocean and the chemistry of carbon in the ocean has become important at other levels than before. Something that is driving oceanographers of almost all kinds is to try to be able to answer the question: What will be the carbon dioxide partial pressure in the atmosphere given certain usage of fossil fuels by the year 2000 or by the year 2020! And what will be the consequences of that increase in carbon dioxide? I think it is important to realize that all of the things we as human beings are doing to our world the thing that is now really changing the world in which we live—looked upon globally as a planet—is increasing the carbon dioxide content. Virtually nothing else has had a really planetary influence.

That brings me to the Physics, where as I see it, the principal exterior demands are to understand climate fluctuation, and climate trends. In particular, we are asked to try to understand what the physics of the ocean will do to the carbon dioxide concentration in the ocean and atmosphere, and given certain concentrations in the atmosphere what will be the behaviour of the ocean-atmosphere system and what will be the resultant climate that will effect human beings. There is a great deal of activity now, globally, concentrated on that particular subject. There will be more! Now, of all these things that have been going on in our science, the principal effort has been inside laboratories, inside institutes, inside small groups of institutes. We in IAPSO can’t take credit for them. Of course we can’t. IAPSO is an organization and organizations can only do certain limited things. One thing organizations should not try to do is to organize for the sake of organizing. In fact, my own belief is that we should have as little organization as possible and that we should only use organizations to do those things that can only be done by organizations. And where they can be done without, let’s do without them! That doesn’t alter the fact that organizations are sometimes necessary. One of the things that organizations can do is arrange meetings. It is very hard to organize them if you haven’t got the umbrella of a meeting like this—with the 1900 people we were told registered for this IUGG in Australia. (Someone estimated that this represents about 4% of travel expenses.) Even much smaller groups: working groups, committees, planning groups, often need the umbrella of an international organization. From time to time we have been able to provide that. Another thing that international organizations can do—and its importance depends a good deal on the country—is to provide a kind of international peer group review. Proposals for international expeditions are put forward by national groups or institutional groups. They are examined by people who have been selected for at least some degree of competence, to be on executives or committees of an international organization. The acceptance or the rejection of these proposals often makes a very large difference to the degree of funding that that kind of effort will get back in the local country from which the proposal came. And I don’t think that we should reject this. This is something that we as an international organization should be prepared to do. But if it is to be useful, it has to be done in the way that the interface group has to be able to say that some of the proposals we will receive will not be given our stamp of approval. Because if we agree to every proposal that is put forward then the value of our agreement will be degraded to be essentially worthless. Now some countries, of course, don’t bother with that; they have their own peer review system. There are even some countries—I am told the United Kingdom is a bit like this—that are so suspicious of these international organizations that it is actually a black mark to have the thing approved by some international organization. Be that as it may, for many countries—and the people in the countries generally know who they are—this peer review is useful.

Another international organizations can do is provide a framework in which one can organize observational activities. And there have been a lot of them in the last few years: GATE, the FGGE, JASIN, POLYMODE (although it turned out that for none of those can IAPSO take any special credit). JASIN was largely organized by an international group centred around the United Kingdom and not really under any international umbrella. POLYMODE was organized largely bilaterally between the United States and the Soviet Union, with others coming in as they saw fit. GATE and the Global Oceanographic Experiment were closer to us, in that the organization was done by SCOR. Not done of course, by SCOR. Observations don’t do experiments! It is one of the things that I would like to emphasize: in very many cases the operating arm that IAPSO has used in dealing with the world has been its association with SCOR. We have had very good relationships with SCOR; I hope we will manage to continue them; I see no reason why we can’t. SCOR can act in a way that we cannot, often simply because it has a bigger budget, and they meet more often. We have our meetings every four years and it is not very easy for us to move very fast. Through SCOR, which has an executive meeting about every nine months, it is possible to move at a pace moderately comparable to the pace demanded by the world today. This relationship we have with SCOR is one that I have tried to cultivate, my predecessors have tried to cultivate, and I hope that my successors also will find that a valuable way to go. There are some other things that international organizations do. They can serve as a sort of International Bureau of Standards. We are going to hear some of that in this meeting: we have two groups which have been working in that direction. One of them is Working Group on Symbols, Units and Nomenclature—a topic of the greatest importance in facilitating communication. And then we have had an important group working on a redefinition of salinity—one of our most important parameters in oceanography.

That kind of thing has to be done internationally. It is very unlikely that any national group, without working through some international group, could get its standard accepted. For communications sake we do have to have standards and agreements about the way in which we express ourselves.

With respect to organization: we made an important decision in Berne in 1967. There it was proposed that there be formed an International Union of Marine Sciences, and that IAPSO should break away from IUGG to join this union, together with biologists and some others. There was a great deal of debate at the time which then described (and I have never seen any reason to change my mind) as being something like the internal debate of a man who was really very fond of his wife. But there was another very attractive woman around who was prepared to be his mistress. His difficulty was how to keep his wife and take the mistress as well. I am told that this is common in France, but it is not so easy in the world as a whole. Anyway, we in IAPSO at the Berne Assembly decided to try. If you take our wife as being the IUGG with its meteorologists and its solid earth geophysicists then IAPSO is a liar. But it has been anything so do. But the thing is to say that some of the proposals we will receive will not be given our stamp of approval. Because if we agree to every proposal that is put forward then the value of our agreement will be degraded to be essentially worthless. Now some countries, of course, don’t bother with that; they have their
shares with us the delights of this Captain's Paradise. They are also members of both IUGG and SCOR. Since 1967, we have had three IUGG's including this one and we've had three JOA's. All were very well attended meetings. In addition, we had another very well attended meeting here in Australia. And in addition, we had another Extraordinary Assembly. So in 12 years we have had six major meetings. Now there is a lot of talk in the world about these big meetings not being worthwhile anymore and not being very successful. My feeling is that the evidence is that, by and large, that is not the majority view. Otherwise I can't account for there being 1900 people here. The IAPSO contingent, which as Stewart Turner has indicated, is not all that heavily weighted with Australians, is something like 10%. If we can have attendance like that at large international meetings every couple of years, I conclude that the internal evidence is that it is not too often and not too many. So it is without apology that I will say that it is proposed, and it will probably happen, that there will be another Joint Oceanographic Assembly in Halifax in 1982. So we will have another big meeting coming up. In addition, we have been invited to join with IAMAP with some symposia (not on a full-scale IAPSO contingent perhaps on JASON or some other topic), in the extraordinary Scientific Assembly that they are going to have in Hamburg in 1981.

Again with respect to organization there are a couple of questions that have arisen in the period of four years that I have been your president. One of them you have undoubtedly heard alluded to quite frequently: the Chinese question which came to a head in Durham in August 1977. In that Special Assembly the IUGG decided to move out of ICSU in the acceptance of the People's Republic of China into the IUGG. Of course this has been an anathema that has been sought for very many years. The difficulty has been to find the modality for it. As it has turned out the situation is somewhat complicated for IAPSO. IUGG has moved in one way and it looks as though the other, or at least most of the other, Unions and sectors of ICSU are moving in another way to bring the scientific community of the People's Republic into the world community of ICSU. Because of our associations in SCOR and JOA this difference leaves us a little uncomfortable, because it appears that probably within a couple of years both the People's Republic and the scientific community on Taiwan will be formally accepted as groups which can participate with full rights in the life of most of the other Unions. The IUGG solution to the problem left the Taiwanese scientists with only the possibility of participating as individuals. Now that is a possible way, and it is a lot better than nothing but it leaves Taiwan scientists in a less favorable position within IUGG Associations like IAPSO and IAMAP, than they will have in other ICSU bodies at the JOA. I think, myself, that IAPSO should urge the IUGG to find some mechanism for the formal adherence of the scientific community on Taiwan, perhaps following the same formula which has already been developed in agreement between the People's Republic and the authorities on Taiwan by IUPAC and the International Union of Biochemistry. It seems to me that there are mechanisms by which this can be done and if it is possible I think that we should try.

The other serious question is the one we always have, every organization has, the financial question. In fact, under the careful hand of our secretary, we have husbanded our resources and we are not in bad condition as the Financial Report will show. But we have to take what happened in SCOR as a very serious warning. Two years ago SCOR also seemed to be in bad condition. Last year SCOR found itself in really desperate financial straits. The funds which had been husbanded over the years all vanished in one year, because the inflationary increases simply overwhelmed the budget. Now our work, as I tried to indicate earlier with the changes in motivation, is not less important but is more important than it used to be. We need to do at least as much as we have done in the way of having working groups and
ADMINISTRATIVE REPORTS

Agenda

XVII GENERAL ASSEMBLY OF THE ASSOCIATION


1. Adoption of Agenda
2. Presidential Address
3. Administration
   3.1 Tabling of National Reports
   3.2 Designation of each country’s Chief Delegate to IAPSO
   3.3 Report of the Secretary for Period 1976–1979
   3.4 Financial Report for Period 1976–1979 (Secretary)
   3.5 Action taken on Resolutions passed at the XVI General Assembly of IAPSO in Grenoble 1975
   3.6 Appointment of Nominating Committee
   3.7 Appointment of Resolutions Committee
4. Reports of IAPSO Commissions for Period 1976–1979
   4.1 Commission on Marine Chemistry (J. Gieskes)
   4.2 Commission on Marine Geophysics (S. Uyeda)
   4.3 Commission on Physical Oceanography (W. Dilling)
5. Reports of IAPSO Scientific Advisory Committees for Period 1976–1979
   5.1 Committee on Tides and Mean Sea Level (D. Cartwright)
   5.2 Committee on Physical and Chemical Aspects of the Dispersion of Natural and Artificial Substances, and Heat in the Ocean and Seas (G. B. Kullenberg)
   5.3 Advisory Group to the Executive on Coordination within the Physical Sciences of the Ocean (J. Gieskes)
   6.1 Working Group on Symbols, Units and Nomenclature in Physical Oceanography (M. Menaché)
   6.2 Working Group on Ocean Optics (A. Morel)
   6.3 Working Group on Coastal and Estuarine Regimes (J. B. Matthews)
7. Reports of IAPSO Related Services for Period 1976–1979
   7.1 Permanent Service for Mean Sea Level (G. Lennon)
   7.2 Standard Sea Water Service (F. Culkin)
8. Reports of IAPSO Representatives on Inter-Association Committees, or other Committees or Working Groups, for Period 1976–1979
   8.1 IUGG Committee on Tsunami (R. O. Reid)
   8.2 IUGG Committee on Space Research (Secretary)
   8.3 IUGG Committee on Problems in Geochemistry (E. D. Goldberg)
8.4 IUGG Committee for Advice to Developing Countries (Secretary)
8.5 IUGG Committee on Critical Data (CODATA) (M. Menaché)
8.6 IUGG (IASPEI) International Heat Flow Committee (Secretary)
8.7 IUGG Working Group on General Parameterization of the Earth (W. Burt)
8.8 IUGG Inter-Association Committee on Mathematical Geophysics (W. Zehé)
8.9 ICSU/SCAR Working Group on Oceanography (G. E. R. Deacon)
8.10 ICSU Scientific Committee for Oceanographic Research (SCOR) (President)
8.11 ICSU World Data Center Steering Committee (J. Crease)
8.12 ICSU Scientific Committee on Water Research (J. B. Matthews)
   9.1 Joint IAPSO/SCOR Working Groups (President)
   9.2 Joint IMCO/UNESCO/ISOC/IAPSO/WMO Ad Hoc Group for the Study of External Forces Affecting Ships (R. Dorrsten)
   9.3 Joint IOC/SCOR/IAPSO/CMG Guiding Committee for the General Bathymetric Chart of the Ocean (R. Fisher)
   9.4 Joint IAC/IAPSO Special Study Group on Mean Sea Level and Coastal Geodesy (G. W. Lennon)
10. Establishment of Scientific Committees and Working Groups
   10.1 Establishment, disbandment, change in terms of reference, or change in membership of existing Committees and Working Groups
11. Modification of Statutes and By-Laws
   11.1 Modification of By-Laws
12. Further Administration
   12.1 Adoption of Resolutions
   12.2 Nomination of IAPSO Representatives to Inter-Association and other Committees and Working Groups
   12.3 Election of Officers and Executive Committee
13. Determination of Place and Date of Next IAPSO Meetings
   13.1 General Assembly
   13.2 Business Meetings
   13.3 Joint Scientific Symposia
14. Other Business
MINUTES OF PLENARY SESSIONS OF THE ASSOCIATION
Canberra, Australia

FIRST PLENARY SESSION – 3 December 1979

1. President Robert W. Stewart called the meeting to order at 2:03 PM, and welcomed the delegates.
   Vice-President, Professor J. S. Turner, also welcomed the attendees and pointed out some of the facilities available.

2. (Item 1) The Provisional Agenda, which was circulated on 15 April 1979 by the Secretary to all National Correspondents and officers of the Association and also distributed at the Assembly, was adopted. The President requested that an attempt be made to adhere to the schedule.

3. (Item 2) President Stewart delivered his presidential address emphasizing the "revolution" through which the Physical Sciences of the Oceans have undergone during the past 15 years. Developments in understanding, new techniques, and new motivations were considered for the main fields of Geophysics, Chemistry, and Physics of the ocean.
   In particular, Dr. Stewart concluded that the state of health of both IAPSO and IUGG were excellent as is well demonstrated by the large attendance of IUGG (over 1,900) and the large size of IAPSO representation (at least 350). The President mentioned that the next IAPSO venture would be participation in the Joint Oceanographic Assembly (JOA) in Halifax in 1982. In addition, IAPSO will collaborate with IAMAP in its Assembly in Hamburg in 1981.
   The so-called "Chinese question" was mentioned and the President expressed his wish that this be resolved in a manner similar to that accepted by IUPAC and IUB.
   The President reported IAPSO to be in good financial health, but warned that with present inflation rates we should be cautious in dispensing our funds. The President emphasized the need to impress upon authorities of the member countries the value of non-governmental associations such as IAPSO and IUGG.
   With sadness the President noted the passing of:
   Dr. Bruce Heezen (USA) – Chairman of Commission on Marine Geophysics 1967–1978
   Prof. Iimo Heia (Finland) – Vice-President 1960–1963; Secretary 1963–1967
   Dr. Friede Hermann (Denmark) – Director of Standard Sea Water Service 1959–1974
   Prof. John Lyman (USA) – Member Executive Committee 1960–1963
   Prof. N. K. Panikkar (India) – National Correspondent (India)
   Prof. Kozo Yoshida (Japan) – Vice-President 1970–1975
   as well as other oceanographers not mentioned by name.

4. (Item 3.1) The President noted with pleasure that several National Reports on Physical Oceanography were received for distribution to delegates. They were from Argentina, Chile, France, Federal Republic of Germany, German Democratic Republic, Japan, United Kingdom, U.S.A., and U.S.S.R.

5. (Item 3.2) The President asked that the Chief National Delegate of each country identify himself/herself to the Secretary, for voting purposes.

6. (Item 3.3) The Secretary reported on activities of the IAPSO Secretariat for the period 1976–1979, pointing out the increased activity. (Document 3.3). He mentioned that the IAPSO Executive Committee met on 21 September 1976 in Edinburgh, the minutes of which have been distributed to National Correspondents and IAPSO officers. He reported on the IAPSO-sponsored symposia held during this period. In addition, several JOA symposia were convened under IAPSO sponsorship.
   The Secretary reported the following publications: Proces-Verbaux No. 14, 1976; Publication Scientifique No. 30, Pelagic Tidal Constants, 1979; two Symbols, Units and Nomenclature (SUN) Draft Reports, 1979; and the Program of the present meeting, 1979.

7. (Item 3.4) The Secretary reported on the financial situation of the Association in good health. He pointed out that the allotment from IUGG has increased over the past four years but so have costs. For the period 1975–1978 expenditures were roughly as follows: administration and related travel, 5%; publications, 5%; travel to Assemblies, 44%; symposia expenses, 5%; and held in reserve for this XVII Assembly, 41%. The audited financial report and budget are available as Documents 3.4, 3.4.1, and 3.4.2.

8. (Item 3.5) The President reported on actions taken on each of the ten resolutions adopted at the XVI General Assembly in Grenoble. All ten resolutions adopted in 1975 have been acted upon.

9. The President called attention to the special session of the Working Group on Symbols and Units and Nomenclature (SUN) to be held during this Assembly, and to the Draft Report prepared by the WG for distribution to delegates.

10. Sir George Deacon voiced his concern about large-scale "commissioned" research efforts which often disregard the needs of smaller but important research efforts. In addition, he called attention to the fact that IAPSO should be concerned about the ramifications of the new Law of the Sea. He also called for a resolution resolving the definition of the so-called "continental shelf."

11. (Item 3.6) The President announced the appointment of the following members to the Nominating Committee:
   Sir G. E. R. Deacon, Chairman
   Prof. D. Lal
   Dr. F. P. Anderson
   Prof. G. Pickard
   Prof. H. Lacombe
   Dr. A. Maxwell
   Prof. E. Morozov
   Dr. M. Zore-Armanda
   They were charged with seeking candidates for the IAPSO Executive Committee.

12. (Item 3.7) The President appointed Professor B. R. Morton to chair the Resolutions Committee. Those with resolutions were invited to contact Professor Morton.

13. (Item 4.1) Dr. J. Gieskes reported on the activities of the Marine Chemistry Commission, whose main activities have resulted in two symposia held at this Assembly: "Chemistry and Fluxes of Particulate Matter in the Ocean" and "Ocean-crust interaction." Contact was maintained with SCOR Working Group 10 on Oceanic Standards and with the IAPSO Standard Seawater Service. (Document 4.1).
14. (Item 4.2) Dr. S. Uyeda reported on the activities of the Marine Geophysics Commission. He mentioned with sadness the loss of its Chairman, Dr. Bruce Heezen. He pointed out the contribution of the Commission to several IAPSO-sponsored and co-sponsored symposia during the past four years. He further proposed a complete change in the membership of the Commission and a possible change in name. (Document 4.2).  

15. (Item 4.3) Dr. W. Duing sent a report on the activities of the Commission on Physical Oceanography. It pointed out the work of the Commission in organizing the physical oceanography programs for the XVII General Assembly, offering advice on physical oceanography matters, including appointments, and participating in the Turbulence of the Ocean Symposium. The Physical Oceanography Commission proposed a symposium on the oceanographic results obtained during the First Global (GARP) Experiment, to be held in Italy in 1980. (Document 4.3).  

16. (Item 5.1) The report on the Committee on Tides and Mean Sea Level was presented by Dr. D. E. Cartwright. He pointed out the comprehensive report on Pelagic Tidal Constants prepared by his Committee. (Document 5.1).  

17. (Item 5.2) Dr. G. Kullenberg presented a report on the activities of the Committee on Physical and Chemical Aspects of the Dispersion of Natural and Artificial Substances, and Heat in the Ocean and Seas. It was suggested that the latter part of this name (Heat, etc.) should be dropped. Activities included an extensive symposium organized for the present Assembly. (Document 5.2).  

18. (Item 5.3) Dr. J. Gieskes reported on the Advisory Group to the Executive on Co-ordination within the Physical Sciences of the ocean. Little or no activity of this group was reported and clearer terms of reference were requested. (Document 5.3).  

19. (Item 6.1) Mr. M. Menaché submitted a report on the vigorous activities of the Working Group on Symbols, Units and Nomenclature (SUN). (Document 6.1). This report was read by Prof. Menaché at a SUN meeting on Tuesday, 5 December. He pointed out that through the two SUN Draft reports good progress in establishing appropriate symbols, units and nomenclature for Physical Oceanography has been achieved. Dr. J. Gieskes agreed to have the IAPSO Marine Chemistry Commission consider the nomenclature and units for Marine Chemistry. (Document 6.1).  

20. (Item 6.2) Dr. A. Mordi reported on the Working Group on Ocean Optics. The function of this working group was considered most useful, and its activity has led to the present IAPSO Symposium on Radiant Energy in the Sea. A WG devoted to ocean optics is planned for 1982. Creation of a group on optics, under SCOR/IAPSO sponsorship, which would involve biologists was considered and the matter should be taken up by the Executive Committee. (Document 6.2).  

21. (Item 7.1) Professor G. Lennon, former Director, reported on the history of the Permanent Service for Mean Sea Level and added that the Service has been very productive and has published three volumes of data in three years. He emphasized the continuing problem of support for the Service, and suggested that it will still be needed from IAPSO, IAPSO, and IUGG. He pointed out that if the Service is to do useful work the present staffing is too small and should be expanded from one to two persons. Prof. Lennon also emphasized that longer term support, possibly with the aid of the host country, would make operational planning much easier. (Document 7.1).  

22. (Item 7.2) Dr. F. Culkin submitted a report on the Standard Sea Water Service which was read by Dr. J. Gieskes. The Service is now located at Wemley, England, and administered by the Institute of Oceanographic Sciences. The production of standard sea water vials has been much helped by the expansion of the staff. One hundred thousand ampoules of standard sea water have been prepared in the past four years. (Document 7.2).  

23. (Item 8.1) Professor R. O. Reid submitted a report on the activities of the IUGG Committee on Tsunamis which pointed out the several meetings of the Committee, as well as sponsored symposia and work shops. (Document 8.1).  

24. (Item 8.2) A report was prepared by Dr. J. F. R. Gower on the activities of the ICSU Committee on Space Research, but it did not arrive in time for the Plenary Session. However, a meeting co-sponsored by the Committee, to be held in Venice, Italy, May 26-30, 1980, was announced. (Document 8.2).  

25. (Item 8.3) Dr. L. O. Nicolaysen provided the Association with a report on the IUGG Committee on Geochemistry. He pointed out the major role played by Prof. D. Lal in organizing a symposium at the Canberra Assembly. Another symposium is scheduled for Iceland in 1981. (Document 8.3).  

26. (Item 8.4) The Secretary spoke to the problem of lending advice to Developing Countries. He emphasized that the IUGG Committee for Developing Countries has been active in organizing work shops, short courses, and in the preparation of a book that concerns itself with practical procedures, techniques and inexpensive experiments in geodesy and geophysics. He pointed out that he is preparing a chapter entitled Near Shore Oceanography. IUGG has an ICSU grant for publishing the volume in 1980. (Document 8.4).  

27. (Item 8.5) Mr. M. Menaché made the CODATA report available for publication and emphasized the need to adopt the SI unit system in oceanography. If data are not reported in SI units, appropriate conversion factors should be stated. (Document 8.5).  

28. (Item 8.6) The Secretary reported that the IUGG Commission on Heat Flow will hold a workshop on heat flow at this Assembly on December 5th and 6th, and that a publication on "Heat Flow in Europe," including a contoured heat flow map of Europe, has been published (Springer-Verlag). The Commission is planning a workshop on terrestrial heat flow, to be held in Liblice, Czechoslovakia, in 1981. (Document 8.6).  

29. (Item 8.7) The President stated that an attempt has been made during the last few weeks to start work on the IUGG Working Group on General Parameterization of the Earth, but no report was yet available. (Document 8.7).  

30. (Item 8.8) A report was received from Dr. W. Zehl on the activities of the IUGG Committee on Mathematical Geophysics. Of special interest were two symposia, (1) in Seeheim, FRG, in 1976; and (2) in Caracas, Venezuela, in 1978. (Document 8.8).
31. (Item 8.9) Sir George Deacon reported that the ICSU/SCOR Working Group on Oceanography will pay special attention to synoptic satellite oceanography to study in more detail the surface circulation of the Southern Ocean. This will have special interest for the problem of mesoscale eddies and also for the Antarctic krill problem. (Document 8.9).

32. (Item 8.10) The President reported that interaction with SCOR is of utmost importance to IAPSO. He reminded the Meeting that a large portion of the SCOR membership is also associated with IAPSO. The advantage of SCOR is the fast response time because of its more frequent meetings (every nine months). Interfacing with SCOR working groups is of great importance.

The Meeting adjourned at 5:30 PM, having finished the major portion of its business agenda.

SECOND PLENARY SESSION — 13 December 1979

33. President Stewart convened the meeting at 9:07 AM and discussion of the items remaining on the agenda was continued.

34. (Item 6.1) The President reported that the second part of the SUN draft report needs further work and suggested each topic be referred to its respective group. In the first part, the section concerning σ should also be reviewed. However, the rest of the first part of the report is to be adopted and circulated to scientists and editors. The WG is to be disbanded but Mr. Monnachi will remain in an advisory capacity.

35. (Item 8.11) Dr. J. Crease submitted a report on the work of the ICSU Panel of World Data Centres. The main activity was the publication of the fourth consolidated guide to International Data Exchange. (Document 8.11).

36. (Item 8.12) Dr. J. B. Matthews presented a report on activities of the Scientific Committee on Water Research. He emphasized the need for interaction of physical oceanographers with coastal engineers and sedimentologists, and verification of numerical models of coastal and estuarine systems. (Document 8.12).

37. (Item 9.3) The Secretary presented Dr. R. L. Fisher's report on the Guiding Committee for the General Bathymetric Charts of the Ocean. This Committee has been very active. Eighteen charts are planned for this fifth edition, of which seven have been completed and three are in publication. The drafting and printing are by the Canadian Hydrographic Office. UNESCO helps with distribution and provides an executive secretary for the Committee. (Document 9.3).

The President stated that the next edition will consider Sir George Deacon's wishes for more convenient coverage of the Southern Ocean.

38. (Item 9.4) Professor G. W. Lennon pointed out the problems of levelling, with which the IAG/IAPSO Special Study Group on Mean Sea Level and Coastal Geodesy has been concerned. The need for this Group is somewhat lessened and it was agreed that the Group be disbanded. (Document 9.4).

39. (Item 10.1) The membership of Commissions, Committees, Working Groups and Representatives of the Association, as appointed by the Executive Committee was announced. They will appear in the Procès-Verbaux No. 15.

40. (Item 11.1) It was agreed that the IAPSO By-Laws and Statutes be amended as follows:

(1) Wherever the word Secretary appears, it is now to read Secretary-General.

(2) A statement in the By-Laws is to be added which states: The retiring Secretary-General is to publish the proceedings of the General Assembly at which his successor was elected.

41. (Item 12.1) Professor B. Morton presented 12 resolutions to the President. Each one was read and discussed. After some modifications all 12 resolutions were adopted. They will be printed in Procès-Verbaux No. 15. (Document 12.1).

42. (Item 12.3) Sir George Deacon presented the slate of officers proposed by the Nominating Committee. The President asked for further nominations from the floor. None were proposed and the following officers were unanimously elected:

President: Prof. Devendra Lal

Members: Mr. James Crease

Vice-President: Prof. W. Krauss

Prof. G. B. Kullenberg

Akad. B. A. Nellepo

Dr. A. Moré

Secretary-General: Dr. E. C. LaFond

Prof. S. H. Sharaf-el-Din

Dr. J. M. Gieskes continues as Deputy Secretary-General.

43. The President discussed the need for Marine Geophysics within IAPSO. It was decided that Dr. Y. Uyeda would be a corresponding member of the Executive for advice on policy matters, and that Dr. T. W. C. Hilde would be the sole member of the Commission on Marine Geophysics. He would be concerned with scientific matters, the arrangement of joint symposia, and general liaison with the solid earth geophysical community.

44. (Item 13.3) The President announced that the Executive approved co-sponsorship of:

(1) A workshop, as proposed by the IAPSO Commission on Physical Oceanography, Results of the First Global (GARP) Experiment to probably be held in Italy in 1980.

(2) A few symposia at the IAMAP Special Assembly in Hamburg, Germany, in 1981. Professor R. Pollard was suggested as the co-ordinator for IAPSO contributions to this assembly.

(3) A symposium on the dynamics of the North Sea, as proposed by Dr. J. Sundermann, co-sponsored with SCOR, IABO and ICES. It might be held adjacent to the IAMAP Special Assembly in Hamburg in 1981.

(4) Joint Oceanographic Assembly to be held in Halifax, Canada, in 1982.

45. (Item 14.0) The Secretary reported that IAPSO had received a request from the Argentine National Committee for IAPSO to financially help support a publication of an Argentine scientific journal on geophysical oceanography. He reported the request was discussed by the Executive Committee where it was pointed out that although there was a need for such a publication, the request was reluctantly declined because of limited IAPSO funds and the precedent which would be established. It was suggested that the Argentine National Committee might seek support from UNESCO.

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46. Dr. L. A. Mysak reported that identical acronyms had been used for different programs by two different organizations on the west coast of North America and wondered if IAPSO could do anything to solve the problem. The President suggested that bilateral negotiations between the organizations involved would be the best approach.

47. The President thanked the delegates for making the Assembly such a success and adjourned the meeting at 12:00 noon.

The Association expressed its gratitude to Professor Stewart Turner for his outstanding contribution to the success of the IAPSO meetings at the Canberra Assembly of the IUGG. His arrangements for meeting rooms, secretarial and projection support, and for the poster session helped very greatly in the remarkably smooth functioning of the sessions.


Document 3.3

1. The Executive Committee

The Executive Committee elected at the XVI General Assembly in Grenoble, France in 1975 consisted of: Dr. R. W. Stewart (President), Prof. J. S. Turner, and Prof G. Siedler (Vice Presidents), Dr. E. C. LaFond (Secretary), Dr. J. M. Gieskes (Deputy Secretary), Adm. Paulo Moreira da Silva, Prof. E. S. W. Simpson, Prof. B. L. K. Somayajula, Dr. S. Uyeda (Members).

The Executive Committee met on 21 September 1976 in Edinburgh, Scotland. The minutes of this meeting were distributed to officers and representatives of the Association, affiliated organizations, and to all IAPSO National Correspondents. In addition, the Secretary and President have consulted with the Executive Committee through correspondence.

2. The Secretariat

In accordance with the By-Laws of the Association, the Secretary has managed the routine business and conducted the expanding correspondence; preserved the voluminous records and arranged preliminaries of this General Assembly, in collaboration with the IAPSO President, Dr. R. W. Stewart.

The Secretary has also taken care of the finances of the Association in consultation with the President, Deputy Secretary, and Executive Committee.

The mailing address of the Secretary changed in 1976 to LaFond Oceanic Consultants. The Secretariat has been supported by the U. S. Office of Naval Research, National Science Foundation, and National Ocean and Atmospheric Administration.

3. Scientific Meetings

Assemblies:

IAPSO co-sponsored jointly with SCOR and others the Joint Oceanographic Assembly, 13–24 September 1976 in Edinburgh, Scotland.

In addition to business and committee meetings, nine scientific symposia were organized by IAPSO at the JOA.

An IUGG Special Extraordinary Assembly was held in Durham, England, 5–7 August 1976. The President and Secretary represented the Association.

Symposia:

IAPSO co-sponsored with SCOR, IOC, and IDOE a symposium and workshop on Ocean Turbulence 7–18 May 1979 in Liege, Belgium.

IAPSO co-sponsored, through IUGG, with IUTAM an international symposium on Monsoon Dynamics, in New Delhi, India, 5–9 December 1977.

IAPSO co-sponsored with IAG a symposium on Applications of Geodesy to Oceanography, 10–13 October 1978 in Miami, Florida, U.S.A.

4. Scientific Meetings to Which IAPSO Sent Representatives

(1) Conseil International pour l'Exploration de la Mer (ICES)
   (a) in Copenhagen, Denmark, November 1978, represented by Dr. R. W. Stewart.
   (b) in Warsaw, Poland, 1–10 October 1979, represented by Dr. K. Grasshoff.
(2) International Hydrographic Organization Conference held in Monaco, 21–26 April 1977, represented by Dr. D. E. Cartwright.
(3) SCOR Executive Committee and General Meetings
   (a) Stellenbosch, South Africa, 12–15 November 1975, represented by Professor G. Siedler.
   (b) Edinburgh, Scotland, 13–16 September 1976, represented by Dr. R. W. Stewart and Dr. E. C. Lafond.
   (c) Victoria, Canada, 18–21 May 1977, represented by Dr. R. W. Stewart.
   (d) Sao Paulo, Brazil, 23–26 January 1978, represented by Dr. R. W. Stewart.
(4) Brest, France, 13–18 November 1978, represented by Dr. R. W. Stewart (14th General Meeting).
(5) Joint IOC/IHO Guiding Committee for GEBCO meeting, held in Ottawa, Canada, April 1978, represented by Dr. Robert Fisher.
(6) XVI General Session of COSPAR held in Bangalore, India, 29 May–9 June 1979, represented by Dr. J. F. R. Gower.
(6) ICUSU Panel on World Data Centers meeting in Athens, Greece, on 23 September 1978, represented by Dr. J. Crease.

5. Publications of the Association

(1) IAPSO issued its Procès-Verbaux No. 14, as the proceedings of the XVI General Assembly at Grenoble, France, 25 August to 6 September 1976.
(2) IAPSO's Committee for Tides and Mean Sea Level prepared a publication Scientifique No. 50, Pelagic Tidal Constants, in 1979.
(3) IAPSO's Working Group on Symbols, Units and Nomenclature prepared two draft reports on SUN, one in March and another in August 1979.
(4) IAPSO Program for the 17th General Assembly.

6. Report of IAPSO Commissions

The three IAPSO Commissions are: (1) Commission on Marine Geophysics—Dr. Y. Uyeda is Chairman; (2) Commission on Marine Chemistry—Dr. J. Gieskes is Chairman; (3) Commission on Physical Oceanography—Prof. W. O. Dilling is Chairman. Reports of these Commissions are available.

7. Reports of IAPSO Scientific Advisory Committees

IAPSO has three Advisory Committees:

(1) Committee on Tides and Mean Sea Level—Dr. D. E. Cartwright is Chairman and will report on his Committee.
(2) Committee on Physical and Chemical Aspects of the Dispersion of Natural and Artificial Substances, and Heat in the Oceans and Seas—Dr. G. B. Kullenberg is Chairman and will report on his Committee.
(3) Advisory Group to the Executive Committee on Coordination within the Physical Sciences of the Ocean—Dr. J. Gieskes is Chairman and will report on his Committee.


IAPSO has two Working Groups:

(1) Working Group on Symbols, Units and Nomenclature in Physical Oceanography—Maurice Menaché is Chairman; and (2) Working Group on Ocean Optics—Dr. A. Morel is Chairman. Each Chairman will report on his Working Group.

9. Report of IAPSO Services

IAPSO has two permanent services: (1) IAPSO Permanent Service for Mean Sea Level—Dr. D. P. Pugi is Director, however, Prof. Lennon, former Director, will report; and (2) IAPSO Standard Sea Water Service—Dr. F. Culken is Director and has submitted a report.

10. Report of IAPSO Representatives on Inter-Association Committees, on Other Committees or Working Groups

(1) IUGG Committee on Tsunami—Prof. R. Reid
(2) IUGG Committee on Space Research—Dr. J. F. R. Gower
(3) IUGG Committee on Problems of Geochemistry—Prof. E. D. Goldberg
(4) IUGG Committee on Advice to Developing Countries—Secretary
(5) IUGG Committee on Critical Data (CODATA)—Mr. M. Menaché
(6) IUGG (IASPEI) International Heat Flow Committee—Secretary
(7) IUGG Group on General Parameterization of the Earth—Prof. W. Burt
(8) IUGG Inter-Association Committee on Mathematical Geophysics—Dr. W. Zahal
(9) ICSU/SCAR Working Group on Oceanography—Sir George Deacon
(10) ICSU Scientific Committee for Oceanographic Research (SCOR)—President
(11) ICSU World Data Center Steering Committee—Mr. J. Crease
(12) ICSU Scientific Committee on Water Research—Prof. Brian Matthews
(13) Joint IAPSO/SCOR Working Groups—President
FINANCIAL REPORTS

Income for the Association is received primarily as semi-annual allotments from IUGG. This amounted to $9,600 per year in 1975 and was increased to $18,200 per year in 1978. This allotment was supplemented with $5,000 from UNESCO and $2,500 from IUGG as travel grants for special meetings. A small amount of funds was derived from interest on bank accounts and from the sale of IAPSO publications. This income totaled $74,366 for the four calendar years 1975–1978.

The expenditures can be broken down in the following categories: administration (including administrative travel), 5%; publication (proceedings and reports), 5%; travel to assemblies (JOA and IUGG Special Assembly), 44%; symposia expenses, 5%; and a reserve for travel and organization of this Assembly, 41%. A more detailed audited breakdown is contained in documents 3.4.1, and the budget is covered in document 3.4.2. As of 25 November 1979, IAPSO had $24,000 in the bank, from which several budgeted travel grants are to be paid.

In summary, IAPSO is still financially healthy, even though this has been an unusually expensive Assembly.

Eugene C. LaFond
Secretary
<table>
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<tr>
<th>RECEIPTS:</th>
<th>IUGG</th>
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<tr>
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<tr>
<td>11 ADMINISTRATION</td>
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<tr>
<td>11.1 Personnel</td>
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<tr>
<td>14.2 Travel</td>
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<tr>
<td>15 SCIENTIFIC MEETINGS</td>
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<tr>
<td>16 GRANTS (Permanent Services, etc.)</td>
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<td>17 CONTRACTS WITH UNESCO, etc.</td>
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<tr>
<td>18 MISCELLANEOUS</td>
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| TOTAL RECEIPTS: | $154,000 |

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<td>19 Miscellaneous</td>
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<tr>
<td>20 Cash on hand (estimate) (31 December 1982)</td>
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<td>20 TOTAL EXPENDITURES:</td>
</tr>
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</table>

Prepared by The Bureau
BREAKDOWN OF FINANCIAL ESTIMATE
FOR THE PERIOD 1979–1982

Document 3.4.2

11 Administration
   Personnel $ 2,500
   Quarters (rents and services) 2,500
   Supplies and Services 9,500
   Communications 500
   Travel (administration) 12,000
   Miscellaneous 1,500
   $ 27,500

12 Publications
   Periodicals (Publication Scientifique) 2,000
   Procès-Verbaux (Canberra) 6,000
   Program (Canberra) 2,000
   Proceedings (W. G. Symposia) 1,500
   11,500

13 Assemblies
   Commission on Marine Geophysics
   (2 meetings) 4,500
   Commission on Marine Chemistry
   (2 meetings) 4,500
   Commission on Physical Oceanography
   (2 meetings) 4,500
   Canberra 41,000
   JOA 7,500
   62,000

14 Symposia (with IAG, IAMAP) 14,000

15 Scientific Meetings (Two) 5,000

17 Grants (Permanent Services, etc.)
   IAPSO Working Groups and Committees 12,000

19 Miscellaneous 1,000
   $133,000

Cash on hand (estimate) (31 December 1982) 21,000

TOTAL: $154,000

Prepared by The Bureau

STATUTES OF THE ASSOCIATION

Adopted by the General Assembly at Berne, October 1967
Modified at Canberra, December 1979

I. Objects, Composition and Membership of the Association

1. The International Association for the Physical Sciences of the Ocean
   (IAPSO) is a constituent of the International Union of Geodesy and Geophysics.
   The Association is subject to those articles of the Statutes and By-Laws of the
   Union which apply to Associations, and also to these Statutes.

2. The objects of the Association are:
   (a) To promote the study of scientific problems relating to the ocean and
       interactions taking place at its boundaries, chiefly insofar as such study may be
       carried out by the aid of mathematics, physics and chemistry;
   (b) To initiate, facilitate and co-ordinate research into and investigations of,
       those problems of the ocean which require international co-operation;
   (c) To provide for discussion, comparison and publications.

3. Those countries which adhere to the Union are Members of the
   Association.
   By resolution of a General Assembly of the Association, other interna-
   tional organizations which are concerned with the study of physical sciences of
   the ocean may be admitted to Membership, with the status of guests.

II. Administration

4. The Authority of the Association shall be vested in the countries adhering
   to the Union, and exercised collectively by their delegates meeting in General Assem-
   bly of the Association.

5. The Association shall hold business meetings at the General Assemblies
   of the Union, to be held normally once every four years.
   The Association may recommend to the Executive Committee of the
   Union, at a General Assembly of the Union, arrangement of joint sessions of two or
   more Associations or of joint meetings of two or more Committees or Commissions,
   for the discussion of topics of an interdisciplinary character.
   With the concurrence of the Executive Committee of the Union, the
   Association may arrange General Assemblies and other meetings of its own in the
   interval between the General Assemblies of the Union, either singly to deal with
   topics of specific interest, or jointly with another Association or other Associations.

6. The General Assembly of the Association shall elect the President, the two
   Vice-Presidents, the Secretary General and the Deputy-Secretary General of the
   Association.

7. The Bureau of the Association shall consist of the President and Secretary
   General. Its duties shall be to conduct the affairs of the Association in accordance
   with the decisions of the foregoing General Assemblies of the Association. It shall
   prepare the Agenda for General Assemblies.
8. The General Assembly of the Association shall elect, from countries which adhere to the Union, four persons who, together with the President, Vice-Presidents, Secretary General, and Deputy-Secretary General, shall constitute the Executive Committee of the Association.

III. Voting

9. On scientific matters, each delegate present shall have one vote.

10. In questions of administration or of mixed, administrative and scientific character not involving questions of finance, voting shall be by countries, each country having one vote with the provision that its subscription shall have been paid up to the end of the year preceding the voting.

11. In questions involving finance, voting shall be by countries, with the same provision as for administrative questions. The number of votes for each country shall be one greater than the number of its category of membership to the Union.

12. In case of doubt as to which class a question belongs, and in all cases of equality of votes, the chairman shall decide.

13. A delegate shall represent only one Member Country. An adhering country not represented by a delegate may forward by post its vote on any specific question of an agenda.

14. Guests will not vote.

IV. General

15. These Statutes shall be changed only by a majority of two thirds of the votes cast at a General Assembly by delegates or by post.

16. The Association may make By-Laws which may be changed by a simple majority of the votes cast at a General Assembly by the delegates or by post.

17. This English text shall be the authoritative text of the Statutes of the Association.

BY-LAWS OF THE ASSOCIATION

Adopted by the General Assembly at Berne, October 1967
Modified at Canberra, December 1979

I. Membership of the Association

1. It is recommended that each adhering country shall form a National Sub-Committee for the Physical Sciences of the Ocean, to which correspondence may be addressed.

2. Each adhering country and each international member may contribute to the Agenda of General Assemblies of the Association.

II. Administration

3. (a) The President and Vice-Presidents of the Association shall be elected for one period, the term "period" being taken to mean the interval between the ends of two successive General Assemblies of the Association other than Union Assemblies, except that if no such General Assembly of the Association is held in the interval between two General Assemblies of the Union, the election of officers will take place at second General Assembly of the Union.

(b) The Secretary General and Deputy-Secretary General shall be elected for two periods, and may be re-elected for subsequent single periods.

4. The Secretary General shall manage the routine business, conduct the correspondence, preserve the records, and arrange the preliminaries of General Assemblies. The retiring Secretary-General is to publish the proceedings of the General Assembly at which his successor was elected.

5. Of the four persons referred to in Article 8 of the Statutes, two shall retire after each General Assembly where elections have taken place and they shall not be eligible for re-election until after the expiration of one period. Each retiring member shall have served at least as long as each non-retiring member.

6. The Executive Committee shall:

(a) Prepare for the Executive Committee of the Union recommendations concerning the arrangement, at a General Assembly of the Union, of scientific meetings to be confined to joint sessions of two or more Associations or of Joint meetings of two or more Committees or Commissions, for the discussion of topics of an interdisciplinary character.

(b) Seek for the concurrence of the Executive Committee of the Union, for the arrangement of General Assemblies and other meetings of the Association in the intervals between the General Assemblies of the Union, either singly to deal with topics of specific interest, or jointly with another Association or other Associations.

(c) Fill any vacancy which may occur among the officers of the Association between General Assemblies. Such appointments shall be subject to the subsequent approval of the next General Assembly. Tenure of office for part of a period shall not be counted as a period for the purpose of these By-Laws.

(d) Consider matters of general administration and finance, and report thereon to the General Assembly.
(e) Make recommendations on matters of policy.
(f) Frame the budget for the ensuing period and report to the General Assembly of the Association and to the Secretary General of the Union. The budget period of the Association coincides with the budget period of the Union.
(g) Advise upon the distribution of funds.
(h) Consider proposals for changes in the Statutes and By-Laws, and report thereon to the General Assembly.

7. Officers designated by these By-Laws for special duties or for special committees may appoint substitutes in their stead. Notice of the intention to so must be sent in writing to the President or Secretary General. No substitute shall represent more than one officer.

8. Decisions and actions of the Officers and Committees of the Association, taken during and between General Assemblies, shall be subject to the sanction of the General Assembly.

9. Proposals for the Agenda of a General Assembly shall reach the Secretary General six months before the General Assembly. The Secretary General shall send the Agenda to adhering countries, through the National Sub-Committees where such exist, at least four months before the General Assembly. No question which has not been placed on the Agenda shall be discussed unless a proposal to that effect be approved by two-thirds of the votes of the countries represented at the Assembly.

III. Finance

10. The President and Secretary General shall individually have power to sign documents on behalf of the Association.

11. The Secretary General shall receive the allocations of funds from the Union, and administer the funds of the Association. At the end of the calendar year preceding a General Assembly of the Union he shall prepare and send to the Secretary General of the Union the Accounts of the Association.

12. Each Account shall be audited by a qualified accountant.

13. Travelling expenses may be paid by the Secretary General, but only (a) in connection with meetings on specific Association business, and (b) when those concerned represent the Association and not adhering countries or other organizations, and (c) in cases where those concerned cannot draw proper allocations from their own national sources. Such payments may cover travelling costs and a reasonable contribution to other expenses while attending such meetings.

Document 4.2

During the period 1976–1979, the Commission lost its chairman Bruce Heezen in 1977. Seiya Uyeda was appointed the acting chairman for the remaining term and John Ewing was appointed a new member of the Commission.

The Commission has contributed to organizing and convening numerous IAPSO-sponsored or co-sponsored symposia. This includes:

- And several symposia to be held in Canberra, December, 1979.

Apart from the above the Commission has not been very active. Present members feel that changes of membership at this stage would be appropriate.

Also, the acting chairman strongly feels that the name, especially its acronym (CMG), is extremely confusing because of the Commission for Marine Geology (CMG) of IUGS. The name of the Commission should be duly changed, if the Commission is to continue to exist.

Seiya Uyeda  
Acting Chairman

REPORT ON THE ACTIVITIES OF THE COMMISSION ON PHYSICAL OCEANOGRAPHY FOR THE PERIOD 1976–1979

Document 4.3

The Commission on Physical Oceanography has been active in selecting topics and recommending conveners for IAPSO-sponsored and co-sponsored symposia dealing with physical oceanography, especially the symposia for the General Assembly in Canberra.

The Commission has furnished advice on physical oceanographic matters which are passed to the Association. In addition, the Commission has cooperated with the President in the nomination of candidates for various international committees and activities.

An outstanding event in physical oceanography was the second symposium on turbulence, entitled "Turbulence in the Ocean, Millimeters to Megameters," co-sponsored by IAPSO through the Commission, and held in Liege, Belgium, 7–18 May 1979. The great success of this symposium showed that it was timely for people with expertise in different scales and different mechanisms to get together and discuss how scales might influence one another.

For the future, the Commission recommends sponsoring a symposium on oceanographic results obtained during the First Global (GARP) Experiment (FGGE). Preliminary discussions have been made with Dr. R. Frascatto to hold such a symposium in Italy in 1980.

Compiled from material furnished by W. Döling, Chairman
REPORT ON IAPSO ADVISORY COMMITTEE ON TIDES AND MEAN SEA LEVEL, 1976–1979

Document 5.1

The Committee was formed at the General Assembly at Berne in 1967 by uniting the Committee on Tides and the Committee on Mean Sea Level. Its principal mandate was to give technical and scientific advice to the IAPSO Executive Committee.

The Committee is chaired by David E. Cartwright; the other core members are Bernard D. Zetler and Bruce V. Hamon. During the 1976–1979 period, the Committee:

a) completed IAPSO Publication Scientifique No. 30, Pelagic Tidal Constants, 1979;

b) organized the oceanographic portion of the Tidal Interactions symposium in Canberra (IUGG-20) with sessions on (i) Numerical and other models, and (ii) Open-sea measurements and related theory;

c) assisted in the programs of the Permanent Service for Mean Sea Level; and

d) advised the IAPSO Executive Committee on questions relating to tides and mean sea level.

B. D. Zetler

REPORT ON IAPSO SCIENTIFIC ADVISORY COMMITTEE ON PHYSICAL AND CHEMICAL ASPECTS OF DISPERSION OF NATURAL AND ARTIFICIAL SUBSTANCES AND HEAT IN THE OCEAN AND SEAS

Document 5.2


2. Terms of Reference: To advise IAPSO and other bodies on the physical and chemical aspects of marine pollution and to assess or propose interdisciplinary symposia to be sponsored by IAPSO.

3. The Committee was established as a result of discussions held during the XVI General Assembly in Grenoble 1975. The Committee did not start its work until mid-1976, when it was agreed that the Committee should attempt to make an inventory of:

(i) laboratories where recognized groups of scientists are carrying out research on dispersion problems;

(ii) relevant symposia and active working groups through which reports of limited circulation may be published; and

(iii) relevant ongoing large projects, primarily international.

The purpose is to establish what is going on in the field, spread information, possibly identify shortfalls between practical needs and ongoing research and information gaps.

4. Part of the work has been completed, and we have a fairly complete list of laboratories. It has been suggested that our information can be passed on to international organizations, like IMCO, IAEA, UNESCO/IOC, where there is great interest in dispersion problems, the most up-to-date research and in scientific expertise with an international reputation. There are also Commissions for international conventions, such as the London Dumping Convention, where the information would be of interest. The hope would be that some action along these lines from the scientific community would create feedback, so that the IAPSO community would become involved in the scientific problems these bodies have to deal with.

5. The Committee proposed a symposium for the XVII Assembly, IAPSO PS9. The initial response from invited lecturers was very positive, showing that leading scientists are interested to apply their scientific results to marine pollution problems. However, several invitees have had to withdraw owing to the limitations of funds for travel support to the Assembly. Information about the symposium has been sent to several international organizations.

The most relevant of other symposia held during the period is the IAPSO/SCOR/IDOE on Ocean Turbulence, May 1979.

6. Several requests were received for comments on publications and programmes, some directed to IAPSO, which have been answered through this committee.

7. One period is too short to get a justified impression of the value of such a committee, and it is suggested that the Committee continues one more period.
8. It is suggested that the name of the Committee be changed to "IAPSO advisory committee on dispersion of artificial and natural substances." The name IAPSO covers the other points specified in the present title.

Gunnar Kullenberg

REPORT ON THE IAPSO WORKING GROUP ON SYMBOLS, UNITS AND NOMENCLATURE IN PHYSICAL OCEANOGRAPHY (SUN-WG)

Document 6.1

The creation of the SUN WG, during the XVIth IUGG General Assembly held in Grenoble in 1975, seemed a logical consequence of the adoption by the same GA of Resolution X (annex 1 of this report) recommending the use of the International System of Units (SI). The terms of reference of this WG are condensed in IAPSO Resolution 6, in favour of the SI (annex 2).

As soon as it was formed, the WG began by reflecting deeply on the most important problems arising in the application of the SI to physical oceanography. The fruit of these reflections has been summarized in two papers:

Paper 1: "Specific Problems . . ." Paper 2: "The use of units not belonging to the SI." Successive versions have been distributed for comments to a great number of physical oceanographers. The comments received were so numerous and pertinent that Paper I appeared in four different versions: February 1975, February 1977, April 1977 and April 1978.

The first draft report written by the WG (March 1979), incorporating the two above papers, was in turn submitted for criticisms. These were examined by the WG at a meeting held in Paris, Institut Oceanographique, 27–29 August 1979, which resulted, after substantial changes, in the adoption of the Draft Report (amended version of August 1979). I am bound to say here, at the request of the interested member, that one of the Group declined to approve the draft report, both in the original and in the amended version.

The WG is conscious therefore of having worked in close contact with an important number of representative members of our oceanographic community.

The Draft Report submitted for your approval now, comprises two parts. Part One contains the main rules governing the use of the SI and its accompanying standards. It aims to promote, in this important field of physical measurements, a better harmonization in scientific language and writing and the progressive elimination of all sources of confusion.

Part Two, containing tables only, has been written in conformity with the terms of reference of IAPSO Resolution 6. A specialist contributor was made responsible for each of the six oceanographic fields dealt with. After a preliminary exchange of views, the contributors were free to prepare their tables as they thought fit.

The WG not only wishes to see its draft report adopted, but hopes that all members of our scientific community will make the effort to use the SI progressively as well as all the accompanying rules. This would be most beneficial and not too time-consuming.

Maurice Menaché
REPORT ON WORKING GROUP ON OCEAN OPTICS
FOR THE PERIOD 1976-1979

Document 6.2

Despite its infrequent meeting, the WG on Optical Oceanography serves a useful function and has been active during the past four years.

- This activity has resulted in a series of papers by the WG members, some of these papers being cooperative work, dealing specifically with our terms of reference. This activity also will result in the Symposium PS-8, “Radiant Energy in the Sea,” to be held next week.
- Another activity of our WG has been to prepare and propose a document about Symbols, Units and Nomenclature in the field of Optical Oceanography. The definitions are based upon the recommendations formulated in 1964 by the Committee on Radiant Energy, set up by IAPSO and are in full agreement with the International System of Units.

This work has been carried out only by means of correspondence. So, a special meeting of our WG is necessary to establish a final version of this document before presentation in the PS-7 Symposium.

- An important cooperative effort of our WG is in the future, since a joint cruise is being organized. We have a reasonable chance to obtain some French authorities' ship time in 1982 with accommodation aboard for 20 scientists. This ship time will be entirely devoted to optical oceanography and its subsequent applications, namely chemical oceanography, sediment or particle transport, and marine biology with a special emphasis on phytoplankton assessment by means of optical methods and on Primary Production.

By some aspects, the recent works by the WG members and the future cooperative activity at sea can be regarded as an extension of the work initiated by the former IAPSO/SOR/UNESCO WG15 on “Photosynthetic radiant energy.”

Moreover, it appears to us that, among others, biological applications of optical studies are gaining increased attention (e.g., in photo-ecology and in remote sensing). Thus the question of modifying our terms of reference and membership has been considered. Two solutions have been discussed:

i) the membership of the present WG could be expanded to include biologists and the WG transformed into a IAPSO/SCOR WG.

ii) alternatively, the creation of a companion SCOR/IAPSO WG focused on bio-optical studies could be recommended, without any change in our own Group.

Through the letters I have received, this second solution seems to be the most generally proposed. However, the merit of these alternative ways will be discussed during the meeting of our WG and a definitive answer given at the Executive Committee.

André Morel
Chairman

REPORT ON THE ACTIVITIES OF THE IAPSO PERMANENT SERVICE
FOR MEAN SEA LEVEL 1976-1979

Document 7.1

The Permanent Service for Mean Sea Level has had a very productive phase marked by the publication in three successive years of a volume of mean sea level data which together comprise a world coverage:

Volume 1, 1976, Europe, Africa and India
Volume 2, 1977, North, Central and South Australia
Volume 3, 1978, Japan, Philippines, Australia and the Pacific Islands

These data include all available material which can be reduced to homogeneous MSL time series referred to a local stable bench mark. These volumes and their separate catalogue provide a sound basis for the future development of the Service. They are in steady demand by the scientific community and some 200 sets have been distributed.

The immediate objective is to institute a means of updating the existing information and to access new data to improve the global coverage in both time and space. A systematic review of all previous contributors, now in progress, is producing a good response. In addition, the Service is trying to identify a very small number of new remote Stations, for example on mid-ocean islands, to give a more representative distribution. For these few Stations (probably not more than five) the Service may be able to reduce original gauge charts, if the local authorities are not able to do so. Members of IAPSO are invited to suggest suitable Stations.

To enable a more efficient handling of the library of sea level data, the information is now being stored on a demountable disk pack of the Institute of Oceanographic Sciences’ computer. When this work is completed programs will be developed for the automatic processing and plotting of data. Specialized inquiries may then be dealt with more effectively, for example, by scanning the whole data set where necessary, for a particular area or year.

The major problem facing the Service is financial. Since 1970, when the Federation of Astronomical and Geophysical Services provided most of the necessary funding, their contributions in real terms has, by 1979, gradually dwindled to 24% of the 1970 level. The level of activity of the Service is maintained at one full-time staff member, because of support from the International Oceanographic Commission, and recently, from the United Kingdom Natural Environment Research Council. The FAGS 1979 subvention of $5200 is the lowest since 1974, even in simple cash terms. For 1980, provisional estimates show that a FAGS subvention of $10,000 is needed to keep our activities at their present level, and that this would represent only 42% of the total expenditure. It should be noted that in the period up to 1972 the Service had two full-time staff members. Despite the fact that this would represent a minimal acceptable level of staffing, in relation to the tasks which the Service faces, funding levels have not allowed a return to this capability. Against this background the present financial situation is viewed with grave concern.

This Permanent Service is one of many administered by FAGS and clearly their problems will be discussed during the Canberra General Assembly. It is however suggested that due note be taken of the somewhat sensitive relationships which exist between FAGS, IAPSO, IAG and the UGG Executive, and also that the Constitution and terms of reference of the FMSL Advisory Committee be given careful consideration.

D. T. Pugh and G. W. Lennon
REPORT ON THE ACTIVITIES OF THE IAPSO STANDARD SEAWATER
SERVICE 1976–1979

Document 7.2

At the end of 1974 Mr. Fred Hermann retired as Director of the Standard Seawater Service and was succeeded by Dr. F. Culk in the Institute of Oceanographic Sciences, Wimereux, Godalming, England. With the aid of a grant from IAPSO, the equipment was transferred from Charlottetown to Wimereux where it was installed early in 1975.

Only minor modifications were made to the method of preparing the standard and for the first 2½ years the Service was operated much the same as previously, with administration and preparation being carried out with the help of two part-time workers. Because of the high demand for Standard Seawater, this system led to occasional administrative problems and consequently in July 1977 the administrative side of the Service was taken over by I.O.S. Two full-time members of staff have been recruited, one of whom will be trained to deal with the preparation and calibration of the standard. It is hoped that these changes will eliminate delays in supplying Standard Seawater and also ensure continuity in the operation of the Service.

Demand for Standard Seawater has remained high and in the past four years more than 100,000 ampoules have been prepared. Details are given in Table 1.

It is sad to record the death, which occurred on 21st February 1977, of Fred Hermann, former Director of the Standard Seawater Service. From 1941 until 1974 Hermann was in charge of the preparation and calibration of the standard and he was largely responsible for its widespread use in the determination of salinity.

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F. Culk in

REPORT ON IUGG COMMITTEE ON TSUNAMIS
FOR THE PERIOD 1976–1979

Document 8.1

Symposia relating to the subject of tsunamis were held at several international meetings during the reference period. These include:

- Session on Tsunami at the 15th International Conference on Coastal Engineering, 11–17 July 1976, Honolulu, HI
- I.U.G.G. Symposium on Tsunamis, 23–26 March 1977, Ensenada, Mexico
- Symposium on Long Waves in the Ocean, National Research Council of Canada, 6–8 June 1978, Ottawa, Canada. Endorsed by IUGG, among others.

The following workshop to identify needed research on tsunamis is also relevant:

Workshop on Tsunamis, 6–9 May 1979, Trabuco Canyon, California. Sponsored by the U.S. National Science Foundation

The Tsunami Committee of the IUGG met in business session on 26 March 1977 at Ensenada with eleven members in attendance. Vice-Chairman K. Iida (Japan) presided in the absence of Chairman S. L. Soloviev (USSR). Dr. H. Loomis (USA) was selected to fill the vacancy left by the death of Dr. Gaylord Miller (USA). Dr. T. S. Murty (Canada) was elected as second vice-chairman and Dr. Loomis as secretary.

Agenda items included plans for the Tsunami Symposium at the present IUGG General Assembly in Australia. Also, a sub-committee (chaired by Dr. W. M. Adams, USA) was named to look into the matter of data exchange and data requirements for tsunami research. Several resolutions were adopted, including a recommended procedure to be followed by the International Tsunami Information Center (ITIC) in conducting tsunami surveys for large tsunamis.

Other meetings pertinent to tsunami-related activities include the 5th and 6th meetings of the International Coordination Group for Tsunami Warning System in the Pacific (ICG/ITSU) of IOC which were held in Lima, Peru, 23–27 February 1976 and Manila, Philippines, 20–25 February 1978. The next meeting of this group will be in March 1980 in Chile.

In closing this report, I should like to draw attention to the subsuming of the Joint Tsunami Research Effort (JTRE) under the newly established Joint Institute for Marine and Atmospheric Research (JIMAR) of the U.S. Department of Commerce, NOAA, in cooperation with the University of Hawaii, Honolulu.

- R. O. Reid
RELATIONS DE L'IUGG AVEC CODATA. DEPUIS LA XVIÈME ASSEMBLEE GENERALE DE L'IAUGO - GRENOBLE, 1975

Document 8.5

Venue de CODATA aux Sciences de la Terre — Rappelons que l'extension de la compétence de CODATA au domaine des Sciences de la Terre (Géosciences) avait été décidée en 1973, à la suite d'un changement de constitution. Un tel événement avait été accueilli avec beaucoup d'inquiétude par diverses unions, dont l'IUGG. Les choses se sont arrangées grâce à l'élection pour 8 ans (1974-1978) du Secrétaire Général de l'Union à la tête de CODATA. De nombreuses initiatives du nouveau président, en premier lieu la mise en place d'une Commission Consultative pour les Géosciences (CODATA Advisory Panel on the Geosciences), ont aidé CODATA à faire plus rapidement face à ses nouvelles responsabilités, et permis d'établir entre elle et l'Union des relations de collaboration confiantes et fructueuses.

Cooperation IUGG-CODATA — Une partie importante de la coopération IUGG-CODATA revient à la Commission Consultative pour les Géosciences, dont deux membres sur les six appartiennent à l'Union. On doit à son initiative les réalisations suivantes:

1) nouveau changement de constitution permettant l'adhésion à titre de membres "co-optés" d'une nouvelle catégorie d'organismes scientifiques. Le premier membre co-opté a été l'"IUSI Panel on WDC";
2) création d'un Groupe de Travail sur la Méthodologie pour la manipulation des données à caractère spatio-temporel (Task Group on Methodology for handling Spacetime Dependent Data);
3) rédaction d’un "Guide pour la présentation dans la littérature primaire des données en Géosciences" (Guide for the presentation in the primary literature on numerical data derived from observations in the Geosciences).

On doit également souligner la contribution active de déléguées des diverses Associations Internationales de l'Union à la préparation du nouvel "Annuaire des Sources Données pour les Sciences et la Technologie" (Directory of Data Sources for Sciences and Technology).


Les A. G. sont toujours précédées de Conférences Internationales consacrées à des problèmes scientifiques.

Vote d'une Résolution en faveur du SI — Sur recommandation de l'IUGG, la 10ème A. G. a voté la résolution suivante:

CODATA REAFFIRMS ITS INTENTION TO USE IN ALL ITS WORK THE SYSTEME INTERNATIONAL D'UNITES (SI) UNLESS EXCEPTIONAL CIRCUMSTANCES MAKE THIS IMPRACTICAL, AND RECOMMENDS THAT THIS PRACTICE BE ADOPTED THROUGHOUT THE SCIENTIFIC AND TECHNOLOGICAL COMMUNITY.

CODATA FURTHER STRONGLY RECOMMENDS THAT WHEN DATA ARE EXPRESSED OTHERWISE THAN IN THE SYSTEME INTERNATIONAL D'UNITES EITHER THE SI VALUES SHOULD ALSO BE QUOTED OR THE APPROPRIATE CONVERSION FACTORS BE STATED.

- M. Menaché
REPORT ON IUGG COMMITTEE ON MATHEMATICAL GEOPHYSICS

The purpose of the Committee consisting in encouraging and developing the exchange of ideas and information in the application of mathematics, statistics and computer sciences to broadly based geophysics of the atmosphere, magnetosphere and hydrosphere as well as the solid earth has considerably been enlarged as opposed to the objectives of the former Upper Mantle Project from which the Committee emerged in 1971. Indeed, this transition in the emphasis of the scientific program has been gradual and is still in progress. This fact is reflected in the main topics comprehended by both the symposia regularly at two-year intervals having been held in the period under review, and that 1976 in Seeheim (Federal Republic of Germany) and 1978 in Caracas (Venezuela), respectively.

Besides several sessions referring to upper mantle solid earth geophysics the Seeheim symposium included sessions on 'Geophysical Model Building' and on 'Analysis of Large Amounts of Data' in the sense of mathematics applied to broadly based geophysics. On occasion of this symposium the Committee concluded to add to the program of future symposia organized by the Committee sessions and workshops which focus on mathematical methods generally being relevant to geophysical problems, such as finite element methods or methods concerning the theory and numerical treatment of inverse differential and integral equation problems.

As topics of general geophysical interest the Caracas symposium included those about 'Automatic Processing of Large Amounts of Data,' 'Models of Evolution of the Earth's Solid, Liquid and Atmospheric Regions,' 'Inversion Problems in Geophysics,' 'Mathematical and Computational Problems in Prediction of and Risk due to Natural Catastrophes' and 'Finite Element Methods in Geophysics.'

About half the number of papers that were presented in Seeheim have been published in a special issue of the Journal of Geophysics (43, 1/2, 1977), while as large a number as possible of those papers given in Caracas are going to be published in a special issue of the journal Physics of the Earth and Planetary Interiors.

— W. Zahel

REPORT ON THE SCAR WORKING GROUP ON OCEANOGRAPHY
FOR THE PERIOD 1976–1979

The group has not met, but its correspondence includes recognition of some of the growing points in studies of the Antarctic ocean. Satellite observations and communications are providing a new outlook. Apart from the overall efficacy of satellite navigation, radiation measurements are providing unique information on variations of water temperature and ice coverage, particularly on the varying position of the ice edge and the percentage cover within this northern limit. Although drifts of FGGE satellite-monitored buoys have not yet been related to day-to-day variations in pressure gradients, several publications have given useful general information.

Ship studies have brought more information about the horizontal eddies with space and time scales of 50 km and 10 days, and their possible bearing on effect of wind stress, and on mixing of Antarctic and subantarctic waters. There is evidence from the Drake Passage that the eddies play an important part in meridional heat transport. Representative arrays of current meters show that the actual transport in the circumpolar current is much more variable than that inferred from the density distribution.

Geophysical measurements and analysis of deep-drilling samples continue to provide new information on the history of the Southern ocean, past climates and sediments.

Members of SCAR are taking an active part in preparations for the international Biomass programme. They have stressed the advantage of co-operative physical and biological studies, showing how the distributions of plankton, particularly the Antarctic krill, birds and mammals, are related to the water movements.

The group wants to promote active continuation of the drifting buoy programme. It is hoped that supply ships will continue to help, and, when possible, extend their effort to current measurement and other oceanographic measurements. The Biomass programme is likely to include recommendations for krill sampling using the engine-room filters, as well as acoustic surveys.

— G. E. R. Deacon
REPORT ON THE ACTIVITIES OF THE ICSU PANEL OF WORLD DATA CENTRES

Document 8.11

Since my last report the panel has had one formal meeting. This was held in Athens on 23 September, 1978. The Panel is now chaired by Sir Granville Beynon; membership is shown on the attached list.

The main activity of the Panel has been to provide and publish in June 1979 the 4th consolidated guide to International Data Exchange (113 pages). This provides a valuable directory giving addresses and scope of the activities of some 75 data centres specializing in one or other branches of geophysics and solar/terrestrial physics. It is intended to make copies of the guide available through the Secretaries of IAPSO, SCOR and IOC.

Oceanographers are fortunate in having a well-developed sub-set of these exchange activities under the auspices of the Working Committee on International Oceanographic Data Exchange and with substantial national support.

In anticipation of the impact of the World Climate Programme on data exchange the committee wish to develop an effective meteorological input to its work and propose to invite representatives from WMO, JSC of ICSU/WMO for the W.C.P., and from IAMAP.

A draft of the minutes of the Athens meeting are available whilst a copy of the resolutions prepared at that meeting are attached to this report.

— J. Crease

REPORT ON ICSU SCIENTIFIC COMMITTEE ON WATER RESEARCH (COWAR)

Document 8.12

I attended the meeting of the Committee on Water Research (COWAR) in Stockholm in June 1979. As the IAPSO/IUGG representative, COWAR has recently been reorganized under the chairmanship of Professor James Donge (Ireland), who is also IAHS President. COWAR is the sister organization to SCOR and operates under the sponsorship of ICSU (International Council of Scientific Unions) and Union of International Engineering Organizations (UAEO). The division between SCOR and COWAR is determined by NaCl (Sodium Chloride) with COWAR concerned mainly with fresh water. Its activities, therefore, are of interest to IAPSO in the region where the fresh water reaches the ocean and influences marine processes. Principally this covers such subjects as influence of large dams on coastal run-off, and the introduction of foreign substances into river waters. I reported the activities of IAPSO’s commission on physical and chemical aspects of the dispersion of natural and artificial substances and heat in the oceans and seas, chaired by Dr. Kullenberg and also the work of SCOR/IAPSO WG57 on Coastal and Estuarine Regimes, chaired by Professor J. B. Matthews. These appear to be the principal areas of interest to COWAR.

Discussions in Stockholm concerned details of the seminar on hydraulic research and river basin development to be held in Nairobi, Kenya, 8—16 September 1980. COWAR, UNESCO and IAHR are the organizers. COWAR has set up a clearing house for hydrologic (ground water) numerical models at Delft under the direction of Professor Schoemaker. At my suggestion, COWAR will investigate the possibility of extending the work of the clearing house, in cooperation with SCOR, to include numerical models of tides and storm surges in estuaries and coastal seas. Such a clearing house had been suggested to SCOR by our WG57 on Coastal and Estuarine Regimes.

COWAR produces a listing of conferences related to water research as a supplement to the Journal of Hydraulic Research. The publication contains the chronological listing as well as details of the objectives, organization and contacts for further information. It is circulated to many international and national organizations, is reprinted by some, and is a very useful tool in planning further conferences or reviewing which ones are already planned.

Finally, I would like to thank IAPSO for inviting me to represent them on the COWAR.

— J. B. Matthews
REPORT ON THE JOINT IOC/SCOR/IAPSO/CMG GUIDING COMMITTEE FOR THE GENERAL BATHYMETRIC CHART OF THE OCEAN (GEBCO)

Document 9.3

The GEBCO Guiding Committee currently consists of ten members, five each from IOC organizations and from the International Hydrographic Organization; the group is chaired by E. S. W. Simpson of South Africa.

The earlier editions of GEBCO were derived primarily from efforts of government hydrographic and survey groups. From the outset it was mandated that preparation of the 5th Edition would involve strong involvement of practicing field oceanographers/marine structural geologists. Each chart has a scientific coordinator responsible for its content and contouring; four of the five IOC committee members have been appointed responsible for at least one sheet, and other experts, sometimes meeting with the committee, have been co-opted for the remaining sheets. Their products are being subjected to inspection and peer review at several stages of sounding compilation and contouring.

The GEBCO 5th Edition also is serving as a base map of a convenient scale, i.e., Mercator at 1:10,000,000, for several other international studies. The guiding committee as a whole, meeting annually at Paris or Ottawa, reviews production and sets priorities. Colors for the 5th Edition are somewhat different from those for earlier editions and conformity throughout this series is being maintained. Of the 18 sheets comprising the 5th Edition and due for completion and distribution by May, 1982, seven have been printed and distributed while three are currently in press. Cartographic production and printing of this edition are being funded and carried out by the Canadian Hydrographic Service, Ottawa, under Gerald N. Ewing, with David Monahan on-site chief technical officer. UNESCO helps with the distribution, provides an executive secretary for the GEBCO committee, and on occasion serves as a setting for meetings. Funding of individual scientific coordinators, their technical aids, and their expenses do not come from these sources.

Several members of the GEBCO Guiding Committee, serving as its Subcommittee on Nomenclature, have met with representatives of the "UN Group of Geographic Names" and with members of the "US Board on Geographic Names" to work out commonality on definitions of undesea physiographic features and on designations of geographic entities. Another subcommittee has been in contact with experts in data processing and archiving to determine the feasibility and advisability of widespread digitization and standardization of bathymetric data storage.

Robert L. Fisher

IAPSO RESOLUTIONS

ADOPTED AT ITS PLENARY SESSION IN CANBERRA, AUSTRALIA
13 DECEMBER 1979

Document 12.1

1. LONG-TERM RESEARCH

The Association notes the increasing proportion of marine science funding going to solution of practical problems, in spite of the fact that many fundamental problems are still poorly understood. It therefore stresses the continuing importance of both long-term support for fundamental research and support for both large and small groups to provide diversity of ideas.

This resolution is directed to National Committees, SCOR, and UNESCO.

2. DELAYS AND DIFFICULTIES ARISING FROM LEGAL REQUIREMENTS

IAPSO notes that unnecessary delays arising from legal requirements may seriously hinder marine research of world-wide importance directed towards problems of climate, fisheries, navigation and natural disasters. It therefore directs the attention of international, governmental and scientific organizations to the deleterious effects on marine research caused when the legal requirements of coastal states are not handled promptly by the authorities proposing or of the country conducting the research, or by the coastal country.

This resolution is directed to the National Committees and IOC.

3. THE CONTINENTAL SHELF

The Association urges that to avoid serious confusion an expression other than continental shelf be used in law of the sea discussions to denote the oceanic zone contiguous to land masses when the meaning extends far beyond that long established in oceanography.

This resolution is directed to the Drafting Committee of the Law of the Sea Committee.

4. INCREASE IN NUMBER OF IAPSO-SPONSORED SYMPOSIA

Noting the great success of the recent IAPSO/SCOR supported Liege symposium on ocean turbulence, the Association urges that further symposia be held between Assemblies, as finances permit. Suggested subjects are theoretical aspects of certain oceanographic studies, elaboration of perspectives for new directions for research and discussion of results of research work.

The Association further urges that in each such case an overview paper be prepared.

This resolution is directed to IAPSO Executive and SCOR.

5. EQUATORIAL AND TROPICAL ZONE DYNAMICS

The dynamics of the equatorial and tropical zones provides one of the most interesting problems of oceanic and atmospheric physics, as is evidenced by the Joint Expeditions. International co-ordination may be desirable for certain programs on equatorial current dynamics. This Association is prepared to work with SCOR in organizing
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international programs on the dynamics of equatorial currents, and in assisting information exchange, should it be requested by several countries. 

This resolution is directed to National Committees and to SCOR.

6. ENDORSEMENT OF DEFINITION OF PRACTICAL SALINITY AND EQUATION OF STATE OF SEA WATER

IAPSO appreciates the work of the Joint Panel on Oceanographic Tables and Standards on the definition of a practical salinity scale and the of the equation of state for sea water. It accepts their proposal for the practical salinity scale and agrees to support a final decision by SCOR on the acceptance of the defining equations for the equation of state which will be passed on to SCOR before April 1980.

IAPSO urges that arrangements be made, in conjunction with other interested bodies, to ensure the orderly and simultaneous adoption of the new equations as soon as practicable thereafter.

This resolution is directed to the National Committee, SCOR, UNESCO, ICES, and editors of journals.

7. IAPSO SECRETARIAT SUPPORT

Recognizing the importance of IAPSO to the oceanographic community and the need to support the Secretariat.

Noting, with appreciation the support provided by the U. S. Office of Naval Research, the National Science Foundation, and the National Oceanic and Atmospheric Administration over the past four years,

Recommends the continued financial support for the Secretariat.

This resolution is directed to the USA National Committee.

8. PERMANENT SERVICE FOR MEAN SEA LEVEL

Recognizing the singular importance of long time series of oceanographic data sets, such as those provided by the Permanent Service for Mean Sea Level at Bidston, to studies within the framework of the World Climate Research Programme, particularly those future programs related to climatic changes and the ocean.

Noting that the Service is now receiving financial support from the United Kingdom.

Welcoming the decision of the Intergovernmental Oceanographic Commission to provide substantial financial support for the Service in the biennium 1981-1982.

Recommends that the financial aid provided for the Service by the Federation of Astronomical and Geophysical Services (FAGS) be continued at least at the current level of U. S. $5,000, and preferably be raised to U. S. $10,000 in cognizance of continuing cost inflation.

This resolution is directed to IUGG, FAGS and the UK National Committee.

9. SYMBOLS, UNITS AND NOMENCLATURE REPORT

IAPSO, having carefully considered the report of the IAPSO Working Group on Symbols, Units and Nomenclature in Physical Oceanography, adopts the first part, with minor modification, of the draft report on the use in the physical sciences of the ocean of the International System of Units (SI). IAPSO urges the scientific community to use henceforth this system so as to ensure greater uniformity in the reporting of oceanographic data.

10. DATA FROM DRIFT BUOY PROGRAM

IAPSO expresses its gratitude to the Working Group and in particular to Mr. M. Menache for the large effort which went into this report. IAPSO urges a speedy completion of Part Two of the SUN report which will serve as a guideline to the use of uniform symbols and corresponding units within the SI system.

This resolution is directed to National Committees and editors of journals.

11. IAPSO expresses deep gratitude to its retiring President, Dr. R. W. Stewart, for his devoted and effective work for the Association over the past four years.

12. SATELLITE ALTIMETRY OF THE OCEAN SURFACE

Noting the impressive, though limited, results achieved by satellite altimetry on GEOS-3 and SEASAT-1, IAPSO draws attention to the great potential of this new technique for estimating barotropic components of geostrophic currents and tides in the open ocean, given also a continued improvement in measurements of the oceanic geoid.

Conradticates the organization responsible for the recent successes with satellite altimetry, and encourages them and others vigorously to advance plans for further developing the technique and launching new altimeter satellites.

Recommends that plans for launching satellites for this purpose during the 1980s should be co-ordinated internationally to optimize the value for dynamical oceanography.

This resolution is directed to the National Committees.
APPOINTMENTS

REPRESENTATIVES OF THE ASSOCIATION

COMMISSIONS, SCIENTIFIC ADVISORY COMMITTEES AND WORKING GROUPS OF THE ASSOCIATION APPOINTED IN CANBERRA 1979

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SESSION 1: REVIEW PAPERS

Tuesday, December 4, A.M. (2)
Chairman: J. S. Turner
1. O. M. Phillips
2. M. C. Gregg

SESSION 2: REVIEW PAPERS

Tuesday, December 4, P.M. (1)
Chairman: J. S. Turner
3. P. F. Linden
4. A. D. McEwan
5. M. Wimbush

SESSION 3:

Tuesday, December 4, P.M. (2)
Chairman: S. A. Thorpe
6. J. S. F. Jones
7. A. Aitsam, J. Laaenems and M. Lilover
8. W. R. Crawford and T. B. Osborn
9. C. H. Gitchon
10. E. Inoue

SESSION 4:

Wednesday, December 5, A.M. (1)
Chairman: S. A. Thorpe
11. T. J. McDougall
12. R. W. Schmitt
13. M. Revault d’Allonnes
14. J. H. Simpson

SESSION 5: JOINT SESSION WITH PS-2, INCLUDING REVIEWS OF THE RESULTS OF THE TURBULENCE WORKSHOP HELD IN LIEGE IN MAY 1979

Wednesday, December 5, A.M. (2)
Chairman: H. Lacombe
15. J. D. Woods
16. L. Armi and E. d’Asaro

SESSION 6: CONTINUATION OF JOINT SESSION WITH PS-2

Wednesday, December 5, P.M. (1)
Chairman: H. Lacombe
17. M. G. Briscoe
18. I. Orlanski
19. W. Krauss
20. D. M. Farmer
21. T. B. Sanford and C. H. Johnson

POSTER SESSION:

Thursday, December 6, P.M. (1) (2)
6. I. S. F. Jones
7. A. Aitsam, J. Laaenems and M. Lilover
8. C. H. Gitchon
9. E. Inoue
10. T. J. McDougall
11. R. W. Schmitt
12. M. Revault d’Allonnes
13. J. H. Simpson
14. D. M. Farmer
15. C. S. Nilsson
16. F. Ostapoff and S. Worthem
17. F. Ostapoff and S. Worthem
18. R. C. Paliwal and C. F. Chen
19. B. Rudnick
27. T. G. L. Shirtcliffe, A. E. Gilmour and A. G. Cole
28. S. A. Thorpe
29. J. H. Simpson
30. S. A. Thorpe
32. A. Garrett
33. R. D. Driver and T. B. Sanford
34. T. D. Allan
35. M. K. Robinson

**STEVE**: A developmental microstructure profiler

Internal gravity waves in shear flows

The physical, chemical, and biological structure of coastal fronts

The near-surface mixed layer of a fresh water lake

Studying the atmospheric mixed layer evolution using a triple monostatic doppler sonde

Turbulence measurements through a train of internal waves

An expendable temperature and velocity profiler (XTVP)

Preliminary analysis of SEASAT synthetic aperture radar imagery of selected ocean areas around Europe

Atlas of northern hemisphere monthly temperatures

1. **TURBULENCE DUE TO BREAKING SURFACE WAVES**

O. M. Phillips — Department of Earth & Planetary Sciences, The Johns Hopkins University, Baltimore, Maryland 21218, U.S.A.

Surface and internal waves frequently lose energy following the development of sporadic local instabilities that lead to breaking and energy transfer to small scale turbulence. Four different types of breaking will be reviewed and illustrated by films. These are: (1) microscale breaking of short surface waves under the influence of wind, (2) large scale surface wave breaking following the storm local instability of Longuet-Higgins, (3) the shear and overturning instabilities in internal waves as they approach a critical layer, and (4) the shear-induced instabilities of long interfacial internal waves. In some of these situations, estimates can be given for the rate of energy dissipation and the characteristics of the turbulence produced.

2. **MIXING AND MICROSTRUCTURE IN THE UPPER OCEAN**

M. C. Gregg — Applied Physics Laboratory, University of Washington, 1013 NE 40th Street, Seattle, Washington 98105, U.S.A.

Several of the recent results of microstructure measurements will be discussed in the light of the related uncertainties that they produce in the understanding of small scale mixing.

The levels of temperature microstructure in the main thermocline of mid-ocean regions appear to be quite low in relation to the activity expected if the vertical heat fluxes required by global budgets result from uniformly distributed small-scale turbulence. However, evidence of strong mixing has been found adjacent to islands, in bottom boundary layers, in the Equatorial Undercurrent, in the seasonal thermocline under storms and in frontal areas. Although no direct evidence exists, plausible arguments have been advanced that salt fingers are also major factors in the subtropical thermocline.

Since direct flux estimates based on correlations produced by small-scale processes, e.g., WVT, are not now possible, the evidence for these various mechanisms depends upon the interpretation of signatures in observed data which are usually single profiles. Some of the uncertainties and controversial interpretations of these signatures will be discussed.

3. **DOUBLE-DIFFUSIVE PROCESSES**

P. F. Linden — Department of Applied Mathematics and Theoretical Physics, University of Cambridge, Silver Street, Cambridge, CB3 9EW, England

It is now widely accepted that double-diffusive processes play an important role in the production and properties of small scale temperature and salinity structure in the ocean. Recent advances in the study of these mechanisms will be reviewed, in particular, the results of laboratory experiments compared with oceanographic observations.

4. **MIXING AND DISSIPATION BY INTERNAL WAVE BREAKING AND FINE-SCALE CONVECTION**

Angus D. McEwan — CSIRO Division of Atmospheric Physics, Box 77, Mordialloc, Victoria 3195, Australia

A critical review is made of the theoretical and experimental estimates of the diffusion and dissipation properties of stratified fluids under the action of breaking internal waves and other fine-scale mixing processes. New experiments are described in which the partition of energy between dissipation and buoyancy diffusion in a saturated internal wavefield is measured directly. Measurements of the internal diffusivity of a fingering double-diffusive medium under the action of an internal wave are also presented, indicating the capacity of processes of widely separated scale for mutually destructive interaction.

5. **THE EFFECTS OF BOTTOM CURRENTS ON SEA FLOOR SEDIMENTS**

Mark Wimbush — Graduate School of Oceanography, University of Rhode Island, Kingston, Rhode Island 02881, U.S.A.

Sea floor sediment is susceptible to two types of disturbance: biotic and hydrodynamic. In shallow waters where wave action extends to the bottom, hydrodynamic disturbances dominate, but at a deep-sea site, both types of disturbances are likely to be important, though rare in occurrence. In most deepsea regions, current induced shear stresses are only occasionally significant to move sediment. But when sediment is moved, the transported site is very sensitive to the current strength. Predicting hydrodynamic transport of sediment depends, for the prevailing environment, on knowing (1) the critical flow conditions at which sediment motion begins and ends, and (2) the functional dependence of sediment transport on the supercritical flow. These properties are principally determined by the nature of the sediment grains, but are also influenced by the effects of organisms, the presence of bedforms and the character of the turbulent boundary layer. Hence, in situ study is necessary to determine these properties for a given region.

An example study of this type was conducted in the Florida Straits at 710 m depth. Currents were measured at several levels within and above the turbidity boundary layer, while time lapse motion pictures of a 1 m patch of the rippled sea bed were taken for six weeks. The resulting film record of bed- and suspended-load transport was analyzed with the current meter data, to relate the sediment transport to the current flow. These results in turn were related to the nature of the sediment by analyzing a core of surf sediment taken by submersible.

6. **ENTRAINMENT AT THE BASE OF THE WIND MIXED LAYER**

Ian S. F. Jones — RAN Research Laboratory, P. O. Box 796, Darlington, N.S.W., Australia

The stable region at the base of the ocean wind mixed layer has been examined with the aid of a Richardson Number Probe. This device combines a pair of electromagnetic current meters with temperature and depth sensors to measure gradients on the scale of meters and minutes. Careful attention to the flow around the sensor case allows excellent resolution of horizontal velocity components despite large vertical motions of the package relative to the water.
In conditions suggestive of entrainment we found a Richardson number profile through the base of the wind mixed layer with Richardson numbers less than unity, while for situations where entrainment was low, the maximum Richardson number was greater than unity. The overall Richardson number of a sheared stratified layer frequently assumes a value near 0.25 but the nature of the maximum gradient Richardson number through the interface appears important in parameterizing the entrainment across this layer.

7. FINESTROGRAPHIC MEASUREMENTS IN THE BALTIC SEA

Aim Attem, Jan Lassemets, and Maal Llevier — Institute of Thermophysics and Electro physics, Tallin 110, U.S.S.R.

In this study vertical profiles of temperature, salinity and density in the Baltic Sea are analyzed. All vertical measurements were carried out during the SEVEX (1977) with Neil Brown's Mark III probe system. Preliminary data processing follows Fofonoff's (1974) and Scarf's (1975) ideas. Taking into account the characteristic vertical change of temperature and salinity, the profiles are divided into three layers: upper mixed layer, thermocline, and halocline. For these layers spectra of temperature variance are calculated. The Paschen window is used in harmonic analysis to reduce the undesirable effects related to spectral leakage. In the upper mixed layer the spectral slopes changed from 2.0 to 3.3. In the thermocline (depth interval from 40 m to 0.5 m) spectra have a break in slope in wavelengths 10-40 cm. For wave-lengths less than these scales temperature variance spectrum follows the -5/3 slope characteristic of the inertial subrange. For wavelengths bigger than these scales temperature variance spectra have slopes from -3.2 to -3.8. In the halocline temperature variance spectra have a break in slope in the wavelength 40 cm. For wavelengths bigger than this the spectral slope is approximately -4 and for wavelengths less than 40 cm the spectral slope is -2.8. Using the Kremkow and Milne method of vertical density profiles are calculated from temperature and salinity profiles. There are small-scale density inversions in the upper part of the thermocline. Ten percent of the thermocline layer is formed by reliable density versions.

8. MICROSCOPIC MEASUREMENTS IN THE TROPICAL PACIFIC

W. R. Crawford — Institute of Ocean Sciences, P. O. Box 6000, Sidney, B.C., Canada; and T. R. Osborn — Department of Oceanography, University of British Columbia, Vancouver, B.C., Canada.

During the FGGE cruise of the Canadian Survey Ship PARIZEAU to the tropical Pacific in January and February 1979, a free fall microstructure instrument was deployed at the depth of 45 times from the surface to depths ranging from 270 to 470 metres. Two airfoil shear probes and a microband thermistor sensed two components of microstructure shear and temperature gradients respectively. These profiles were usually timed to within an hour of a profile with an over-the-decade three-axis current meter.

The rate of viscous dissipation of turbulent energy can be computed from the microstructure shear. The regions of highest dissipation were found in the wind mixed layer, within 50 nautical miles of the center of the upwelling, and were associated with relatively high winds. Turbulence in the core of the upwelling and below was much weaker. No pattern emerges for these deeper regions. While analysis is still in progress, we find the dissipation rates to be more variable than we found near the Atlantic Equatorial Undercurrent, and expect the average dissipation rate to be lower than that measured in the Atlantic Equatorial Undercurrent in 1974.

9. ACTIVE AND FOSSIL TURBULENCE IN THE OCEAN

Carl H. Gibson — Scripps Institution of Oceanography, University of California—San Diego, La Jolla, California 92039, U.S.A.

Methods to distinguish between temperature microstructure produced by active turbulent mixing and from temperature remnants of previous turbulence in non-turbulent or partially turbulent fluid are applied to ocean data. Most of the microstructure is fossil temperature turbulence at all scales; some indicates small scale active turbulence with large scale fossil turbulence; none appears to be completely active even though the tower measurement records are from the most active layers and are very long compared to those from vertical profilers. Either the time and distance of measurements must be increased to include the intermittent, active patches, or improved theoretical models must be developed to infer the patch properties from fossils; otherwise, errors due to undersampling will result in incorrect estimates of statistical parameters such as the fluxes, dissipation rates, and diffusion coefficients. The rate of strain T is inferred from the diffusive cutoff of the temperature gradient spectrum, and compared to the Brunt-Väisälä frequency N. When T/N < 1, the fluid is fossil; when 1 < (T/N) < (C/P^2), only the small scales are active; and when T/N > 1, the fluid is actively turbulent at all scales of the microstructure, where C/P, the Cobb number, and Pr, the Prandtl number.


2. C. Schmittbuhl, "Microwave measurements of temperature in the upper ocean from a towed body" (1979), Ph.D. dissertation, University of California—San Diego, La Jolla, California. (Work supported by ONR No. N0001479-C-0152 and NSF No. ENG-7727398.)

10. SOME FACETS OF OCEANIC TURBULENCE OF MICROSCALE

Eichi Iriou — 2-1-1 Tamegawa Denenchou, Setagaya-ku, Tokyo 158, Japan

Since 1950 the present author has long been concerned with the oceanic turbulence as well as the atmospheric turbulence. Especially, it has been much interested in problems of turbulent fluctuations in salinity, temperature, dye, contaminants, etc., since their behaviors look different from them in moments expressed by such as the speed of u, v and w. The spectral functions of the latter are confirmed well to follow the so-called negative three-thirtieths power law developed firstly by A. Kolmogorov and A. M. Oboukhov of USSR in 1941, and I examined the validity of their results in the turbulence oceanic bottom current, too. With regard to the spectral function of matters in the former such as temperature the present author proposed the negative seven-thirds power hypothesis, which is quite different from that proposed by Obukhov, i.e., the spectral law of turbulent fluctuations in temperature obeys the negative five-thirds law just the same as those of momenta. The contradiction between these two hypotheses is still actively discussed.

In this paper the author deliveratory presents results obtained recently in Japan, USSR and many other countries concerning temperature, salinity, and dye fluctuations spectra supporting the negative seven-thirds power spectra, and further extends his idea to the fishery problems related to the turbulent dispersion of plankton, fish eggs, pollutants, etc. Attached is an example of the spectral function of turbulent fluctuations in salinity and temperature in the ocean obtained by Nakata et al. (1976) in Japan. The straight line indicating the negative seven thirteenth power relation is added by the present author.

11. DOUBLE DIFFUSIVE CONVECTION WITH A NON-LINEAR EQUATION OF STATE

Trevor J. McDougall — Research School of Earth Sciences, The Australian National University, P. O. Box 4, Canberra ACT 2600, Australia.

Profiles of temperature and salinity in parts of the Weddell Sea show a series of steps which are stratified in the diffusive sense. The steps below a depth of 100 m are very close to the conditions under which convection may be expected to occur. This situation has been investigated in a laboratory experiment using a single interface between a layer of hot salty water below a layer of cold, nearly 0°C, less salty water. Because of the non-linearity of the equation of state, vigorous convection is driven in the upper layer while the convective activity in the upper layer is substantially reduced. This causes an entrainment flux from the upper layer into the lower layer and so contributes to the rate of change of the layer properties in addition to those changes caused by the symmetry of the processes of double diffusion convection. The implications of these experiments for the step structures in the Weddell Sea are discussed.
12. A DOUBLE-DIFFUSIVE INTERPRETATION OF THE T-S RELATION IN THE CENTRAL WATER


Theory predicts that double-diffusive mixing will dominate the exchange processes when the stability ratio (R = αST/βSL) is near one. This occurs where (1) T and S gradients exist along the horizontal, (2) both T and S decrease for increase with depth. Both forms of double-diffusion are possible in case (1); the density compensated interlayering found at fronts is thought to be the oceanic finestructure signature. The different transport rates of heat and salt cause warm, salty (cold, fresh) intrusions to rise (sink) across isopycnals. Schmitt (1967) finds that this is an effective mechanism for maintaining the tightness of the T-S relation in a region, acting to remove T-S anomalies on an isopycnal.

In case (2) only one mode of double-diffusion is possible; the “thermohaline staircase” is the oceanic response. The salt finger regime is expected for the Central Waters of the main thermocline. Strong staircases have been observed only when R < 1.7; this suggests a connection with the theory of Schmitt (1959) which showed that fingers e-fold in less than a local biogeochemical period when R < 2.0. The fingers transport more salt than heat and thus increase R as the system runs down. This explains the relative rarity of the staircases and the tendency for the T-S relation in the Central Waters to fit a curve of constant R (Ingham, 1966). It is shown that a constant R curve is a better fit to the T-S relation than a straight line. This result argues against the traditional notion of equal “eddy” diffusivities for heat and salt.

The enhanced mixing in the above two cases can explain the slope and tightness of the Central Water T-S relation with only low mixing levels in the interior. This is consistent with recent tracer and microstructure studies which find that the main thermocline is dominated by advection rather than vertical mixing.

References:

13. OBSERVATION AU LARGUE D’UNE PHASE ACTIVE D’INTERACTIONS ENTRE L’ATMOSPHÈRE ET L’OCÉAN


Cet exposé évoque l’essentiel d’une expérience effectuée en octobre 1976 à partir de la Béoule-Laboratoire française BORLA II, moulées en Méditerranée par 42°N et 44°5E. On a alors pu suivre, au cours d’un coup de vent “en crème”, l’évolution pendant sept heures de la tension du vent, des spectres et des caractéristiques statistiques des vagues de vent, des structures verticales de courant et de température dans l’eau entre la surface et trente mètres, de même que la partie haute de la fréquence des spectres des composantes horizontale et verticale des oscillations turbulentes de vitesse dans l’eau, à six mètres d’immersion.

Les résultats permettent d’évaluer de manière empirique et pour cette expérience, les parts relatives d’énergie que le vent cède aux vagues d’une part et aux structures verticales moyennées de courant et de densité de l’autre. Ces travaux posent par ailleurs deux types de problèmes plus fondamentaux relatifs d’une part à la relation nombre d’onde-fréquence de la micro-turbulence en présence de vitesse orbitales élevées devant la vitesse moyenne du courant, d’autre part à l’apparition d’une anisotropie de la turbulence altimétrique observée en fréquence, due à l’effet des vagues ou à un important écart à l’hypothèse de Taylor.

14. THE DISTRIBUTION OF THE SHEAR MODULUS IN THE OCEAN AND ITS RELATION TO THE DENSITY GRADIENT

J. H. Simpson – Department of Physical Oceanography, Marine Science Laboratories, Menor Bridge, Gwynedd, Wales.

Observations of the vertical gradient of the horizontal velocity are described. The data were obtained from a variety of oceanic regions using the free fall probe Protag which detects shear in a bandwidth of 0.1 to 1 cycles/m.

The relation of velocity and density gradients in the fine scale is considered for a number of specific examples and more general results concerning the relation of the r.m.s. shear and the mean B-V frequency are also presented. An interpretation of the observed relationship in terms of the internal wave spectrum is suggested.

15. THE PHYSICS OF ENERGY AND ENSTROPHY CASCADES IN THE OCEAN

John Woods – Institut für Meereskunde an der Universität, Kiel, F.R.G.

A new flow diagram for the oceanic cascades of energy and enstrophy through the spectrum from micrometer to millimeter is proposed as a synthesis of discussions at the Second International Symposium on Turbulance in the Ocean (Château de Colonnes, Lège, May 1979). A central feature of the diagram (which includes geostrophic eddies, semi-geostrophic fronts, internal waves, Rossby waves, fine structure and Kelvin-Helmholtz billows) is the separation of the mesoscale (100 km – 1 metre) cascade into two parallel branches, the first of which carries enstrophy to small scale by turbulent frontogenesis, while the second carries energy to small scale by internal wave-wave interaction. This dual cascade solves the problem posed by potential vorticity conservation which, as in the closely related theory of inviscid two-dimensional turbulence, requires energy to flow only to larger scale. The new diagram has implications for the parameterization of unresolved motions in models of oceanic circulation.

16. FLOW STRUCTURES OF THE BENTHIC OCEAN


Three-dimensional structure of the near bottom density field was observed with a towed yo-yo profiler and a fixed current/temperature measuring array on the Hatteras Abyssal Plain. A great variety of structures were seen. Immediately above the bottom a well-mixed bottom layer
extends vertically 5 to 60 m, with less than 1 m°C potential temperature change. This mixed layer is often capped by a region of strong vertical potential temperature gradient, with up to 100 m°C potential temperature change in ~10 m. Above the bottom layer, a vertically nearly homogeneous interior layer, up to ~100 m thick, is seen ~25% of the time. Horizontally, the boundary layer may be uniform for 10 km, or exhibit a bottom temperature gradient of up to 20 m°C per 10 km. Interior layers have horizontal scales from 2 to 100 km. When an interior layer is present, the bottom mixed layer is thinner. On two occasions an interior layer was seen to be continuous horizontally with the bottom mixed layer, suggesting formation of interior layers by entrainment of the bottom mixed layer. A benthic front was observed. Differential horizontal advection is required to explain the observed structures. Velocity fluctuations above 1 cm/s increase in energy near the bottom, presumably a signature of turbulence in the mixed layer, and these fluctuations are modulated by the passage of structures observed in the moored record.

17. OCEANIC OBSERVATIONS OF INTERNAL WAVE BREAKDOWN BY RICHARDSON NUMBER — 1/4 INSTABILITIES

Melbourne G. Briscoe — Woods Hole Oceanographic Institution, Woods Hole, MA 02543, U.S.A.

A vertical array of moored current and temperature sensors in the upper ocean in JASIN 1978 was used to estimate the joint fluctuation of N-squared and shear-squared over vertical separations of a few meters. The N-squared fluctuations are largest when shear is small, which is consistent with the fluctuations being driven by internal wave train that is dominated by high-frequency, high-wavenumber internal waves that are removed by shear destruction and critical-layer absorption when the shear increases. Estimates are given of how often the joint fluctuations yield R₁/4 and of the effects this causes; in particular, the likelihood that this is a significant sink for internal wave energy is assessed.

18. EQUILIBRIUM AND SATURATION IN THE SPECTRUM BANDS OF INTERNAL GRAVITY WAVES

Isidro Orlanski — Geophysical Fluid Dynamics Laboratory/NASA, Princeton University, Princeton, New Jersey 08540, U.S.A.

A detailed study of energy transfer among two-dimensional internal gravity modes in a fully non-parallel model was conducted. A finite difference numerical model was used to create a random, finite amplitude internal wave field, and two sets of experiments were performed. In the first set, energy was introduced to one or two discrete modes of low, medium and high wavenumbers in the second set. The results show that when the basic state energy level is low and non-linear time scales are much greater than intrinsic wave periods, multiple interchange interactions account for the distribution of any input energy. As the energy level increases, the high wavenumbers become saturated and localized overturning provides the dissipation mechanism. Additional energy input to low and medium wavenumbers will eventually result in an equilibrium state, whereby any extra energy input will result in very rapid, localized overturning. This equilibrium level depends on the presence of saturated high wavenumbers and, once achieved, the system is very inefficient at transferring energy via wave-wave interactions but is very efficient at dissipating energy via localized overturning.

19. THE EROSION OF A THERMOCLINE BY BREAKING INTERNAL WAVES IN A FIELD OF INERTIAL WAVES

W. Kraus — Institute for Marine Research, Kiel, Germany.

The erosion of thermocline in the Baltic Sea during a heavy storm has been observed during September, 1977. The mixing process, which redistributed the heat, within the upper 60 m was due to breaking small-scale inertial waves.

In the stratified water mass the storm created a system of very strong inertial waves of first mode, approximately. Within the surface layer and the layer of maximum shear of these inertial waves the Richardson number reduced to values of less than 1/4 and small-scale internal waves broke.

A spectral model which allows to resolve the detailed structure of inertial waves due to wind and bottom topography was used to simulate the process. It turns out that is stratified water of 100 m depth the bottom topography influences the vertical shear of inertial waves dominantly. The erosion of the thermocline happened within 1/2 inertial period.

20. AN UNSTABLE FREE SHEAR LAYER IN KNIGHT INLET, BRITISH COLUMBIA

D. M. Farmer — Institute of Ocean Sciences, Patricio Bay, P. O. Box 6000, Sidney, B.C., Canada.

Under suitable conditions of stratification and tidal amplitude, advection over a sill in Knight Inlet can result in separation of the flow at the sill crest, leading to the development of a free shear layer. The flow is unstable, and provides an opportunity for studying a mixing layer that has a Rayleigh's Number of about 4 x 10^7 based on the wavelength of the instability. Observations with a profiling CTD and current meter, high frequency acoustic soundings, and data from a profiling ADCP and current meter, high frequency acoustic soundings, and data from a profiling ADCP and current meter, provided further information on the structure of the layer. Time series measurements at a fixed location close to the separation point, just before the flow became unstable, disclosed a strongly sheared zone embedded within a thicker, uniformly stratified layer. As the background flow slowly changed a sequence of unstable structures passed the observation point in various stages of development. Initially a series of thin, inclined braids were seen to emanate from undulations of the shear layer, subsequent instabilities that had reached a later stage of growth, showed the braids rolling up to form the cores of evolving vortices. A separate set of acoustic observations was made along the axis of the mixing layer. The images obtained in this way showed that the vortices spread at a rate of about 0.06 as they travelled downstream, achieving a diameter of 50 m before interacting with the strongly stratified surface water and collapsing. There was no evidence of vortex pairing and initially the structures remained well defined and separate throughout the mixing layer. However a prominent feature was the formation of secondary instabilities on the braids.

21. INTERNAL WAVE ANISOTROPIES AROUND BERMUDA


Velocity profiles reveal that the internal wave field undergoes changes from open-ocean characteristics of stable wave number spectral slope, vertical symmetry and horizontal isotropy at Bermuda is approached. The near-inlet velocity structures are of smaller amplitude and vertical scale resulting in very uniform values of shear variance, regardless of distance from the island. The low-frequency flow was estimated as the fit of a first-order polynomial to the velocity profiles between 200 and 2000 m. Deviations from the fit are considered to be internal waves. It is found that the major axes of the principal axes of shear variance point mostly toward the island. This anisotropy is indicative of several mechanisms, such as internal wave shoaling and boundary generation. Control to the determination of these mechanisms is determined the direction of wave energy propagation. The direction is determined from computation of rotary vertical spectra, showing upward energy flux, and temperature—velocity coherence, showing out from inside propagation. Evidence for upward and outward propagation is strong when a cyclonic Gulf Stream is colliding with Bermuda.

22. THE FORMATION AND EVOLUTION OF WELL-MIXED EDDY CORES

C. S. Nibson — Royal Australian Research Laboratory, Edgcliff 2024, N.S.W., Australia.

The East Australian Current generates about three anti-cycloic warm-core mesoscale eddies each year. Surface cooling during winter creates a deep mixed layer within each eddy which may extend to 400 m depth at the centre. During the following summer this eddy core is overlaid by a new surface layer so as to create a sub-surface lens-shaped core of mixed water. This sub-surface core, initially of the order of 2 x 10^3 m^2, then decays in volume with a time constant of about 22 weeks. During this decay, the temperature of the core does not alter measurably, indicating that the diffusive process acting on the core is one-way only.
23. DENSITY INSTABILITIES IN THE TROPICAL MAIN THERMOCLINE: PART I. INSTRUMENTATION

F. Ostapoff and S. Worthing — Sea-Air Interaction Laboratory, Atlantic Oceanographic and Meteorological Laboratories, 15 Rockenbacher Causeway, Miami, Florida 33149, U.S.A.

A dual microstructure probe, CTD instrument, which has variable sensor head separation of up to 3m and 50 Hz/100 Hz dual/single mode sampling rate has been utilized to investigate the evolution of cm to 10 cm scale thermohaline structures in the upper tropical Atlantic Ocean. The instrument package was deployed from a drifting ship in such a way that it was decoupled from the pitch and roll motion of the ship.

Because of the uniqueness of the high resolution instrumentation and our data quality requirements, considerable calibration checks were carried out during the field experiment. Also, an extensive test of laboratory tank tests as well as electronic circuitry response experiments were made. Results of the response requirements show that the instrument performs to within design specifications. The laboratory tank tests included making a number of profiles through two layer salt water baths of various configurations to assess the response and matching of the temperature and conductivity measurements, and to determine how these in situ measurements should be used to obtain reliable temperature, salinity, and density data. Using the results of these laboratory tests, appropriate formulas were developed based on the relative probe configuration on the sensor heads and the local drop rate. We further redesigned the sensor head configuration, which optimizes probe matching. The probe placement is similar to that on an NSBS Mark III CTD. Therefore, such a construction and sensor head redesign may be of interest to the oceanographic community, as well as to document our results.

24. DENSITY INSTABILITIES IN THE TROPICAL MAIN THERMOCLINE: PART II. DATA ANALYSIS AND INTERPRETATION

F. Ostapoff and S. Worthing — Sea-Air Interaction Laboratory, Atlantic Oceanographic and Meteorological Laboratories, 15 Rockenbacher Causeway, Miami, Florida 33149, U.S.A.

During November, 1977, a large number of high resolution temperature and conductivity profiles were made through the main thermocline east of the Bahamas using a specially designed high resolution conductivity-temperature-depth (CTD) instrument. The method of deployment from a drifting ship effectively isolated the instrument package from pitch and roll motions of the ship. The instrument package was configured for profiling with a stabilizing fin. The sensor heads were mounted with a 2m vertical separation in a manner so that they were both in an uncontaminated flow regime. Details of the instrument configuration and calibration are presented in Part I (Poster Session).

The mean thermohaline structure of the upper 125m of the water column (limits of our observations) consisted of a region of relatively weak stratification to about 50m over which the effects of the diurnal cycle dominated. The transition region for the next 10m below this layer was characterized by very strong stratification, with temperature rapidly decreasing and salinity rapidly increasing. The main pycnocline region below had a typical low-latitude mean temperature gradient and a broad salinity maximum region.

The microstructure in the transition region and thermocline region was observed to contain a number of density instabilities. They are often associated with temperature steps although temperature measurements were also observed. These density instabilities had a vertical extent of about 20 cm and were spaced on the average about 200 cm apart. Although various possibilities have been considered, we interpret these instabilities in terms of Kelvin-Helmholtz shear instability. If this is indeed the case then vertical mixing or transport of properties through the thermocline region is accomplished at least in part by this process.

25. DOUBLE-DIFFUSIVE INSTABILITY IN AN INCLINED FLUID LAYER

R. C. Palival and C. F. Chen — Department of Mechanical, Industrial and Aerospace Engineering, Rutgers University, New Brunswick, New Jersey 08903, U.S.A.

Now at the Department of Earth and Space Sciences, UCLA

When a uniform horizontal density gradient is heated from below, the onset of instabilities is in the unstable mode (Veronis, 1965; Shubertiff, 1969). If heating is further increased, horizontal layers are generated successively from the bottom (Turner, 1968). Within each layer, the convection is driven by rising plumes randomly situated. In the case of a stable salinity gradient being heated from the side, the onset of instabilities is in the stationary mode (Thorpe et al., 1969; Hart, 1971). Within each layer, an organized circulation is driven by the horizontal density (Thorpe et al., 1969; Chen et al., 1970). In this paper, we examine the effect of simultaneous horizontal and vertical temperature gradients on the stability of a stable salinity gradient.

Experiments were conducted in a 10 cm x 11.1 cm x 2.7 cm slot with the inclination angle from -75° to +75°. Positive inclination angle denotes heating from the lower wall while negative angle denotes heating from the upper wall. The initial stratification due to salt was stable and linear in the vertical direction. The temperature difference across the slot was increased slowly until onset of instability was observed by means of shadowgraph. Consistent to intuition heating of the upper wall was less stable than heating of the lower wall. This is because of the larger vertical salt solute gradient in the steady state regime prior to the onset of instabilities when the lower wall is heated. The secondary flow consisting of horizontal convecting layers was very weak in the case of heating from below because of the stabilizing temperature effect. The motion of the layers when a > 0° was quite vigorous. At a = +75°, the secondary flow became unstable in a rather dramatic manner not observed heretofore.

The linear stability analysis was applied to the problem. Within the range of a considered, critical instability was found to be of the stationary type. Results of critical thermal Rayleigh numbers and wave numbers at all inclination angles are in good agreement with the experimental results.

References:

26. FRICTION AT A SHEARED FINGER INTERFACE

Barry Ruddick — Research School of Earth Sciences, The Australian National University, Canberra, A.C.T., Australia.

When a sheared finger or a salt finger is developed in an otherwise quiescent fluid, the finger finger interface is marked by an interfacial standing wave and observing its rate of decay. Compared to the frictional effect of a double Stokes boundary layer at a sharp density interface, the finger friction is large (i.e., several times the Stokes value) when the finger flux is large, decreasing to below the Stokes value when the interface is thick and run down.

27. STEVE: A DEVELOPMENTAL MICROSTRUCTURE PROFILER

T. G. L. Shubertiff — Physics Department, Victoria University, Private Bag, Wellington, New Zealand, and A. E. Gibson and A. G. Cole — New Zealand Oceanographic Institute, Box 12246, Wellington, New Zealand.

STEVE (Salinity Temperature Velocity Equipment) is a nearly neutrally buoyant device which slides down a hydrographic wire at approximately 20 cm/s to a maximum depth of 500 m. Conductance, temperature, pressure, three components of velocity and orientation data (three components of magnetic field and two projections of the vertical) are measured once per second and recorded internally on digital cassette tape. Relative water velocity is measured by Doppler-shift acoustic backscatter flowmeters.

The instrument will be described. It has been used to make a preliminary investigation of microstructure in a region south of Norfolk Island, particularly near the Mid-Tasman Front, and results from this region will be presented.

28. INTERNAL GRAVITY WAVES IN SHEAR FLOWS

S. A. Thorpe — Institute of Oceanographic Sciences, Wormley, Godalming, Surrey, U.K.

Laboratory experiments have been made to examine the effect of shear on internal gravity waves. In particular experiments (Thorpe, 1978a, b), the development of a long train of waves was studied at the mean shear flow accelerated uniformly from rest. Wave breaking and energy transfer between the fluctuations and the mean flow were observed. In these experiments the waves propagated at speeds in excess of that of the mean flow, and were thus non-singular.
In the new experiments waves are generated by uniformly accelerating stratified shear flow over a fixed rectangular bed. The upward propagating wave encounters a critical layer above their speed matches that of the mean flow. The experiments are compared with a linear model, and follow the development of the waves to finite amplitude and overturning, with the development of "broad-like" regions of intense density gradients. These "broad-like" regions are observed in the atmosphere, and it is suggested that similar phenomena occur in the ocean.

References:

29. THE PHYSICAL, CHEMICAL, AND BIOLOGICAL STRUCTURE OF COASTAL FRONTS
James J. Simpson - MLRG A-630, Scripps Institution of Oceanography, La Jolla, California, 92037, U.S.A.

Simultaneous measurements of temperature, salinity, dissolved oxygen, pH, alkalinity, nitrate, phosphate, silicate, and chlorophyll-a were made continuously, while underway, from RV New Horizon during the period 6-26 July 1979 as part of the California Coastal Fronts program. Water for the measurements was drawn from a depth of 3 meters. Intensive sampling with a cross-shelf range of 120 km was done near Pt. Conception and in a region of the northern California shelf bounded by Pt. Arena to the north and Pt. Reyes to the south. En route between these two sites, the variability associated with these signals in the along-shelf direction was measured. High variability, both in the cross-shelf and along-shelf directions, was found in all signals. For example, chlorophyll-a ranged from 10 to over 400 relative to fluorescence units, salinity range less than 0.1 to 28, 1/mole, and temperature range from 10°C to 18°C. Discrete surface sampling confirms the structure found in the continuous data. The results of discrete biological sampling, including surface net tow, particulate organic carbon analysis, chlorophyll-a extractions, and particle size distributions, are also consistent with the underway observations.

The combined set of measurements provides a unique synoptic picture of the physical, chemical, and biological characteristics associated with the transition region between warm- and cold-water boundaries. Both large- and mesoscale structure was observed, including offshore jets, upwelling fronts, coastal currents, and intrusions of warm Central Pacific water into the California Current. The influence of these structures on chemical and biological processes occurring in the mixed layer and on the spatial distribution of phytoplankton and zooplankton is evident in the data. The along-shore data also shows the influence of topography on upwelling.

31. STUDYING THE ATMOSPHERIC MIXED LAYER EVOLUTION USING A TRIPLE MONOSTATIC DOPPLER SONDER

This communication shows the different scientific results obtained in France using the triple acoustic Doppler sonder of the CNR/CRF. In a first part we discuss the method of measurement, in the case of wind profiles, turbulent dissipation rates, variance and skewness of vertical velocity. We also mention the limit and the number of redundant measurements using this instrument. In a second part, considering the different campaigns of measurement of CHICGNE (1975), VOVES (1977, 1978), we present results about:
1) Gravity waves and kinetic energy budget in oscillating inversion layers;
2) Description of turbulent structure of the inversion layers as observed by Doppler sonders.
3) How the measurements are used to infer similarity theory and variances of vertical velociy obtained by vertical Doppler shift. We show how this information can be utilized for tidal and for intermittent thermal darts. How heat flux measurement using vertical similarity theory and variances of vertical velocity obtained by vertical Doppler shift. We show how this information can be utilized for tidal and for intermittent thermal darts. How heat flux measurement using vertical similarity theory and variances of vertical velocity obtained by vertical Doppler shift. We show how this information can be utilized for tidal and for intermittent thermal darts.

4) Winter evolution of the planetary boundary layer. A discussion is undertaken about atmospheric boundary layer evolution during stable inversions, in a case of low level of solar radiation.

In the third part, as a conclusion, a synthesis of the different results obtained is presented.

33. CONCEPT, CONSTRUCTION AND PERFORMANCE OF AN EXPENDABLE VELOCITY PROFILER
Thomas R. Sanford and Robert G. Dreyer - Applied Physics Laboratory, University of Washington, 1013 N.E. 40th Street, Seattle, Washington 98105, U.S.A.

Weak, motionally induced electric currents in the sea are measured by an expendable probe. Ten measurements of salinity and temperature on a line between two points in the water column are taken and are interpreted in real time in terms of water velocity. The profile is completed in less than four minutes and yields velocity measurements at 1 m resolution with RMS uncertainties of about 1 cm/s.

PS-2 INTERMEDIATE SCALE MOTION AND STRUCTURES IN THE OCEAN
Convenor: J. D. Woods
Co-Convenor: M. G. Briscoe

SESSION 1: INTERNAL WAVES
Wednesday, December 5, P.M. (2)
Chairman: M. G. Briscoe

1. R. Pinkel and R. Kliz (invited paper)
2. E. G. Morozov (invited paper)
4. R. A. Weiler

SESSION 2: INTERNAL WAVES
Thursday, December 6, A.M. (2)
Chairman: M. G. Briscoe

5. J. M. Brubaker
6. R. E. Thomason and S. Huggett
7. R. Pinkel
8. T. B. Sanford
9. B. Ruddick
10. C. H. Macnas and P. Müller
11. M. G. Briscoe and C. J. R. Garrett

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SESSION 3: UPWELLING AND DOWNWELLING
Thursday, December 6, P.M. (1)
Chairman: J. J. O'Brien
12. N. Sugimoto
Coastal trapped waves in a stratified ocean with continental shelf-slope
A linear stratified model of the coastal upwelling
Mesoscale mixing at the frontal zone between North and South Atlantic Central Water and its impact on water masses in the Canary Current upwelling area
Piegeage d'ozone par une interface de pente constante dans un ocean à deux couches ou par la bande de courant geostrophique associe
A model of the seasonal variability of the thermocline in the Equatorial Pacific

13. J. P. McCreary
14. M. Tomczak
15. H. Lacombe
16. J. J. O'Brien, J. Kindle and T. Busalacchi

SESSION 4: UPWELLING AND DOWNWELLING (continued)
Thursday, December 6, P.M. (2)
Chairman: J. J. O'Brien
17. F. Jarrige and C. Colin
Equatorial upwelling review in Pacific and Atlantic oceans
Unsteady upwelling and coastal currents over a continental shelf
Buoyancy driven flows in the upper ocean
Topographic upwelling and related microstructure near the Shokoku-Sone

18. I. A. Johnson
19. A. E. Gill
20. Y. Nagata and M. Fukasawa

SESSION 5: OCEAN FRONTS
Friday, December 7, T.M. (1)
Chairman: G. Kullenberg
The influence of tidal stirring on the structure of the shelf
Shelf fronts
The interaction of internal waves with mesoscale fronts in the upper ocean

22. R. Piggot (invited paper)
23. D. Olbers (invited paper)

SESSION 6: OCEAN FRONTS (continued)
Friday, December 7, T.M. (2)
Chairman: G. Kullenberg
24. M. Gregg
Intrusions across isopycral surfaces
Homogeneous intrusion into a rotating stratified fluid
The vertical length scale of double-diffusivity driven interleaving at an oceanic front
Critical control through bathic ocean passages
A numerical study on effects of seasonal variations in wind and thermal conditions upon subtropical countercurrent

1. THE CHARACTER OF THE OPEN OCEAN INTERNAL WAVEFIELD
Robert P. Klein — University of California—San Diego, Marine Physical Laboratory of the Scripps Institution of Oceanography, San Diego, California 92112; and Rolf Klein — Institut für Meereskunde, Dierinnenbroeker Weg 20, DE239 Kiel 1, West Germany.

During the past four years, observations of the oceanic internal wavefield have continued at a more or less steady rate. While the size of individual experiments has not dramatically increased, the emphasis has shifted in several ways. Early in this decade, observational efforts were directed toward the identification of the internal wave spectrum. Attempts were made to observe water motions over much of the range of scales of internal waves in a single experiment. As a consequence, large arrays were constructed. Due to the short vertical coherence length of the oceanic internal wavefield (20 to 100 m), most of the measurements within these arrays were incoherent. More recently, observational arrays have been designed reflecting this short vertical coherence scale. Clusters of ~30-100 m vertical scale tend to be densely instrumented. Clusters at several depths are being used to observe the variability of the wavefield incoherently. The emphasis has shifted toward process-oriented experiments, aimed at looking in detail at interactions within the wavefield, and between specific wave bands and other environmental phenomena. The necessity of monitoring the winds, large scale currents, fronts, etc., in the region surrounding the internal wave observations has led to a tendency toward combining internal wave observation with other atmospheric and oceanic measurement efforts.

From extensive measurements of internal wave velocity and vertical displacement, a generally accepted picture of the spectral form has emerged. However, existing measurements of shear and slope, which are more sensitive to the high wavenumber portion of the spectrum, do not strongly support the general picture. Additional measurements would be useful to resolve this issue. Significant progress has been made in understanding the interaction of near inertial waves with atmosphere. Surface generation of high frequency internal wave motions has also been observed. The interactions of the smaller scale internal waves with surface swell, layer internal waves, and oceanic eddies are currently being investigated. Coupled with an additional awareness of the behavior of oceanographic sensors, these studies should result in increased understanding of the dynamics of the oceanic internal wavefield.

2. EXPERIMENTAL STUDY OF INTERNAL WAVES
E. C. Mestrous — Institute of Oceanology, 73, Krakowska Street, Moscow 17218, U.S.S.R.

The analysis of experimental data deals with internal waves of different scales: tidal, inertial and short-period. The mooring data in different parts of the world ocean including Pogonik-70 and POLYMODE areas are analyzed. The characteristics of internal tidal waves such as wave length, velocity and direction are calculated. The half-month variability of tidal internal waves amplitudes caused by appropriate variability of barotropic tide is discovered. It is shown that the interaction of internal waves with intensive currents in synoptic eddies causes the Doppler shift of internal wave frequency. The analysis of internal oscillations with inertial period's denotes that two types of inertial motions (two- and three-dimensional) can be specified. The spectrum of temperature oscillations near the inertia frequency is studied. It is found that it has the shape resembling W. Munk and N. Phillips model. The packet structure of short-period oscillations is studied. The generation of wave packet is associated with certain phase of large scale internal wave when necessary conditions of the latter breaking are formed.

Recent Soviet work will be reviewed.

3. INTERNAL WAVES IN THE UPPER OCEAN AT STATION P
R. A. de Szoeke — School of Oceanography, Oregon State University, Corvallis, Oregon 97331, U.S.A.; R. E. Davis — Scripps Institution of Oceanography, La Jolla, California, U.S.A.; D. Hallock — Pacific Marine Environmental Laboratory, NOAA, Seattle, Washington, U.S.A.; and P. F. Niller — School of Oceanography, Oregon State University, Corvallis, Oregon 97331, U.S.A.

Two recordings with up to 30 current meter-thermographs were maintained in the upper 175 m at Station P (50° 30' N, 149° 50' W) from 19 August to 7 September 1977, as part of a joint mixed layer experiment (MILE), and analyzed for internal wave motions. The layers shallower than 400 m exhibit buoyancy frequencies of 2 to 3 cph, except for very low values in a surface mixed layer and high values of up to 15 cph in a seasonal thermocline occupying 30 to 60 m depth, and up to
7 cph in a halocline occupying 90 to 150 m depth. Examining vertical coherence of inertial motions and tides we found: coherent inertial motions within the mixed layer (30–35 m depth); a low-amplitude counterclockwise (positive) component of barotropic tidal motion, very coherent in the vertical; higher-amplitude clockwise rotating internal tides with relatively low coherence over vertical separations of 50 m. This coherent internal tidal structure is also evident in isotherm displacement. Velocity and displacement spectra show -1.6 to -1.8 frequency power dependence above inertial and tidal bands (with occasional peaks at harmonics of inertial and tidal frequencies). The spectra of displacement and, when current noise levels permit discrimination, of velocity, are sharply cut off at 3 to 5 cph, independent of depth of measurement, even when local buoyancy frequency considerably exceeds this frequency. Just before this cut-off, between 2 and 3 cph, there is a peak of displacement energy. Cross-spectral analysis of velocity and displacement show a vertically coherent band of anisotropic motions between 1 and 3 cph. We can interpret some of these spectral features in terms of internal wave theory applied to the peculiar buoyancy frequency structure of the upper ocean.

4. GENERATION AND DECAY OF NEAR-INERTIAL INTERNAL WAVES OBSERVED DURING JASIN

Robert A. Weller
Woods Hole Oceanographic Institution, Woods Hole, MA 02543, U.S.A.

During the Joint Air Sea Interaction Experiment (JASIN) an array of three current meter moorings in place at a site (59°N, 125.5°W) between Scotland and Iceland for 38 days. One mooring included a surface riding float with meteorological instrumentation. The most dramatic wind event during the deployment was a storm from 17 to 20 August, 1978, when the maximum wind speed was 5.2 m s⁻¹ and peaked at 10 m s⁻¹. Large oscillations in frequencies slightly higher than inertial were observed in the mixed layer shortly after the storm and some time later. The amplitude of the near-inertial internal wave below the mixed layer, at depths of up to 300 m, was observed. On 29 August the amplitude of the near-inertial motion in the mixed layer decreased sharply, approximately one day later the amplitude of the near-inertial motion just below the mixed layer showed a sharp decrease, followed by 30 m (the decay rate of obvious. The observed temporal and vertical variability of the near-inertial motion is examined in the context of downward propagating near-inertial internal waves observed by Ekman suction.

5. OBSERVED SCALES OF TEMPERATURE VARIABILITY IN A FRESHWATER SEASONAL THERMOCLINE

John M. Brooks — School of Oceanography, Oregon State University, Corvallis, Oregon 97331, U.S.A.

Thermal structure in the seasonal thermocline at Lake Tahoe was investigated through the analysis of temperature profiles taken in the upper 70 m during late summer stratification. Different ranges of horizontal and temporal scales were sampled at each of the series of profiles. (1) The sequence begins at a midlake station, (2) a 24-hour, 12 km transect across the lake, and (3) a 24-hour sequence of intensive sampling at a 200 m transect line at midlake. The ensemble mean profile was very smooth for each set, but the ensemble temperature variability, similar for (1) and (2), was smaller at all depths and distributed differently in the vertical for (3). As a working hypothesis, it is assumed that a substantial amount of the observed temperature variability is due to internal wave displacements. Within this framework, the observation of set (3) is found to be consistent with generation by a field of small-scale internal waves obeying WKB internal wave scaling. In contrast, the observed time scales (3) of, or the larger area of (2), the dominant contribution to the variability appears to have come from a few low-order, vertical modes. Vertical wavenoise spectra of temperature fluctuations for all three sets were similar for frequencies greater than about 0.1 cph, falling as wavenumber to -5/2 power. When interpreted as spectra of vertical displacements, the level in the 0.1 to 1 cph decade was fairly constant even though the local buoyancy frequency for individual records varied from 3 to 13 cph, this temperature power spectrum somewhat lower by a factor of 0.5. Various ocean results. WKB internal wave scaling did not improve the spectral collapse effect for the "displacement scaling" of temperature spectra. Horizontal-temporal coherence fell to 0.5, for vertical wavelengths of 13 m, at a separation of 70 m and 12 minutes. For 6.5 m wavelengths the separation was 44 m and 7 minutes.

6. M² BAROCLINIC TIDES IN A DEEP AND NARROW CHANNEL

Richard E. Thomson and S. Haggard — Department of Fisheries and Oceans, Institute of Ocean Sciences, Patricia Bay, P. O. Box 6060, Sidney, British Columbia, Canada.

Current meter and time-series STD measurements in Johnstone Strait, British Columbia, reveal the presence of a highly damped, seaward propagating internal tide of predominantly semidiurnal period. Generation of the baroclinic motions appears to originate through interaction of the progressive surface tide with a shallow (70 m) partially still at the landward end of the main basin of the channel. The first mode internal Kelvin wave has a wavelength of 20 km and, at a distance of 7.5 km from the generation region, has a magnitude of 50% of the 35 cph barotropic wave. Within one wave period the amplitude has decreased by 1/2. Estimates of the tidal power within the system indicate that less than 1% of the power lost from the barotropic tide is transferred to the baroclinic mode, and that most frictionally dissipated. The possibility of vertical-layer absorption in the presence of the mean estuarine-type flow is discussed.

7. DOPPLER SONAR MEASUREMENTS OF INTERNAL WAVES FROM FLIP

K. Pinkel — Scripps Institution of Oceanography, University of California—San Diego, La Jolla, California 92032, U.S.A.

It is possible to sense the upper ocean velocity field remotely, using Doppler sonar. In this approach, high frequency sound is transmitted in narrow beam. The sound scatters off particles (and seers) in the beam. From the Doppler shift of the backscattered return echo, the component of scatterer velocity parallel to the sonar beam can be inferred at many ranges. At the Marine Physical Laboratory, a scattering sonar has been constructed specifically for internal wave research. This sonar transmits at a 17 MHz frequency at frequencies between 65 and 90 kHz, at a beam width of 1.8°. The sonar is equipped with a 22 kW E.W. Velocity measurements are made at ranges to 10 km in excess of 1.6 km, depths to 1.2 km, with a range resolution of 25 m. Velocity precision is of the order 1 cm/sec, after 80 seconds of averaging, out to ranges of 800 m. Precision decreases beyond that range due to decreasing signal strength with range. Examples of radar images showing typical results will be presented. The form of the various power spectral estimates which can be derived from sonar information depends strongly on the angle of depression of the sonar beam. Frequency spectra, wave number spectra, and combined wave number-frequency spectrum distributions will be discussed. The wave number-frequency resolution of these measurements will be quantified.

8. HORIZONTAL SECTIONS OF VELOCITY PROFILES

Thomas B. Sanford - Applied Physics Laboratory and Department of Oceanography, University of Washington, 1013 E. 40th Street, Seattle, Washington 98105, U.S.A.

Results are presented of velocity profile observations from an expendable velocity profiler. The emphasis of past velocity profiling has been on the collection of time series at one location or isolated profiles at various sites. With an expendable profiler it is possible to obtain sections of velocity structure from a ship underway. Profiles over the Cayn Seamount in the NW Atlantic reveal strong (20 cm/s peak to peak) inertial currents of short vertical (100 m) wavelength and short horizontal amplitude scale (10 km). A series of about ten profiles was obtained along a 50 km E-W section followed by another ten profiles on a N-S line across the peak. These data show a strong anticyclonic eddy over the seamount and strong spatial dependence to the inertial currents. The former has vertical shears of 60 cm/s/km, and rater has a horizontal scale of less than 10 km. The effects of the inertial are not strong, however, there is significant variability. A second series of velocity sections indicated that velocity structure (inertial currents) were advected by the low-frequency motion. Multiple current meter data will be used to distinguish between these mechanisms. Finally, this section shows velocity structures having very little spatial correlation because there was little inertial period motion.
9. CRITICAL LAYERS AND THE GARRETT-MUNK SPECTRUM
Barry Ruddick - Research School of Earth Sciences, The Australian National University, Canberra 2600 A.C.T., Australia.

The effects of critical level absorption of oceanic internal waves by a mean flow are estimated using the Garrett and Munk (1975) model spectrum. The horizontal currents of the wave field are found to be more intense perpendicular to the mean flow than parallel to it. The cause of this anisotropy is preferential absorption of waves travelling with the mean flow. However, the predicted current anisotropy is only half as large as would be necessary to explain Frankignoul's (1974) observations. Deposition of wave momentum at critical levels throughout the 400 m thick shear zone of the main thermocline is roughly equivalent to a wave-induced negative vertical eddy viscosity of \(-100 \text{ cm}^2\text{ s}^{-1}\). The effect of the absorbed momentum on the mean flow is to cause a slow (2.5 m/day) downward phase propagation, and slow broadening of the shear profile.

10. DYNAMICS AND ENERGY BALANCE OF INTERNAL WAVES IN THE OCEAN

Internal waves are a likely cause for the mixing of mass and momentum in the ocean interior and an understanding of the mean current, temperature and salinity fields might hence require a full understanding of the dynamics of the internal wave field. In this review we describe recent theoretical results concerning the dynamics and energy balance of internal waves in the ocean interior. The role of weak nonlinear interactions in shaping the spectrum has been considerably clarified. A spectral model of the dissipation by wave breaking has been suggested. There are, however, many areas where improvements must be sought. The main sources of internal wave energy have not yet been identified. The interactions among waves of high vertical wavenumber are strongly affected by the Weak Interaction Limit. Also, the role of waves, fine and microstructure in dissipating energy needs to be clarified. Nevertheless, a tentative energy balance is proposed. Inertial oscillations pass energy from a variety of sources directly to small-scale motions. The internal wave continuum is inert and noncascading, but controls the energy flow through the inertial oscillations.

11. IS PROGRESS IN A FORWARD DIRECTION?

The 1970's have seen considerable advances in the description and understanding of internal waves in the ocean, but the progress arising from this program may actually be standing in the way of a test of the inviscid problem of internal wave generation, dissipation and interaction with other phenomena. In particular, we discuss the questions:

1) Is our preoccupation with mean spectral quantities distorting us from the physics of processes (like dissipation) that are related to instantaneous properties?

2) Are wave-wave interactions so strong that we should return to dimensional arguments of the sort used in turbulence, or even to the primitive equations, rather than working further with the radiation balance equation and simplified interaction terms?

3) Is our concern about the whole frequency spectrum justified in view of the dominance of the inertial component? Do inertial tides only modulate the picture?

4) Is it time to abandon the woofy idea of "saturation" that has arisen from the observed universality of deep ocean internal waves, and relate the universality instead to the long time constant implied by direct measurements of dissipation?

5) Is the upper ocean strongly coupled to the deep ocean buoyancy profile? Does this show up as different upper ocean states in different oceans?

Starting from these and other considerations, we suggest a number of experimental, analytical and numerical approaches that deserve attention.

12. COASTAL TRAPPED WAVES IN A STRATIFIED OCEAN WITH CONTINENTAL SHELF-SLOPE
Nobuo Sugimoto - Geophysical Institute, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan.

For low-frequency coastal trapped waves, the internal Kelvin waves and the baroclinic shelf waves are defined in basically different models, i.e., internal Kelvin waves in a stratified ocean with a flat bottom and barotropic shelf waves in a homogeneous ocean with a continental shelf-slope. In a stratified ocean with a shelf-slope, these waves are coupled. Modification of mode waves from the internal Kelvin waves, and shelf waves becomes larger as the ratio \( L_i / L_g \) approaches unity, where \( L_i \) is the characteristic width of the shelf (off-shore scale of the first mode shelf waves) and \( L_g \) is the internal deformation radius. When \( L_i / L_g \cong 1 \), the two waves are the Internal Kelvin and shelf waves, although the characteristics of the shelf waves are those of the internal trapped waves for \( L_g / L_i < 1 \) (shelf along-shore scale). At \( L_i / L_g = 1 \), the phase speeds of the internal Kelvin and shelf waves are identical and the characteristics of those waves are interchanged.

The mode waves described above may respond to a local forcing. Forced waves may show combined characteristics of the internal Kelvin and shelf waves, and the relative phase speed \( L_i / L_g \cong 1 \). But, for waves propagating poleward from equatorial regions, waves observed at middle latitudes need not satisfy the local dispersion relations. For example, an internal Kelvin wave observed even at the latitudes where \( L_i / L_g = 1 \) may retain its original characteristics which satisfy the local dispersion relation at latitude where it is generated, although the trapped width becomes narrower in accordance with changes in the value of \( L_g \).

13. A LINEAR STRATIFIED MODEL OF THE COASTAL UNDERCURRENT
J. P. McCreary Jr. - Nova University Ocean Science Center, 8000 N. Ocean Drive, Dania, Florida, U.S.A.

A linear continuously stratified model is used to study the steady-wind driven response of the ocean along the coast. The model can be regarded as an extension of the Lightbush (1969) model which allows the diffusion of heat and momentum into the deep ocean. In order to retain the ability to expand solutions into sums of vertical normal modes, mixing coefficients must be inversely proportional to the square of the background Väisälä frequency.

The eastern boundary of the ocean is assumed to consist of a vertical wall (that is, there is no continental shelf), which is oriented in a north-south direction. A zonally uniform band of northward flow (that is, there is no wind curl), confined between 20°N and 60°N, forces the ocean. The resulting flow field has many features in common with observational data. Strong alongshore flow is confined within 10-20 km of the coast. There is a surface equatorward jet, but also a poleward Coastal Undercurrent beneath the surface mixed layer in the main thermocline. At greater depths there is again equatorward flow, but considerably weaker than the near-surface flows. Coastal upwelling does not extend to great depths but occurs only in the upper 100-200 meters of the ocean column, in fact, at and below the core of the Undercurrent there is (weak) downwelling. There is an offshore Ekman drift in the surface mixed layer and a compensatory return flow at a depth near that of the core of the Undercurrent.

The coastal flow field described above is quite analogous to that observed at the equator, suggesting that the two regions may share a common dynamics. It is noteworthy that virtually the same model produces a realistic equatorial current structure as well (McCreary, 1979).

14. MESOSCALE MIXING AT THE FRONTAL ZONE BETWEEN NORTH AND SOUTH ATLANTIC CENTRAL WATER AND ITS IMPACT ON WATER MASSES IN THE CANARY CURRENT UPWELLING AREA
Matthias Tomczak, Jr. - CSIRO Division of Fisheries and Oceanography, P. O. Box 21, Cronulla, N.W. 2230, Australia.

In the eastern central Atlantic Ocean, North Atlantic Central Water (NACW) and South Atlantic Central Water (SACW) meet at about 21-33° N forming a well-developed inclined front which extends from below the surface mixed layer to approximately 600 m. The temperature jump is compensated by a corresponding salinity jump, and density surfaces are not affected. A study of the water mass distribution based on the assumption that mixing across density surfaces is negligible reveals the presence of several small bodies of water-NACW, SACW or mixtures of both-in the frontal zone. By linking these observations to simultaneous current measurements.
15. PIEGEAGE D'ONDES PAR UNE INTERFACE DE PENTE CONSTANTE DANS UN OCEAN A DEUX COUCHES OU PAR LA BANDE DE COURANT GEOSTROPHIQUE ASSOCIEE

H. Lacombe — Laboratoire d'Oceanographie Physique du Muséum, 43, rue Cuvier-75231 Paris Cedex 05, France.

Des ondes de frontière ("edge waves") peuvent être piégées par un fond côtier de pente constante; l'interface inclinée d'un océan à deux couches de profondeur très grande constante, peut faire de même, tout comme le courant géostrophique associé. L'équation hypergémétrique conique (nu² + (1-μ²)c²u²) u = 0 qui gouverne la petite perturbation du courant géostrophique de base est analogue à celle des ondes de frontière citées. Mais les conditions de rayonnement des niveaux et des vitesses transverses, de chaque côté de la bande de courant à deux ondes latérales de type Kelvin sont plus complexes. L'introduction de ces conditions permet en principe la détermination des ondes d'interaction et du paramètre à qui définit la relation de dispersion. Une solution analytique de ces conditions est inaccessible, mais l'étude de deux cas particuliers pour montrer que des ondes de première classe (+ f) et de deuxième classe (c < f) sont possibles. Les nouvelles se propagent dans l'océan sous la forme d'une onde étranglée verticalement et regardant vers la pente montante de l'interface.

L'une des difficultés rencontrées est l'absence de tables pour la "solution logarithmique" de l'équation (1).


J. H. O'Brien, J. Kindle, and T. Busalacchi — Florida State University, Tallahassee, Florida 32306, U.S.A.

A single-layer numerical model is used to examine the baroclinic response of the equatorial Pacific Ocean to time-variable winds. The model basin extends from 125°S to 125°N, with open boundary conditions being applied at the north and south boundaries. The model is utilized to examine the suggestion of Meinen (1979) that remote forcing is responsible for the large semi-annual signal of the vertical displacement of the thermocline in the eastern equatorial Pacific Ocean. Using the model's simulations of the long-term mean and seasonal easterly winds along the equator, the model reproduces the observations of the average seasonal vertical displacement of the pycnocline at the eastern boundary and the mean east-west tilt of the thermocline across the Pacific.

17. UNSTEADY UPWELLING AND COASTAL CURRENTS OVER A CONTINENTAL SHELF

John A. Johnson — School of Mathematics and Physics, University of East Anglia, Norwich NR4 7TT, England.

Coastal upwelling over a continental shelf driven by an unsteady wind stress is discussed in terms of analytical and numerical models. Associated with the upwelling is an unsteady longshore current which is often accompanied by a countercurrent. Account is taken of stratification and of variations in the topography including ridges and canyons. The model shows that countercurrents are produced after a change in direction of the wind stress with time and if the wind stress carries across the coast. Comparisons are made with observations of upwelling events off the North West African coast. The effects of eastward propagating Rossby waves and northward moving shelf waves may be detected in the numerical solutions.
The first, which will be called a sill region, has unidirectional flow from one benthic basin to the next. Features of well known critical flows from sill regions such as the Denmark Strait, Faeroe overflow region, Anagadu, Junken Passage, Strait of Sicily, and Samoan Passage will be given. Emphasis will be given to recent observations over the Cura Abyssal Plain (approximately 4000 m deep) where water of Antarctic origin must move northward over the abyssal plain at approximately 4400 meters depth if it is to enter the western North Atlantic. Currents and plumes near the critical region will be displayed, and an estimate, with error bars, of flux of this water into the North Atlantic basin will be given. Theoretical predictions of the pressure and vorticity field will be tested against the data. Evidence will be given that the flow in such sills contribute significantly to the water mass which exits the downstream basin, and that theory allows one to obtain a fairly accurate estimate of the volumetric flux in such sill regions.

The second general type of region in which critical flows occur will be called a strait region. It has a flow and counterflow, and occurs when two large bays are connected by a relatively small passage. The well known examples of the Strait of Gibraltar, other connecting passages to the Mediterranean, and the Red Sea will be reviewed. Generally one basin contains denser water than the other—dictated by the climate over the individual basins. The water that flows out of the dense water basin may be either some level, and forms an easily identified water mass. Evidence that critical control applies at the mouth of large gulf and bays such as Spencer Gulf, South Australia, and Chesapeake Bay in North America will be given. Finally, evidence that one can estimate volumetric fluxes in straits through critical control principles will be presented.

28. A NUMERICAL STUDY ON EFFECTS OF SEASONAL VARIATIONS IN WIND AND THERMAL CONDITIONS UPON SUBTROPICAL COUNTERCURRENT
Kensuke Takeuchi – Ocean Research Institute, The University of Tokyo, Tokano, Tokyo, 164, Japan.

Effects of seasonal variations in wind and thermal conditions upon ocean currents, especially upon Subtropical Countercurrent, are studied with three-dimensional multiple-level model of the North Pacific. The modeled ocean is uniform in depth (5200 m) and is rectangular in shape. At first, a steady state of the model is calculated under the annual mean wind and thermal conditions. The distributions of wind and thermal conditions used are ideally simplified. Then, the calculated circulation model is subjected to seasonal variations in either or both of wind and thermal conditions on assuming the variations to be sinusoidal. The result indicates that the seasonal variations in wind and thermal conditions are not only important to produce seasonal variations of ocean circulation but also to give much effect on the annual mean structure of Subtropical Countercurrent.

SESSION 2: EQUATORIAL PACIFIC OCEAN
Friday, December 7, 7 P.M. (2)
Chairman: Bruce Taft

4. K. Wyrki
5. J. R. Donguy and C. Henin
6. G. Philander

SESSION 3: NUMERICAL MODELLING AND INVERSE TECHNIQUES
Saturday, December 8, A.M. (2)
Chairman: Armen Sarkissian

8. H. J. Federich, V. L. Klimov, V. P. Kochergin and V. A. Suchurukov
9. R. L. Haney
10. A. J. Willmott and L. A. Myers
11. L. Mageed
12. K. Hertzer
13. D. Roemmrich
14. P. Müller and G. Franck
15. D. B. Haidvogel and I. M. Held

SESSION 4: NORTH PACIFIC OCEAN
Saturday, December 8, P.M. (1)
Chairman: Robert L. Haney

17. E. R. Levine and W. B. White
18. R. A. Fine, C. G. Roeth and H. G. Ostlund
19. K. E. Kenyon

SESSION 5: INDIAN AND SOUTHERN OCEANS
Saturday, December 8, P.M. (2)
Chairman: G. Philander

20. J. R. Layton
21. J. G. Bruce, Jr.
23. R. A. Knox
24. M. Fleux, J. Gonella and F. Maldeam

SESSION 6: POLYMODE
Monday, December 10, A.M. (2)
Chairman: Henry Chanock
25. A. R. Robinson
26. A. S. Sarkisyan
27. W. R. Holland

POLYMODE and advances in ocean current dynamics
Theoretical and experimental investigations of synoptic-scale ocean currents
Results from wind-driven, eddy-resolving gyre-scale numerical models of oceanic circulation
Eddies and the mean circulation of the western North Atlantic

SESSION 7: POLYMODE
Monday, December 10, P.M. (1)
Chairman: John Gould
29. B. A. Nelepo, N. P. Bulgakov and G. K. Korotan
30. V. K. Kosnyny and Yu. M. Koltzkov
31. R. Robinson and D. B. Haidvogel
32. A. F. Bennett

The structure of synoptic variability of the ocean from hydrological survey data
Mixed layer in the problem of synoptic variability in the ocean
Forecast error in an open ocean model
Matching initial and boundary data for open ocean models

SESSION 8: POLYMODE AND THE NORTH ATLANTIC OCEAN
Monday, December 10, P.M. (2)
Chairman: Boris Nalego
33. B. A. Taft, C. C. Ebbesmeyer, J. C. McWilliams and C. Y. Shen
35. W. B. Owens
36. W. J. Gould, R. Dickson, T. J. Muller and C. Maillard
37. N. Broz
38. R. A. Clarke and J. C. Gascard

Fluctuations over a two-month period of dynamic height and salt fields southwest of Bermuda
Structure and dynamics of a small-scale eddy observed during POLYMODE local dynamics experiment
Observations of oceanic vorticity balances
Measurements of mesoscale variability in the northeast Atlantic
Annual variations in the salt anomaly field in the eastern North Atlantic: Observations and a simple dynamical model
Deep convection and the formation of the Labrador sea water

SESSION 9: WESTERN BOUNDARY CURRENTS
Tuesday, December 11, A.M. (1)
Chairman: Allan R. Robinson
39. H. E. Hultburt
40. J. D. Thompson
41. C. S. Nilsson and G. R. Crosswell
42. H. L. Bryden and M. M. Hall
43. Dean Roemmich

The influence of internal dynamics on eddy shedding by the loop current in the Gulf of Mexico
Sensitivity and response of the Gulf of Mexico loop current to external forcing
The evolution of East Australian Eddies
Heat transport by currents across 25° south latitude in the Atlantic Ocean
Heat transport by inverse methods

1. SCALES OF UPPER OCEAN VARIABILITY IN THE CENTRAL TROPICAL PACIFIC
W. C. Patzer, T. P. Barrett, and G. P. McNally — Scripps Institution of Oceanography, A-930, University of California, San Diego, La Jolla, California 92039, U.S.A.
D. Hansen — AMOL, NOAA, 31 Rickenbacker Causeway, Miami, Florida 33149, U.S.A.
B. A. Taft — University of Washington, Department of Oceanography, Seattle, Washington 98105, U.S.A.
K. Wyrki — University of Hawaii, Department of Oceanography, Honolulu, Hawaii 96822, U.S.A.

In preparation for the 1979-80 Global Weather Experiment, North Pacific Experiment (NORPEX) scientists began during the winter of 1977-78 with a three-month pilot experiment to obtain preliminary information on spatial and temporal scales of upper ocean variability and to refine measurement techniques for use during the sixteen-month field experiment in 1979-80. From November 1977 to February 1978, measurements were made from ships, Hawaii/Tahiti along 150°W and 115°W, from ships, long-range aircraft, moored instrumentation, satellite-tracked drifting buoys and various mid-Pacific island stations.

Analysis of these data indicates that large-scale coherent variability exists in the region within 180° of the Equator. The time scale associated with this variation is of order two to three months. At 150°W, the large-scale variability generally extends coherently across the Equator, the boundaries between major Equator currents, and the intertropical convergence zone. Although there existed some dissimilarity between the two meridians, a large-scale coherence between the two sections exists near the bottom of the mixed layer. This variation was found within 5 to 10° of the Equator and was most intense in bands 2 to 6° north and south of the Equator.

Comparisons between velocity transport derived from T/S relations and actual current meter observations in the North Equatorial Countercurrent indicate that the variability of the upper ocean temperature field also applies to the velocity field. The east/west scales of features sampled by ships and aircraft in the north/south are derived from the trajectories of the satellite-tracked drifting buoys.

2. TROPICAL PACIFIC OCEANOGRAPHIC PROGRAM DURING FGGE
B. A. Taft — Department of Oceanography B-10, University of Washington, Seattle, Washington 98105, U.S.A.
J. Barberan — Departamento de Oceanografia, Instituto de Geofisica, U.N.A.M., Torre de Clavijos, 3er piso, Ciudad Universitaria, Mexico 20, D.F.
F. Jamieson — Centre ORSTOM, B.P. 4, Nouméa, New Caledonia
M. Miyata — Geophysical Institute, University of Tokyo, Tokyo, Japan
W. Crawford — P.O. Box 5000, Sidney, B.C., Canada
D. Rochford — CSIRO Div. Fisheries & Oceanography, Box 21, Cronulla, N.S.W., Sydney 2223, Australia
S. Zuta — Instituto del Mar, Esq. Gamboa y Gral, Valle, Callao, Peru
Planning for a joint tropical oceanographic experiment in the Pacific during FGGE (1979) was carried out by a panel of SCOR Working Group 47. Most of the effort was concentrated in the two Special Observing Periods (SOP-1, SOP-2), but some programs covered all of 1979 and will be continued beyond FGGE. There were three programs in the western Pacific, the circulation in the vicinity of the Costa Rica Dome (SOP-1 and SOP-2, Mexico); quarterly hydrographic surveys of the Costa Rica Dome (SOP-1, SOP-2, Peru, Ecuador, Chile); and a study of the equatorial current system by the research vessel KERMAID (SOP-1). These programs were conducted in the eastern Pacific over five areas: air/sea surface temperature sections, equatorial current meter moorings, and satellite tracked surface drifters. The following programs were carried out in the western Pacific: time series of velocity and pressure were obtained at the Equator in the Gulf of Guinea in 1979 (USA); meridional sections of water properties and current velocity between 29°00' and 32°00'N were made (SOP-1 and SOP-2); and a subsurface current meter mooring deployed on the Equator at 16°6′E (U.K.). Hydrographic sections along 170°W and 160°W (SOP-1, SOP-2, Australia); and CTD and XBT sections along 140°0E and 150°0E and moored current meter measurements at 25°0 (14°0E SOP-2, Japan). Preliminary results of the measurements are discussed.

3. PRELIMINARY RESULTS FROM THE FGGE ATLANTIC TROPICAL EXPERIMENT

By the participants (paper to be delivered by El Katz).

Intensive oceanographic observations were made in the equatorial Atlantic during the first half of 1979 for the most part as a result of the FGGE experiment. Current meter and thermistor chain moorings were set in the Gulf of Guinea and the equatorial Somali Basin.

The surface buoy and anemometer set was deployed in the western Atlantic. Surface buoys with anemometers and other meteorological sensors were set across the Atlantic. Long meridional hydrographic sections, shorter cross-equator sections and zonal sections along the Equator were repeated over a wide range of longitudes across the Atlantic. Several other expeditions focused on the summer Atlantic are distinctive. The oceanographic observations planned for FGGE will provide us with the best opportunity to study the transition between the two phases. Within the limits of the preliminary data we hope to identify the sequence of events which occur as the upper ocean responds to seasonally variable atmospheric forcing.

4. EL NINO AND THE PROBLEM OF OCEAN MONITORING AND PREDICTION

Klaus Wyrtki — University of Hawaii, Honolulu, Hawaii, U.S.A.

The interaction between ocean and atmosphere causes large oscillations in the ocean-atmosphere system. One of the most pronounced events of this nature in the Pacific Ocean is El Nino. Based on a study of recent El Nino events in 1957–58, 1965, 1972–73 and 1976, a new theory of its occurrence has been developed, which explains El Nino as the result of the equatorial Pacific Ocean to atmospheric forcing. During periods of prolonged strong southeast trade winds warm water is accumulated in the western Pacific raising sea level and depressuring the thermocline. As soon as the trade winds relax, the accumulated potential energy causes an internal wave, which triggers El Nino off South America.

The existence of this theory on El Nino allows us to forecast the event. A scheme will be outlined which makes use of sea level monitoring as a predictive tool and of satellite observed wind fields to determine the triggering of the event.

The most energetic variations of sea level are longer than one year and are related to El Nino events. They constitute a massive exchange of water between the western and the eastern equatorial Pacific, an adjustment of all major processes on the west as well as on the east. One thousand km and 10 years, sea level and temperature changes are observed.

To study these low frequency adjustments of the circulation, NORPAX obtains hydrographic sections between Hawaii and Tahiti for 16 consecutive months during 1979 and 1980 to coincide with the NORPAX/EPIC experiment. To determine the amplitude and frequency of this adjustment, an experiment was conducted from November 1978 to February 1979, during which measurements from ships, aircraft, drifting and moored buoys and sea level gauges were compared.

Early results from these experiments show that the major fluctuations in the equatorial current system are due to the thermals, and that the thermal structure of the Pacific is not an adequate substitute for the ocean's response to changes of atmosphere. Sea level and temperature observations from ships of opportunity can be used to monitor these changes.

5. NORMAL AND ANOMALOUS HYDROCLIMATIC CONDITIONS IN THE SOUTHWESTERN TROPICAL PACIFIC


Two kinds of hydroclimatic conditions occur in the southwestern tropical Pacific:

- Normal ones characterized by the existence, west of 180°W, of an Equatorial upwelling induced by the East component Trade Winds. The Inter-tropical convergence zone of the winds moves generally as a single (or double) band of pressure between January and March under the influence of the wind field. Its presence brings the starting of the rainy season and the occurrence approximately three months later of a surface salinity minimum. West of 180°W, the maximum of heat content spreads from 10°S to 10°N, the tropical storms which originate there move to Fiji, New Caledonia and Australia.

- Anomalous conditions characterized by the absence of the equatorial upwelling west of 180°W. The inter-tropical convergence zone of the winds is located on the Equator and its absence at 10°S induces the lack of the rainy season. The surface salinity minimum is set on the Equator instead of the man in the north and south of 10°S. The cold water formed by the upwelling consists east shifts from the western Pacific to the central Pacific: the tropical storms which originate there move to Polynesia. These anomalous conditions occur usually six months after an El Niño phenomenon.

6. THE CROMWELL CURRENT REVISITED

George Philander — Geophysical Fluid Dynamics Laboratory/NOAA, Princeton, New Jersey 08540, U.S.A.

Over the twenty years following the discovery of the Equatorial Undercurrent in 1951, there were several expeditions to the Equator to define the structure of this current along meridians, and there were numerous theoretical studies that attempted to explain the current as a response of the ocean to the trade winds. These steady-state models simulated and explained features of the Undercurrent but for a stringent comparison between theory and measurement it is necessary to understand the variability of the current first. Because of large-scale experiments over the past decade we now know that the variability occurs over a spectrum of timescales ranging from 1953 to 1963. The Undercurrents: observations and simulations of the flow from the surface to the thermocline at periods of one month and two weeks. On seasonal and interannual timescales the variability of the density field is known in outline but the associated changes in the currents are unknown. The Undercurrent has been implicated in the occurrence of El Niño/La Niña events which have concerned the generation and decay of the Undercurrent, and are of direct relevance to the Indian Ocean where the winds intensify and relax suddenly. They are in indirect relevance to the Pacific and Atlantic Oceans, and suggest how phenomena such as El Niño can occur.

7. VARIABILITY OF THE UPPER OCEAN IN THE EQUATORIAL PACIFIC

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Donald V. Hansen — NOAA/AGML, 15 Rickenbacker Cutoff, Miami, Florida 33149, U.S.A.

George Philander — NOAA/GFDL, Princeton University, Princeton, New Jersey 08540, U.S.A.

Large-scale, long-period sea surface temperature variations found within 3° of the equator in the eastern and western Pacific are generated by lateral heat advection by ocean currents, air-sea exchange, and equatorial waves. A principal goal of the Equatorial Pacific Ocean Climate Studies (EPOCS) program is the determination of the processes relating seasonal and interannual variations of the zonal slope of the thermocline and redistribution of heat along the equator with changes in the wind-stress. A principal objective of the 1979–1981 Phase of EPOCS, which started in January 1979, was with the planning of FGGE SOP-1, to make observations on the time changes of the wind, current and temperature fields of the upper 200 m in the eastern Pacific. The large-scale, low-frequency fluctuations and large-scale variations in the equatorial region are an important part of the tropical climate system and the response of the ocean to the forcing by the wind.
the South Equatorial Current at ~3°S, 85°W moved with daily speeds of about 0.2 m/s
towards west-northwest with reversals in direction occurring at monthly intervals, the drifters
deployed at ~7°S, 85°W moved towards the southwest at about 0.07 m/s. Vertical profiles
of temperature, salinity and current along 110°W were measured and will also be discussed.

8. NUMERICAL RESULTS FROM A SEASONAL MODEL OF THE WORLD OCEAN
CIRCULATION WITH A TURBULENT UPPER LAYER
Hans J. Freeden, Institut fuer Meereskunde, Universitaet Hamburg, 2 Hamburg 13, Hein-
Hugowissenschaftsstr. 71, F.R.G.; and V. I. Klimok, V. P. Kochergin, and V. A. Sucharnov –
Computing Center Siberian Branch of the Academy of Sciences of the USSR, 630090, 
Novosibirsk-50, Prospekt Nauki, 6, U.S.S.R.

The ocean general circulation model developed at the Computing Center of the Siberian
Branch of the USSR Academy of Sciences has been used to compute the large-scale circulation of
the world ocean at twenty levels in the vertical between 0 and 2000 meters with a horizontal
resolution of five degrees.

Essential to the model is the parameterization of turbulent vertical mixing according to
Obukhov's formula for stationary turbulence in the upper ocean.

The linearized momentum equations and an equation for the diffusion of density anomalies are
solved from prescribed climatological data at the boundaries.

The effect of bottom topography and seasonal variability of boundary values are taken
into account.

Numerical results will be discussed and compared with observations.

9. A NUMERICAL STUDY OF THE DEVELOPMENT OF LARGE-SCALE THERMAL
ANOMALIES IN THE CENTRAL NORTH PACIFIC
Robert H. Haney – Naval Postgraduate School, Monterey, California 93940, U.S.A.

A ten-level primitive equation ocean circulation model is used to investigate the formation
and evolution of large-scale thermal anomalies in the Central North Pacific Ocean during the fall
and winter of 1976–77. A simplified parameterization of the effects of turbulent vertical mixing
produced by wind stirring and surface cooling is included in the model. The numerical experiments
consisted of prescribed change experiments in which monthly mean ocean temperature anomalies,
observed down to 400 m by the North Pacific Experiment (NOPAX), are used to define the
prescribed changes (anomalies) in the initial conditions and observed monthly mean anomalies of
surface winds and surface heat fluxes are used for the prescribed changes (anomalies) in the
atmospheric forcing.

Oceanic processes are investigated by computing prescribed change experiments with observations.
With anomalous wind forcing, horizontal advection of mean temperature by anomalous
wind driven surface Ekman currents and anomalous turbulent vertical mixing contribute to the
development of a large-scale cold anomaly in the upper 100 m of the Central North Pacific Ocean
in qualitative agreement with the observed anomaly development. The effects of anomalous
convection are primarily confined to the upper 50 m while turbulent vertical mixing, which
is anomalously strong during the period, produces strong cooling down to 125 m and warming
below that. The effects of anomalous surface heat fluxes improve the simulation and are especially
important for the development of a shallow warm anomaly to the east of the large-scale cold anomaly.

In all the experiments the pattern correlation between simulated and observed temperature anomalies
is greatest near the surface (r ~ 0.88) and decreases with depth (r ~ 0.25 at 262 m).

In order to more accurately assess the relative importance of advective and turbulent mixing
processes in the generation of large-scale thermal anomalies, a fully developed, second order closure
mixed layer model (Garwood, J. Phys. Oceanogr., 1978) has recently been embedded into a 25 level
primitive equation model. The vertical mixing of horizontal momentum by wind and convectively
generated turbulence is also included. Results from preliminary experiments will be shown.

10. ATMOSPHERICALLY FORCED EDDIES IN THE N. E. PACIFIC
A. J. Willmott and L. A. Mysak – Department of Mathematics, 1984 Mathematics Road, 
and Department of Oceanography, 6270 University Boulevard, University of British Columbia,
Vancouver, B.C. V6T 1W5, Canada.

In the N. E. Pacific eddies are observed in the thermal anomalies. In particular, a pronounced
eddy is frequently observed off Sitka, latitude 57°N. This paper investigates a possible mechanism
for the production of such eddies. The N. E. Pacific is approximated by a quarter-plane and a
continuously stratified, linear model is used to study the reflection of a wind wave from the
coast near the absence of topography. In the model the anomalies take the form of planetary
waves and by choosing forcing which is sinusoidal in time the problem reduces to solving the Helm-
holts equation. The solution, obtained via Green's function approach, produces eddies in the
density anomalies as a result of the complicated reflections undergone by the planetary waves in the
coast. The effects of the flow produced by lifting the quarter-plane from the north-south direction
are discussed.

11. ROSSBY WAVES IN THE NORTH PACIFIC
Loczeit Magnus – Department of Oceanography, University of Hawaii, Honolulu, Hawaii
96822, U.S.A.

Internal temperature data (XBT and hydrographic data, time series of monthly mean values up
to 20 years) from various parts of the North Pacific have been analyzed with respect to baro-
clinic Rossby waves by means of model fitting (cross spectral fit). The results show that for periods
from about 1 to 10 years the internal temperature fluctuations in the area 20-30N, 145-150W
are widely dominated by first order baroclinic Rossby waves traveling in NW directions with wave
lengths of about 1000 to 2000 km. However, north of 30N baroclinic Rossby waves play a signifi-
cant role at the annual frequency only. The fitting of a Rossby wave model, considering the mean
shear flow of the North Pacific Current, to the TRANSPAC data collected under the NOPAX
project shows a consistent pattern of annual first order baroclinic Rossby waves traveling NW in the
area 30-40N, 170-150W. However, except for the annual period, fluctuations at periods between
2 months and 10 years are dominated by processes other than Rossby waves in all cases considered
north of 30N. Various attempts to model the generation of the observed Rossby waves have not led
to conclusive results yet.

12. INVERSE MODELLING OF SEA SURFACE TEMPERATURE ANOMALIES IN
THE NORTH PACIFIC
K. Herterich – Max-Planck-Institut für Meteorologie, Bundesstr. 55, 2 Hamburg 13, West
Germany.

Starting from time series of mean monthly sea surface temperature anomalies for the years
1947 to 1975 specified for a 5 x grid covering the North Pacific (NOPAX-data) the cross-
spectral matrix for nearest neighbors is calculated. Corresponding model spectra are then derived
from a transport equation for the sea surface temperatures. In the transport equation advection and
diffusion appear as parameters. The parameters in the source term are the atmospheric forcing and
the back interaction from the ocean to the atmosphere. The atmospheric forcing, that is the heat
flux from the atmosphere into the ocean, varies on a time scale (days) much shorter than the time
scale (months) of the variability of the sea surface temperature anomalies. Consequently, the spectra
of the atmospheric forcing are modelled by white noise. Fitting the model spectra to the spectra of
the data, the spatial distribution of the parameters according to their physical meaning is found to
agree well with observations. Especially, the model parameters describing the advection resemble
the mean pattern of ocean currents measured at the surface and the diffusion coefficient in the
model turns out to be of the order 10^{-10} to 10^{-12} cm^2 s^{-1}. In addition, the significance of the model
fit is tested by standard statistical techniques proving the assumption of white noise for the spectra
of the atmospheric forcing.
13. THE ESTIMATION OF OCEAN CIRCULATION BY INVERSE METHODS WITH APPLICATION TO THE CARIBBEAN SEA
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Hydrographic data are used to find a geostrophic flow field that obeys mass and salt conservation constraints and is consistent with a horizontal flow field created by surfaces of constant potential density.

At station X, the grid scales, the flow is formally determined. However, a horizontally smoothed solution, which is the product of a resolution operator acting on the grid scale velocities, is determined uniquely. The Caribbean is used as an example because it is unproblematic. In this case, the resolution operator is local (compact resolution), it conserves transport, and it has moderately low sensitivity to noise, allowing stable estimates of transport to be made. The computed value of $29 \times 10^8 \text{ m}^3/\text{sec}$ leaving the Western Caribbean is in good agreement with direct measurements in the Florida Straits. Out of this total, about $22 \times 10^8 \text{ m}^3/\text{sec}$ is found to flow across the Eastern Caribbean and about $7 \times 10^8 \text{ m}^3/\text{sec}$ to enter the Caribbean through Windward Passage. The smoothed velocity field shows a Caribbean Current mostly in the southern half of the basin joined by a well defined flow through Windward Passage. Evidence of a deep cyclonic gyre is seen in the Eastern Caribbean (Venezuela Basin).

14. SPECTRAL CHARACTERISTICS OF ATMOSPHERICALLY FORCED EDDIES
Peter Miller – Harvard University, Cambridge, Massachusetts, U.S.A. (presently on leave from the University of Hamburg, Hamburg, F.R.G.); and Claude Frankignou – Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A.

The theoretical analysis of the quasi-geostrophic response of a stratified ocean to stochastic atmospheric forcing suggests local wind stress forcing might be an important energy source for large, eddy activity in the ocean. The observations of atmospheric forcing fields on fine spatial scales are compared with available observations. The predicted space-time scale of the eddy field depends significantly on the model parameters and the forcing principal components are determined. The predicted coherence between oceanic and atmospheric forcing is a consequence of the energy cascade in the atmospheric forcing field. Significant west-east and north-south variations in the ocean thermal structure are detected in response to the initial conditions and the variations in atmospheric forcing. The only verification attempted thus far have been with the monthly TRANSPAC dataset and with the passage of an atmospheric wave packet in the transect layer evolution.

15. HOMOGENEOUS QUASIGEOSTROPHIC TURBULENCE DRIVEN BY A UNIFORM TEMPERATURE GRADIENT


A study is described of baroclinic eddy heat fluxes in a particularly simple turbulent system. The system is quasigeostrophic, lies on a 4 plane, and is assumed to have – in the time-averaged sense a horizontally uniform temperature gradient (or meridional shear). The resulting equations for the forced turbulent field are solved numerically over a periodic two level domain for the statistically steady spectra of energy, enstrophy and heat flux. In particular, we seek: (1) to demonstrate the existence of the homogeneous turbulent limit in which eddy statistics are independent of the size of the periodic domain; (2) to determine the dependence of the equilibrium eddy heat flux on the dimensional parameter associated with the quasigeostrophic model.

Results indicate that the limit of homogeneous turbulence depends on at least a certain range of basic parameters. In the limit, the Rossby radius of deformation, $\lambda$, appears as the characteristic “mixing” length of horizontal scale of the eddies transporting heat and potential vorticity. For weak levels of lateral viscosity and sufficient horizontal resolution, the homogeneous turbulent flow statistics are related primarily to two parameters, $\lambda$, which represent respectively the non-dimensionalized influence of $\lambda$ and the surface drag. As a function of these parameters, the variations in energy generation conform to a gross (globally averaged) sense to the

16. PREDICTION OF NORTCPX ANOMALIES WITH A ONE-DIMENSIONAL MIXED LAYER MODEL

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The Analomyc Dynamics Study (ADS) of the North Pacific Experiment (NORCPX) is examining the theoretical mechanisms for the development and maintenance of large-scale temperature anomalies. In this study we consider the effect of anomalous surface buoyancy flux and anomalous buoyancy flux at the base of the mixed layer generated by wind stirring and vertical advection. We represent these vertical mixing processes through the Garwood (1977) oceanic mixed-layer model. The atmospheric forcing fields of wind, solar radiation and surface heat flux on hourly time intervals are interpolated from the surface heat budget calculations in the Fleet Numerical Weather Central (FNCW) atmospheric prediction model. We first examine the suitability of the FNCW heat flux calculations through comparison with the observed heat content changes derived from the TRANSPAC ship-of-opportunity data within 300–500 km, 100W–170E during September to December 1976. Although there are uncertainties in both the heat content change and the surface heat flux calculations, the agreement is surprisingly good for two months or longer intervals. We then use Garwood's model to predict the thermal structure changes with the atmospheric forcing fields and the initial temperature profiles on 15 September 1976. Periods of rapid heating are associated with the passage of atmospheric pressure impulses in the transect layer evolution. Significant west-east and north-south variations in the ocean thermal structure are predicted in response to the initial conditions and the variations in atmospheric forcing. The only verification attempted thus far have been with the monthly TRANSPAC dataset and with the passage of an atmospheric wave packet in the transect layer evolution.

17. LARGE-SCALE EVOLUTION OF SYNTHETIC THERMAL FRONTS IN THE MID-LATITUDE NORTH PACIFIC

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Temperatures data obtained from 1976–78 in the TRANSPAC chips-of-opportunity XBT program have been used to examine the large-scale evolution of synthetic thermal fronts in the North Pacific from 155°E to 135°W, from 30°–50°N, on a 2° latitude by 5° longitude grid. The primary indicator of frontal strength and position is the modulus of horizontal temperature gradient. The thermal data from the Transect layer evolution are referenced to a climatology computed from XBT data collected in the region from 1965–79.

The Subarctic Front was found at the sea surface and 150 m in all seasons over the two-year period. The Subarctic Front is sometimes fractionated into the Central and eastern ocean, particularly in spring when numerous bifurcations, secondary filaments, and possible linkages with the Subtropical Front occurred. In the western ocean during both years, the Subarctic Front at the sea surface and 150 m was strong and well defined. The Subarctic Front can in summer by more than a factor of two, consistent with the climatology but with larger changes, and displaced northward by 2–4°
of latitude. In the eastern ocean, the seasonal cycle of strength was absent; however, the seasonal cycle of position was strong, with the front occurring farther north by 4-6° of latitude during winter, also consistent with the climatology. The Subtropical Front was observed only in the eastern part of the region, and even there was found to be largely north of 30°N. Its strength comparable to the Subarctic Front at the sea surface and 150 m. Month-to-month changes in frontal strength and position will be compared with synoptic meteorological data to examine possible driving mechanisms.

18. CIRCULATION IN THE ABYSSAL NORTH PACIFIC

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The abyssal radionuclide (41Ca) data from the GEROSES expedition clearly show the major contrast between the Atlantic and Pacific Oceans. Nearly all of the Atlantic is younger than 1.2 m.y. (10,000 years) as compared to the Pacific Ocean. This implies that waters deeper than 600 m in the Pacific may be considered not to exchange with the atmosphere on decadal timescales, i.e., they are abyssal. The circulation pattern for the abyssal waters that emerge from the deep ocean is one of two well-mixed basins separated by the eastern Pacific ridge, the cross-shear in the North Pacific is about 20°/m (180 years). The eastern basin is fairly well mixed throughout and contains the oldest water, while the western basin gives the impression of being dominated by processes along the western boundary which bring in younger water from the north and is not mixed. The main surface currents in the north and south of the basin are the Kuroshio and the California Current, respectively.

19. A SHALLOW NORTHEASTWARD CURRENT IN THE NORTH PACIFIC

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Twelve-year mean surface temperatures for the North Pacific are analyzed to map the flow for each month of longitudinal temperature anomaly, in which the large scale eastward and northward temperature gradient is removed from the original temperature field. These maps show apparent parallel areas of positive and negative values of order 1°C oriented in the near-equatorial region of the north-south direction. The largest positive anomaly band, which is a persistent feature, connects the low latitudes of the north Pacific with the high latitudes of the Gulf of Alaska. Its north-south scale is several thousand kilometers and its east-west scale is about 4000 km at mid-latitudes. The large positive anomaly is interpreted to be the surface expression of a shallow nearshoreward current caused by the mean northward temperature gradient. This current is part of a circulation which transports heat away from the western boundary and upwelling northward. A steady circulation in a thin layer under constant rotation is calculated. The circulation is driven by a constant eastward temperature gradient and retarded by internal friction. The flow direction is northward in the upper half of the layer, southward in the lower half, and the flow direction varies with depth only slightly within the upper and lower halves of the layer. The temperature is high in the upper half of the layer and low in the lower half compared to the relatively averaged temperature. The circulation transports heat and dissolved nutrient northward but not vertically.

20. THE INDIAN OCEAN EXPERIMENT: INDEX

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The initial results will be reported from the recently completed cooperative international large scale observational program in the Western Indian Ocean (INDEX). The observations were carried out by a number of scientists during the first part of 1979. The principal focus of the observational work was the oceanographic response of the onset of the Southwest Monsoon, particularly the development of the Somali current and the upwelling along the African coast, including an examination of the special role of the equatorial region in these processes. The INDEX experiment was preceded by several pilot studies since 1976 and the principal results from studies in the Indian Ocean will be summarized. In the equatorial region there is evidence of a westward flow in response to the Monsoon extending to 2000 meters depth. The equatorially trapped multiple zonal jets discovered in 1976 in the Indian Ocean were superimposed upon this larger scale westward flow. The fate of this westward flow and its possible relation to the Somali current will be discussed.

21. LARGE-SCALE MOTION IN THE SOUTHWEST INDIAN OCEAN


The circulation in the Southwest Indian Ocean is described at the hand of hydrographic data and the drift tracks of a number of satellite tracked buoys both of the FGGE period and other. A detailed X-site section has been undertaken across the East Madagascar Current at 21°S and directly south of Madagascar. Taking into account the characteristic T/S/relationship existing in the upper 500 m of this area, the velocity shear has been calculated by invoking the thermal wind equation. By referring the surface velocity calculated in this way to that derived from accurate satellite navigation it has been possible to achieve an absolute velocity shear and hence to estimate the volume transports. The East Madagascar Current's western boundary current character is confirmed and a southward transport of 41 x 10^6 m^3/s is indicated. In the area south of Madagascar an intense, warm, southward flow immediately south of Cape St. Marie is shown to overtop a deep wedge of strong westward flow. Speed and volume transport specifications for these components have been derived and are compared with the tracks of drifting buoys in the same area.

23. TIME VARIABILITY OF INDIAN OCEAN EQUATORIAL CURRENTS

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As part of INDEX, we have obtained two moored current meter records from a single depth (500 m) and location (20° S, 55° 14′E) in the equatorial Indian Ocean. The records extend from January to July 1977 and from October 1977 to April 1978. Spectra analyses at periods shorter than about 500 hr show features consistent with a recently developed model spectrum of equatorial waves (Eckman, personal communication). 1) The presence of 1 spectral peak at subharmonics frequencies, 2) approximate equipartition of energy between the two flow components, and 3) the absence of these two features in the surface region. The latter property is the consequence of the relatively shallow depth of the records. The results are in this sense consistent with the surface forcing being larger than in the deep ocean, where Eckman's spectrum would predict a difference between the rotating components. Generally, this result is not surprising, as the surface forcing region is the same as that of the large-scale circulation. For this reason, the westward flow is stronger than in the deep ocean. The results are consistent with this expectation and show that the deep ocean circulation is not significantly influenced by the shallow ocean circulation. The deeper ocean circulation is, however, affected by the shallow ocean circulation, and this effect is more pronounced in the deep ocean where the Rossby radius is larger. This result is consistent with the hypothesis that the deep ocean circulation is controlled by the shallow ocean circulation, and that the shallow ocean circulation is controlled by the surface forcing.
26. THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF SYNOPSIS-SCALE OCEAN CURRENTS
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New and intensive investigations of synoptic-scale eddies began after the eddies were discovered by the Soviet expedition POLYGON-70. American scientists performed the well-known MODE investigations and afterwards a famous US-USSR POLYMODE program was performed. The temperature and flow velocity charts were plotted, the kinematics, space-time variances and, partly, the energetics of eddies have been investigated on the basis of preliminary data processing. The data processing is not completed yet, but the preliminary results are quite interesting. The experimental observations lead to the theoretical one. Three theoretical eddy resolving models were prepared in the USSR: semilinear, nonlinear and dynamic-stochastic. In the first of them the vorticity equation, the equation for temperature and the energy correlations are nonlinear. In the second model, two equations of motion are nonlinear too. The third is a synthesis of the dynamic equations with the process of error minimizing based on the use of irregular nonsynchronous observational data. The results of preliminary calculations by these three models and the comparison with the observational data are encouraging.

27. RESULTS FROM WIND-DRIVEN, EDDY-RESOLVING GYRE-SCALE NUMERICAL MODELS OF OCEANIC CIRCULATION
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A new sequence of numerical experiments has been carried out using a two-level quasi-geostrophic model of the wind-driven ocean circulation in a closed basin. The horizontal resolution is fine enough to resolve both mean and mesoscale circulations, and the resulting general circulation is turbulent equilibrium. The eddies are generated spontaneously by the instability of the Gulf Stream and determine the amplitude and structure of the time-averaged flow. These experiments were done (i) to examine results obtained in realistic North Atlantic basin; (ii) to compare the results with earlier experiments in smaller basins (Holland, 1978, 1980); and (iii) to compare the results with recent observations. In addition, a beginning has been taken at the role played by topography and by asymmetrical wind forcing on the mean and eddy fields in such basins. Results show much more realistic behavior (comparing the amplitudes and structures of the mean and eddy circulation with observations) as more realistic basin sizes are reached. Topography is also shown to play a part in determining the vertical structure of the eddy field in various parts of the basin.

28. EDDIES AND THE MEAN CIRCULATION OF THE WESTERN NORTH ATLANTIC
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It has been clearly established that the eddies field in the western North Atlantic Ocean is sharpy horizontally inhomogeneous over a variety of scales at all depths. Over that time the character of the North Atlantic for which data are available, eddy kinetic and potential energy vary by orders of magnitude, and vertical distributions of properties of the eddies change qualitatively. The characteristics of the eddy field are related to the structure of the general circulation, and several new properties of the time-averaged circulation have emerged, including previously unobserved vertical structures and in addition variations over comparatively short horizontal scales. Some of these observations are intercorrelated favorably, and some not, with a variety of numerical experiments involving eddy-resolving gyre-scale models.

29. THE STRUCTURE OF SYNOPSIS VARIABILITY OF THE OCEAN FROM HYDROLOGICAL SURVEY DATA
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The paper presents results of analyzing 9 CTD surveys of the POLYMODE region as conducted by the Marine Hydrophysical Institute operated by the Marine Hydrophysical Institute, Ukrainian SSR Academy of Sciences as well as those of investigating isolated synoptic eddies. Based upon large-scale surveys, charts of depth are constructed for the 15° isotherm. By analyzing the charts constructed, evaluated is the number of eddies observed in the region, their paths and velocity at which they travel. The vertical structure of synoptic scale temperature disturbances is calculated both from the data obtained during large-scale hydrological surveys in the region. The calculations show stability of temperature fluctuations and some regular variations in heat energy contained in the water column. Similarity of temperature fluctuation distribution functions at various levels is also an indication of vertical structure instability of temperature disturbances.

The existence of the universal distribution function of temperature disturbances allows one to introduce the concept of an intensive eddy, to calculate the average area occupied by eddies and mean energy involved. With the area occupied by eddies being relatively small (30%), these contain a little as high as 80% energy on synoptic scales. Special investigations of isolated intensive eddies enable estimation of their dynamics. Essentially nonlinear balance in both the equation of heat transport and that of eddy balance is shown to be settled in intensive eddy. A relation between dynamics of this type and stability of the vertical structure is noted.

The stable vertical structure of temperature disturbances on synoptic scales makes it possible to evaluate heat content anomaly associated with eddy and to determine horizontal heat transport by synoptic eddies. The revealed relation between the vertical structure of temperature disturbances on synoptic scales and the Vlasil-Brunt local frequency permits one to parameterize vertical mixing by synoptic eddies.

30. MIXED LAYER IN THE PROBLEM OF SYNOPSIS VARIABILITY OF THE OCEAN
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Analysis of observational data gathered as part of the POLYMODE experiment made it possible to evaluate anew the role and significance of the mixed layer in the problem of synoptic variability of the ocean. Most important is the part played by it in heat, momentum and mass transport by synoptic scale motions as well as (on active layer scales) in the concentration of available potential energy which can be transformed into kinetic energy of disturbances through a mechanism of baroclinic instability. By analyzing experimental data, it was revealed that within 50–500 km scalesthe most energy-carrying portion of spectrum of synoptic scale disturbances in the mixed layer is associated with eddies motions in deep layers of the ocean rather than with the direct atmospheric effect. In so doing, motions on synoptic scales in the main thermocline induce distortion of such inputs, which correspond in scale to the eddy field. The total effect of such disturbances lies in the initiation of resultant heat transport comparable with the total meridional heat flux in the ocean. Various mechanisms of horizontal heat transport are discussed and the efficiency of such a heat transfer is estimated. Also pointed out are possible means for parametrizing these processes. Under real conditions, the efficiency of parametrization of this kind is determined taking into account open ocean observations over 40 years and can be accomplished based upon constant ocean monitoring for introduction of simple techniques from satellites. The development of techniques for identifying eddies from its manifestations in the mixed layer as well as the construction of theoretical models enabling the determination of synoptic eddies' parameters as an integral part of such models is also proposed which allows intensity and a horizontal scale of eddy motions to be estimated from ocean surface temperature field and the pycnocline depth. A system of two first order equations relative to derivatives "functions of eddy" and coinciding rather closely with a stream function at a lower limit of the pycnocline forms the mathematical foundation of the model. The remote technique of IR sounding of the ocean permitted to fix a remarkable phenomenon—the exposure of internal waves on the ocean surface. That appears to be promising for indirect determination of the vertical structure of the upper oceanic layer, the pycnocline depth, in particular.
31. FORECAST ERROR IN AN OPEN OCEAN MODEL
A quasi-geostrophic open-ocean model, suitable for dynamical/forecast studies in an arbitrary block of ocean has been developed. For traditional initial/boundary value problems the model requires a specification of (inflow) flow around the boundaries and vorticity on the inflow. Errors in the evolving flow arise from computational observational, and physical sources. In order to evaluate physical errors for the study of physical processes, and in order to evaluate practical forecast possibilities, a knowledge of the computational and observational error characteristics is necessary. Based on MODE-I data a similar study has been carried out including error sources due to mesh size, bathymetry, initial and boundary condition data, interpolation, derivation of the vorticity from the streamfunction, and updating strategies. The model is being applied to the analysis of POLYMODE field data.

32. MATCHING INITIAL AND BOUNDARY DATA FOR OPEN OCEAN MODELS
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Open ocean models are particularly sensitive to errors in initial and boundary data, because integration of the system of model equations and open boundary conditions is an ill-posed mathematical problem.

The conventional approach to this difficulty is to alter the physics of the model by introduction of length or time scales of decay, which smooth the flow field discontinuities arising from the ill-posedness, but which may not be related to any actual physical process.

An alternative procedure is to perturb the data in order to meet the (over) specifications of the problem which ensure smooth flow fields. The perturbations need be no greater than the data errors.

It is possible to devise data perturbation schemes which do not alter the values of the total eddy flux through the open ocean region given by the original data.

Results of numerical experiments with artificial data sets will be described.

33. FLUCTUATIONS OVER A TWO-MONTH PERIOD OF DYNAMIC HEIGHT AND SALT FIELDS SOUTHWEST OF BERMUDA
Seven 20 km-diameter surveys with 5- to 25-km station spacing were made of the density field southwest of Bermuda (31°N, 66°30'W) during the POLYMODE Local Dynamics Experiment. There were large displacements of the thermocline over the two-month survey period (mid-May to mid-July, 1976). For example, the maximum variation within a survey of the pressure of 15°C varied from 50 db on the first survey to 270 db on the fourth survey. These figures may be compared with historical standard deviation of 15°C pressure of 45 db at 32°N, 70°F. The most energetic feature had geographic speeds of 60 cm sec⁻¹ relative to 3000 db toward the southwest in the upper thermocline and developed from a weak trough in one to two weeks. This feature, which was in the northwest quadrant of the survey region, was roughly linear and in form, had a horizontal scale of 200 km, and moved toward the northwest at a speed of 2-3 cm sec⁻¹. The strong relative flow was vertically coherent down to at least 1400 db. In contrast, during the early portion of the experiment the dynamic height field in the deep water contained smaller scales than the upper thermocline. The most striking discrepancy was the occurrence of a 50 km-scale eddy-like structure in the lower thermocline with a warm, fresh core. The properties of the feature were not evident above 1000 db. Its movement was 10 cm sec⁻¹ toward the southwest. Another 50 km-scale feature was observed in the latter half of the survey. The isotherms were bowed upwards in the upper thermocline but there was no discernible salt signature. Its movement was 15 cm sec⁻¹ toward the southwest along the high gradient region in the southwest quadrant. The salinity distribution in the mid-thermocline was complex with low vertical coherence over pressure intervals of 100 db, whereas the salt anomalies in the lower thermocline are vertically coherent over 200-300 db. A discussion of the role of advection in the movement of the salinity anomalies is presented.

34. STRUCTURE AND DYNAMICS OF A SMALL-SCALE EDDY OBSERVED DURING POLYMODE LOCAL DYNAMICS EXPERIMENT
During the POLYMODE Local Dynamics Experiment, a small anticyclonic eddy (~ 50 km diameter) in the lower thermocline was observed six times during three weeks. Velocity profiles (electromagnetic profiler) showed maximum transverse speeds of 25 cm sec⁻¹ at 1500 db; above 1500 db there was strong cyclonic shear such that the feature was not observed in the middle thermocline. The anticyclonic shear extended down to 2500 db. Dynamic height maps showed that the eddy was advected with no appreciable change in structure toward the southwest at a speed of approximately 19, 1, sec⁻¹. The eddy center was characterized by a low-salinity anomaly of 0.04-0.05‰ on the f₁ = 27.765 potential density surface. This anomaly is 2.5 times the historical standard deviation of salinity on this surface; its water mass characteristics indicate that the water probably originated in the Slope Water north of the Gulf Stream. Three SOFAR floats deployed at 1300 db were entrained by the eddy and showed transverse speeds of about 10 cm sec⁻¹. Maximum entrainment time was one and a quarter revolutions. The translation velocity of the eddy is consistent with both the general drift of the SOFAR floats at 1300 db and deep velocity measurements made with the electromagnetic profiler. The processes that are responsible for maintaining the eddy structure are examined by considering the balance of forces required for dynamical equilibrium.

35. OBSERVATIONS OF OCEANIC VORTICITY BALANCES
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Analyses of two scooped arrays, one centered at 55°W, 36°N, and 4000 m on a seamount, and another centered at 31°N, and 600 m on flat topography, estimate vorticity balances in two different phenomenological regimes. In the first behavior is consistent with that predicted by theories of a generalized, stratified Taylor column. Preliminary results from the second indicate a much different behavior that appears consistent with that predicted for quasi-geostrophic turbulence.

36. MEASUREMENTS OF MESOSCALE VARIABILITY IN THE NORTHEAST ATLANTIC
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A cooperative investigation by several European laboratories of the mesoscale current variability in the North East Atlantic has been carried out over the past three years. Current records of up to 2 years duration have been obtained at nine sites between 33 and 52 degrees north and east of 25 degrees west.

For the most part kinetic energy levels do not differ greatly from those at similar sites in the western basin but there are energetic short period motions (order of days) which dominate some records at the northernmost sites which may be associated with meteorological forcing.
37. **ANNUAL VARIATIONS IN THE SALT ANOMALY FIELD IN THE EASTERN NORTH ATLANTIC: OBSERVATIONS AND A SIMPLE DYNAMICAL MODEL**


Three years of hydrographic data (CTD and STD) collected in the Bay of Biscay region by French investigators suggest a low frequency, large scale oscillation in the salinity anomaly and density field. The time dependent vertical structure further suggests a low mode baroclinic Rossby wave, suitably modified by turbulent diffusion on shorter space and time scales.

The model hypotheses two time scales, as suggested by the observations. The velocity field is presumed to be derivable from the quasi-geostrophic isopycnal and isovorticity equation. The time dependent advection-diffusion equation (with diffusivity a parameter) in density coordinates is solved using the independently determined time-dependent velocity field as described above at a timestepped Fourier series. Different geometries and initial field conditions are examined, and the range of applicability of the model is discussed.

38. **DEEP CONVECTION AND THE FORMATION OF LABRADOR SEA WATER**

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Towed and vertical CTD observations obtained by G. S. S. Hudson during the winters of 1976 and 1978 are analyzed to show the mixing of warm saline Inning Sea Water with colder fresher Labrador Sea Surface water along the western side of the Labrador Sea. This mixture often cools and mixes again to gradually form more homogeneous and denser water bodies. Under the influence of a cyclone lasting from late November to late February in 1976, a column of inflow was isolated in the cold ring forming a density such that deep convection was observed to penetrate to depths greater than 2000 meters. During the convection phase, vertical current meters observed downward velocities as high as 9 cm/s. The newly formed LW in the Warm Core Ring, was entrained in an anticyclonic eddy of diameter 10 km and rotation period the order of a day or more. The behavior of this eddy was observed over a period of a week by tracking vertical current meters within it and also by towing a CTD system through it.

39. **THE INFLUENCE OF INTERNAL DYNAMICS ON EDDY SHEDDING BY THE LOOP CURRENT IN THE GULF OF MEXICO**

Harley E. Harris – Numerical Modeling Division, Code 322, Naval Ocean Research and Development Activity, NSTL Station, MS 39529, U.S.A.

The influence of internal dynamics on the eddy shedding by the Loop Current in the Gulf of Mexico has been investigated using three nonlinear numerical models: two-layer, barotropic, and reduced gravity. There are three of the simplest models that can be used for this problem. The barotropic and reduced gravity models demonstrate the individual behavior of the external and internal modes, and provide insight on how they interact in the two-layer model. Because of the economy of the semi-implicit free surface models, it was possible to perform numerous experiments to investigate the stability properties of the Loop Current. Typically the models were integrated 3 to 5 years to statistical equilibrium on a 1000 x 1000 km rectangular domain with resolution 20 x 1.75 km. Prescribed inflow through the model Yucatan Channel was compensated by outflow through the Florida Straits. The underlying hypothesis is that the Loop Current sheds eddies in response to quasi-analytical variations in the inflow. An important finding from the models is that anti-cycloclonic eddies can be shed at almost an annual frequency with no time variation in the inflow. Two time scales are associated with the eddy shedding: the time for the Loop Current to penetrate into the Gulf and spread westward, which is a large-scale configuration, and the much shorter time scale for the growth of a horizontal shear instability at the eddy separates from the Loop Current. In the most realistic regime, the eddy shedding rate depends on the internal Rossby wave speed, the eddy scale derived from conservation considerations, the initial shear at the time of eddy formation, the angle of the sheet to the phase, the angle to the eddy to the phase, and the Reynolds number. Eddy shedding can be prevented by reducing the Reynolds number significantly. However, the current can be stabilized at higher Reynolds numbers by removing differential rotation (setting β=0). This is true even when we augment the inflow with a large westward component and an annual variation larger than observed. In a few of the two-layer experiments, baroclinic and mixed instabilities were encountered, but in most of the internal modes exhibited a horizontal shear instability, and the latter regime produced the most realistic results. For sufficiently high Reynolds numbers the shear instability occurred in both the barotropic and reduced-gravity models. However, for realistic parameter values eddy shedding occurred in the two-layer and reduced-gravity models, but not in the barotropic model.

40. **SENSITIVITY AND RESPONSE OF THE GULF OF MEXICO LOOP CURRENT TO EXTERNAL FORCING**

J. Dana Thompson – Numerical Modeling Division, Code 322, Naval Ocean Research and Development Activity, NSTL Station, Mississippi 39529, U.S.A.

Limited-area, eddy-resolving (10 to 20 km grid resolution), free-surface numerical models have been used to study the sensitivity and response to the Gulf of Mexico Loop Current to spatial and temporal variations in open-ocean boundary conditions (Yucatan Straits inflow and Florida Straits outflow) and to alterations in bottom topography. In these experiments, baroclinic, reduced-gravity, and two-layer primitive equation model prototypes were integrated to statistical equilibrium over several years and compared to control experiments.

For steady inflow and realistic parameter values, the reduced-gravity and two-layer model prototypes reproduce a realistic Loop Current and vigorous eddy-shedding with a period near annual. When the inflow and outflow ports were relocated by several hundred kilometers the eddy-shedding rate, eddy diameter, and eddy strength were little affected, so long as the western boundary did not interfere with the shedding process and the ports were not unrealistically close. Halving the outflow port width, in contrast to halving the inflow port width, had very little effect on the shedding rate or the potential-to-kinetic energy conversion process in the basin interior.

The response of the current to time-varying inflows is complex. Importantly, the eddy-shedding frequency was not dominated by the forcing frequency for realistic transport fluctuations. The natural frequency was of much greater importance in determining the eddy-shedding rate in these cases. For example, the reduced-gravity model with a constant 20 Sverdrup inflow yielded a natural eddy-shedding period of 327 days. When a semi-annual time-varying inflow having a 10 Sverdrup peak-to-peak amplitude was superimposed on the mean forcing, the eddy shedding period was found to be 356 days.

Bottom topography tended to stabilize the Loop Current to eddy shedding, although reduction in deep-water inflow transport reinitiated the shedding response. Interaction between barotropic and baroclinic modes was important to Loop Current stability. The movement of the shed eddies was significantly modified by the introduction of bottom topography.

41. **THE EVOLUTION OF EAST AUSTRALIAN EDDIES**

C. S. Nilson – R.A.N. Research Laboratory, P. O. Box 704, Darlinghurst, N.W., 2010, Australia, and G. R. Creswell – CSIRO Division of Fisheries & Oceanography, P. O. Box 21, Cronulla, N.S.W., 2230, Australia

The East Australian Current (EAC) is a western boundary current that generates warm core eddies by pinch-off of poleward meanders. One eddy was tracked with satellite buoys and repeatedly studied through 1977-78 over a full life-cycle. A deep isothermal core was formed by surface cooling through winter and overlaid by a new surface layer during the following summer. Only about one third of the dynamic topographic relief was lost during one year. The eddy contracted horizontally and the anti-cycloclonic circumpolar currents increased with age to nearly four knots. The eddy was observed to coalesce with a new meander of the EAC, rather than drift away to the south. It is proposed that the rate of formation of such eddies is governed by the westward propagation of the baroclinic Rossby wave known as the Tasman Front.
1. MODELS OF SECONDARY CIRCULATION AT SHELF-BREAK FRONTS

G. T. Casaday — Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543, U.S.A.

Some distance seaward of the shelf-break front the cross-isobath components of the flow
is offshore at the surface and in the bottom boundary layer, onshore in the rest of the water column.
A somewhat similar flow distribution is found sufficiently far seaward of the front. However,
the mean position of the front only cross-front velocities one or two orders of magnitude smaller
than the observed shoreward or seaward are consistent with the known heat and salt fluxes
or with direct velocity observations. These facts imply a pattern of secondary circulation in a cross-
isobath transect across the front from the atmospheric Hadley cell.

Momentum fluxes calculated for a realistic Hadley cell model show large up-ramp gradient of
"prograde" longshore momentum on the shoreward side, "retrograde" momentum on the seaward side.
Momentum balances for control volumes on the shoreward and seaward sides of the front show
that the longshore momentum balance of the baroclinic jet associated with the front is dominated
by the horizontal momentum flux associated with the Hadley cell. Heat and salt fluxes are also consider-
able; their dynamical role appears to be limited to maintaining the sharpness of the front.

2. THE VARIABILITY NEAR THE SHELF BREAK OFF THE EAST COASTS OF SOUTH AFRICA AND AUSTRALIA

Alan Pearce — CSIRO Division of Fisheries & Oceanography, P. O. Box 21, Cronulla, N.S.W.
2220, Australia

The Agulhas Current generally runs close to the shelf break along the coast of Natal (approximately
28° to 31°S), and can usually be identified by the strong frontal zone associated with the
cyclonic shear "boundary" of the stream. Wave-like meanders along this result in periodic incursions of
the Current onto the shelf, sometimes intruding as far inshore as the 50 m isobath in
some areas. Shoreward of the Current front, the flow is highly correlated with the wind
and accordingly exhibits current reversals with a period of a few days; these reversals can extend as
far as (and beyond) the shelf break on occasion when the Agulhas Current meanders away from
the coast. Intensive current measurements made from the R. V. "Meteor Naude" at three coastal
stations have shown the important effects of the shelf bathymetry on the behavior of the Agulhas
Current and hence on the shelf-edge circulation. Surface temperature maps using airborne radiation
thermometry, and more recently satellite observations, have also revealed scales of variability of
the Current front along various portions of the coastline.

For comparison, some current measurements on the outer shelf of the East Australian cost
are briefly described.

3. TOPOGRAPHICALLY INDUCED UPWELLING IN THE AGULHAS CURRENT

E. H. Schumann — National Research Institute for Oceanology, P. O. Box 17001, Congella
4013, South Africa, and A. E. Gill — DAMTP, University of Cambridge, Silver Street,
Cambridge CB3 9EW, England

A two-layer model with a passive bottom layer has been developed which illustrates the changes
that an inertial jet can undergo when moving along a varying coastal topography. The principle of
the conservation of potential vorticity has been used in this approach, with the position of the inter-
face shifting the topography or breaking the surface determining the nature of the resulting flow.
It is shown that both subcritical and a form of supercritical flow can exist, with upwelling and
the possible formation of an offshore front occurring in the latter case.

A further development is then a more realistic three-layer model with a technique to determine
the long wave speeds of the two baroclinic modes. This model is used to simulate two sections
measured across the Agulhas Current, and the results indicate that the supercritical flow condition
may be reached as the Current concentrates in its movement southward.

Further downstream a persistent upwelling region exists on the inner edge of the Agulhas
Current which may be caused at least partly by the topographically driven upwelling described above.
This is demonstrated by measurements and satellite images of the region. An intriguing possibility
that emerges is the occurrence of hydraulic jumps in the flow as it returns to a subcritical situation.
There are not enough measurements available to show what form such a jump might take, but obser-
vations of bottom sediment structure indicate that abnormal flow conditions may exist at times.
4. TRENCH WAVES
Lawrence A. Myjak, Paul H. LeBlond, and William J. Emery — University of British Columbia, Victoria, B.C., Canada

The cross-sections of four trenches peripheral to the Pacific Ocean are fitted by a double exponential depth profile. Non-divergent trapped wave propagation is shown to be possible in two directions and along the trench axis. In addition to the familiar shelf waves, only slightly modified by the presence of a trench, "trench waves" propagating in the direction opposite to that of shelf waves and at speeds lower by an order of magnitude are also possible.

Dispersion curves and eigenfunctions are presented for the Peru-Chile and Japan-Kuril trenches. Coastal wave records are used to demonstrate phase propagation at "trench wave" phase speeds off both Japan and Peru. The fundamental mode speeds predominate in the phase spectrum off both Japan and Peru.

5. MODEL STUDIES OF THE WIND-DRIVEN TRANSIENT CIRCULATION IN THE MIDDLE ATLANTIC BIGHT
Dale B. Haidvogel — Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543, U.S.A.

A simple numerical model of the wind-driven transient ocean circulation in the Middle Atlantic Bight is described. The model incorporates realistic topography and covers the continental shelf between the coast and the 100 m isobath from Cape Hatteras to the southern tip of Nova Scotia. The standard shallow water dynamics are used, i.e., the vertically integrated and linearized equations for the flow of a homogeneous fluid driven by atmospheric pressure and wind stress fluctuations and damped by a quadratic bottom stress. The finite-difference analysis is integrated in time using a simple modification of the leapfrog’s (1974) scheme. The grid set is uniform with a spacing of 1.27 km. The normal flow vanishes at the coast while the equivalent surface elevation is held constant along the model boundary over the continental slope.

Several initial value experiments have been conducted to study the free and forced modes of this model and the damped flow driven by a spatially uniform and stationary windstress and by an idealized traveling synoptic-scale windstress pattern. The numerical experiments indicate that several time scales are important in the regional adjustment of the flow. The regional scale dependent on the local windstress, the baroclinic scale dependent on the depth of the shelf, the windstress velocity field, and the time scale which reflects the adjustment process within the entire model. The transient response within the Middle Atlantic Bight proper from Cape Code to Cape Hatteras to an alongshore windstress is clearly dominated by friction. The effective spin-up time scale for a 2 dyn cm⁻² windstress is about 10 hours which is sufficient in comparison to the 4 to 10 day time scales characterizing atmospheric transients that the storm-driven current should be quasi-steady. Within the deeper Gulf of Maine basin, the effective spin-up time scale is much longer and the normal modes of the basin excited by the wind forcing are only weakly damped in time. A preliminary comparison of some of the results of these numerical experiments with recent observational data on current and sea level variability is presented.

6. IMPORTANCE OF EDDY HEAT FLUX IN A HEAT BUDGET FOR OREGON COASTAL WATERS
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D. Halpern — Pacific Marine Environmental Laboratory, Seattle, WA 98193, U.S.A.; and
R. D. Pillsbury — Oregon State University, Corvallis, OR 97331, U.S.A.

A heat budget for Oregon coastal waters during the summer upwelling season in 1973 is estimated from current and temperature measurements at a distance of 15 km from the Washington coast. In this heat budget, the time-averaged onshore-offshore circulation transports heat offshore at an estimated rate of 4.5 x 10⁷ cal cm⁻¹ s⁻¹. This offshore heat transport is compensated by a combination of onshore eddy heat flux, advection of alongshore heat transport, radiation, and gain by mixing of heat into the coastal waters during summer. Of these mechanisms, eddy heat flux is the most important, balancing 25% of the offshore heat transport by the mean circulation. The eddy heat flux is directed downstream the horizontal temperature gradient and these mechanisms is the magnitude of the alongshorecirculation in Oregon coastal waters.

8. THREE-DIMENSIONAL EDGE WAVES ON PARALLEL DEPTH CONTOURS
Richard P. Shaw — Faculty of Engineering and Applied Sciences, SUNY, Buffalo, New York 14214, U.S.A.; and
David F. Ross — Marine Sciences Institute, University of Connecticut, Groton, Connecticut 06340, U.S.A.

Edge waves represent a trapping of energy along a coastline by offshore topography. In particular, they represent waves which propagate along shore but do not have any magnitude. They are described unrealistically which lead to edge wave solutions of the full three-dimensional equations for free surface gravity waves on a perfect fluid. Two families of solutions correspond to upwelling and downwelling, respectively. The solutions are obtained on the assumption of edge wave solutions where the vertical wave speed is constant. The wave fields are given and limiting cases of these analytical solutions are examined and found to agree with other edge wave solutions where comparison is possible. A given topography (maximum depth, depth offshore distance and initial bottom slope) will support an edge wave of specific frequency, wavelength, and offshore decay rate and vertical variation. Examples are given.

9. LOW FREQUENCY CURRENTS AND GULF STREAM INTERACTIONS AT THE SHELF BREAK
Peter C. Smith and John Louis — Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

Low-frequency current, temperature and salinity from a two-year mooring program at the shelf break south of Halifax (43°40'N, 63°48'W) are examined. Attention is centered on the interaction of Gulf Stream meanders and warm-core anticyclonic eddies with the shelf water. To aid interpretation, the space-time structures of the shelf/ocean water boundary and the eddies are analyzed in terms of their spatial structure and surface temperature (SST) maps of the area.

In the region from 60° to 65°W, the surface expression of shelf/ocean water front lies 120 ± 70 km off the shelf break. At the western end of this region, warm-core eddies are regularly formed by meanders of the Gulf Stream at ~200 km from the shelf break. In the shelf/ocean boundary region, the eddies induce wave-like fluctuations (scale 100 - 200 km) which propagate westward at the eddy drift speed of 4 km h⁻¹.

Throughout the mooring period, waves generated by the eddies are detected primarily by low-frequency oscillations in the alongshore (eastward) current. The energy appears in bands of 4 to 5 cycles with typical amplitudes of order 10.0 cm s⁻¹ and periods of 15 to 20 d, particularly over the continental shelf. Phase propagation is offshore and the measured offshore wavelength is of the order of the distance between the shelf break and the eddy center (200 km). Examples from July/September, 1976, and August/September, 1977, reveal a barotropic 20 d oscillation and a 14 d oscillation with distinct baroclinic effects at the shelf break, respectively. Simple models for topographic Rossby waves forced by point sources of vorticity on the continental shelf are used to interpret these observations.

10. ON LOW FREQUENCY AND TIDAL PERIOD SHELF BREAK PROCESSES AT SOME CONTINENTAL MARGINS
Friedrich Schott — RSMS, University of Miami, Miami, Florida 33149, U.S.A.

For low frequency current fluctuations observed at the Norwegian shelf break, which had been attributed to baroclinic instability of the Norwegian current based on analytical model calculations, energy interaction calculations were carried out using the moored temperature and current measurements obtained in the area. It is found that energy is transferred into the perturbations by baroclinic instability but that energy is also transferred back into the mean flow by the barotropic terms. Recent measurements of low frequency fluctuations at the East African shelf in the Somali current were also presented, as well as some considerations concerning their possible origin from a barotropic and baroclinic semidiurnal tide and the high low frequency part of the internal wave continuum were derived. The mean distribution of these energies from the shelf to the deep sea is also presented. The relation between the time series of the different frequency bands, which shows systematic phase patterns through the observational area, are discussed.
11. FLUX OF HORIZONTAL KINETIC ENERGY OVER THE SOUTHEASTERN BERING SEA CONTINENTAL SHELF


Current observations obtained from twin-wide moorings on the southeastern Bering Sea shelf in summer 1977 revealed weak mean currents on the central shelf (~1 cm/sec) or less and variable in direction. About 90% of the total variance energy (0.01-1.00 cph) was in tidal bands of less than 1% of the subtidal. Mean current speeds on the inner shelf were of two greater and westerly in this domain, about 95% of the variance energy was in tidal bands and less than 2% subtidal. Total variance energy was similar on the central and inner shelves. An energy shift from lower (0.08-0.35 cph) to higher (0.50-1.50 cph) frequencies was observed between the central and inner shelves.

12. SHELFBREAK CIRCULATION AND EXCHANGE PROCESSES ALONG THE U.S. SOUTHEAST CONTINENTAL SHELF

Thomas N. Lee -- RSMAS, University of Miami, Miami, Florida 33149, U.S.A.; Larry P. Atkinson -- Shidway Institute of Oceanography, F. O. Box 13837, Savannah, Georgia 31406, U.S.A.; and Leonard J. Pietrafesa -- Department of Marine Science & Engineering, North Carolina State University, Raleigh, North Carolina 27695, U.S.A.

Observations from arrays of moored current/temperature recorders, hydrography, satellite imagery, and coastal sea level and meteorological stations are used to examine the circulation and exchange processes occurring in the outer shelf region between Cape Canaveral and Cape Hatteras (South Atlantic Bight). Two distinct current regimes were found: 1) The outer shelf, from about 45°N to the shelfbreak (75°N isobath), where energetic current and the temperature structure develop on a 2-day to 2-week timescale throughout the year due to northerly propagating wave-like meanders of the Gulf Stream front and cyclonic, cold-core spin-off eddies; 2) The mid-to-inner shelf, from approximately the 10°-45°N isobaths, where current and temperature structure develop on a mid-seasonal tidal and wind response in the Georgia Bight, with the addition of occasional Gulf Stream events in the summer. Wind events appear at times to perturb the Gulf Stream cyclonic front, generating an unstable meander which propagates to the north along the shelfbreak with speeds of about 40 cm/sec and wave lengths of about 100 km. The meanders are observed in satellite imagery. The meanders and eddies are observed to reach larger proportions north of a shelf topographic feature off Charleston, S.C. ("Charleston Hump"). Spin-off eddies travel northward along the shelfbreak at the same speed as the parent waves. The cyclonic circulation in the eddies provides a means for rapid shelf-Gulf Stream water exchange, resulting in an outer shelf residence time equivalent to the mean residence time of eddy events, or approximately 2 weeks. Upwelling in the cold-core transports deeper, nutrient enriched Gulf Stream waters into the euphotic zone. The annual nutrient input to the Georgia shelf waters by this process is estimated as 66,000 tons/year, which is about a factor of three greater than all other nitrogen sources combined. Currents at mid-shelf indicate a subtidal response that is primarily wind driven, following Ekman frictional equilibrium dynamics.

13. BAROCLINIC AND BAROTROPIC INSTABILITIES OF COASTAL CURRENTS

E. E. Johnson and L. A. Myers -- Department of Mathematics and Oceanography, University of British Columbia, Vancouver, B.C., Canada.

The baroclinic instability model of the California Undercurrent from Myak (1977) is modified to investigate the effects of the lateral boundary conditions on the stability properties of the system. As is common in baroclinic instability calculations, Myak (1977) assumes the flow to be bounded laterally by vertical rigid walls, thus allowing the cross-stream structure of the flow to be decomposed into a series of simple normal modes. Instability then occurs when waves of the same cross-stream structure interact. The dominant instability is that associated with the gravo mode. In the first model presented here we consider the effect of replacing the rigid outer boundary of the flow with a quiescent, constant depth ocean of infinite horizontal extent. Waves of short longshore wavelength are not greatly affected by the open seaward boundary. However, as consideration is turned to waves of longer longshore wavelength, the cross-stream wavenumber departs farther from the finite length of the channel and another series of numerical experiments occurs due to interaction between waves of differing cross-stream structure. Nevertheless, the dominant baroclinic instability remains that associated with the gravo mode. A new barotropic instability is also presented, drawing energy from the horizontal shear between the coastal current and the quiescent ocean.

In the second model the rigid outer boundary is retained but the inner boundary is replaced by a shallow sloping region, modelling the effects of a sloping shelf adjusting the coastal current against the pressure gradient above the sloping inshore region. The waves are coupled with the channel waves. Once again the cross-stream wavenumber departs from the integral values of the channel problem and instabilities are present due to interaction between waves of differing cross-stream structure. As in the first model, the dominant instability is that associated with the gravo mode.

Recent satellite images of the North Pacific show several northward moving eddies over the continental slope region. Their propagation speed, growth rate and wavelength are in good agreement with those predicted by the above models.

15. THREE-DIMENSIONAL STRUCTURES OF GRAVITY CURRENTS IN A ROTATING BASIN

Masahiro Endoh -- NASA, Wallops Flight Center, Wallops Island, Virginia 23337, U.S.A. (on leave from Ocean Research Institute, University of Tokyo, Nakano, Tokyo 164, Japan)

Gravity currents caused by a lateral buoyancy flux in a rotating fluid are studied by numerical and laboratory experiments. Buoyancy flux is given by heating the near surface fluid in a limited area on one side of a circular basin. Time-dependent structures of flow pattern, density field and dynamical balance of terms are described.

Within a rotational time scale, the light water makes a clockwise turn beyond the buoyancy source with the anti-clockwise basic rotation. After the formation of the clockwise circulation, the light water is advected to the right-hand side (seen from the buoyancy source) and guided by adiabatic form a boundary current whose width is the internal radius of deformation. As an application of the analysis of the case for a single buoyancy source, structures of a thermal front produced by two sources of buoyancy (heat flux in one side and salinity flux in another end) in a rotating straight channel are studied. If the sum of the internal radii of deformation for two buoyant waters is greater than the width of the channel, the dominant circulation in the vertical plane is a thermal front is maintained. Otherwise, the horizontal circulation dominates and effectively mixes the warm water with the cold-water in the center of the channel.
16. A MODEL OF SECONDARY UPWELLING OVER THE SHELF BREAK
John A. Johnson - School of Mathematics and Physics, University of East Anglia, Norwich NR 4 7TJ, England

Over the shelf the flow driven by the surface wind stress spins up rapidly with a spin-up time of a few days. In the deep water the circulation spins up only slowly over a seasonal period. This difference in time scales must be taken into account when matching deep ocean and shelf models.

At the edge of the shelf over the shelf break a shear region often forms in which the two circulations merge and in which secondary upwelling may occur. In an unsteady model of this situation it is found that the strength of the secondary upwelling is proportional to the longshore component of the wind stress and the change in bottom gradient near the shelf break and inversely proportional to the depth of the shelf.

2. THE USE OF UNITS AND NOMENCLATURE IN PHYSICAL OCEANOGRAPHY
R. W. Stewart - Institute of Ocean Sciences, P. O. Box 6000, 9860 West Saanich Road, Sidney, B. C. V8L 4C2, Canada

Physical oceanographers have never been an isolated community. There has always been a considerable flow back and forth between oceanography and meteorology. As a branch of fluid mechanics, there has been an appreciable interaction with other branches of that discipline. In the form of geophysical fluid dynamics, there has been a strong connection with applied mathematicians, particularly in the United Kingdom. Despite these interactions, oceanography has developed a language and a jargon of its own. LAPSO established its Sun Committee in order to examine the wisdom and validity of these units and of this jargon.

The subject addressed by the Sun Committee is that of communication—surely one of the most important subjects for any science. Each time we use a narrow jargon, we reduce the audience to which we can communicate. Each time we use an unfamiliar unit we make it difficult for some portion of our audience. It is incumbent upon us to try to avoid jargon, to avoid jargon, to avoid jargon, to avoid jargon.

So, we have the following recommendations:

1. Use SI units.
2. Use SI prefixes.
3. Use SI units in the oceanographic literature.
4. Use SI units in the classroom.
5. Use SI units in the lab.
6. Use SI units in the field.
7. Use SI units in the computer.
8. Use SI units in the presentation.
9. Use SI units in the discussion.
10. Use SI units in the writing.

The SI units are:

- Length: metre (m)
- Mass: kilogram (kg)
- Time: second (s)
- Temperature: kelvin (K)
- Electric current: ampere (A)
- Amount of substance: mole (mol)
- Luminous intensity: candela (cd)

The prefixes are:

- Deci (d): 0.1
- Centi (c): 0.01
- Milli (m): 0.001
- Micro (μ): 0.000001
- Nano (n): 0.000000001

The SI units are used in all scientific fields, including oceanography, to ensure consistency and clarity in communication.
4. CONDUCTIVITY, SALINITY AND TEMPERATURE RELATIONSHIP—EXPERIMENTAL DATA

Alain Poisson — Laboratoire de Physique et Chimie Marines, Université P. et M. Curie, tour 244, 4, place Jussieu, 75230 Paris Cedex 05, France

The conductivity ratio of diluted or evaporated standard seawater has been measured at temperatures from -1°C to 30°C, and salinity from 0 to 42‰.

These measurements have been made with a Jones-type bridge and Jones-type conductivity cells with bright electrodes. The determined resistance $R$ is the resistance obtained by the well-known extrapolation method of $R = R_{1}(w)$ where $w$ is the frequency of the current.

The data obtained at 15°C, have been fitted in a polynomial

$$ S = 35 [A_{1}(R_{15}^{1/2} - R_{15}) + A_{2}(R_{15}^{1/2} - R_{15}) + A_{3}(R_{15}^{3/2} - R_{15}) + R_{15}] $$

whose standard deviation is 5.10^4 ‰.

All the data have been fitted in a polynomial

$$ S = 35 [A_{1}(R_{i}^{1/2} - R_{i}) + A_{2}(R_{i}^{1/2} - R_{i}) + R_{i}] $$

$$ + R_{i}(R_{i} - 1)(t - 15) [B_{3} + R_{i}^{1/2}(B_{4}R_{i} + B_{2}) + t R_{i}^{1/2} (B_{3} t + B_{4} R_{i}^{1/2})] $$

whose standard deviation is 1.0 10^3 ‰.

These data have been used, with data measured by Dauphinée (in preparation) to establish the new "Practical Salinity scale 1978."  

5. THE PRACTICAL SALINITY SCALE (1978)

E. L. Lewis — Frozen Sea Research Group, Institute of Ocean Sciences, P. O. Box 6090, 9860 West Saanich Road, Sidney, B.C. V8L 4B2, Canada

A historical presentation of existing definitions of salinity and their problems is given. The published data bases for present salinity algorithms are reviewed and their inadequacy is noted when used to reduce data from conductivity-temperature-depth (CTD) instruments. The requirements for a new salinity scale that would be consistent throughout the full oceanic range and yield unambiguous densities under conditions of variation in ion content are explored. New data bases are listed and discussed. Finally, the definitive equation for the "practical salinity scale 1978" is given, together with the secondary relationships necessary for CTD data reduction.

6. TABLE OF SYMBOLS, UNITS AND NOMENCLATURE IN MARINE OPTICS

A. Morel — Laboratoire de Physique et Chimie Marines, La Deme, F-66230 Villefranche-sur-Mer, France, and R. C. Smith — Visibility Laboratory, Scripps Institution of Oceanography, La Jolla, California 92036, U.S.A.

The document presents fundamental terms describing the transfer of radiant energy, and relevant optical properties of natural waters. It is divided into four parts, respectively dealing with:

(1) fundamental quantities of electromagnetic radiation.
(2) quantities describing the underwater radiant energy.
(3) material characteristics.
(4) inherent optical properties of natural waters.

The photometric (luminous) quantities are not defined, only radiometric quantities are considered.

The statements in the definition column are given merely for identification. They are not intended to be complete or perfect definitions. When necessary or useful, the statements are followed by basic relations involving the defined quantities. The symbols and units are based upon and are in agreement with the International System of Units. (Quantities and Units of light and related electro-magnetic radiations, International Standards ISO 31(VI-1973), English and French versions.)

For the more specifically oceanographic quantities, the definitions adopted are based upon the recommendations formulated in 1964 by the Committee on Radiant Energy in the Sea, set up by IAPSO, which to some extent, follow those published by the Commission Internationale de L'Eclairage (1957). With respect to the previous IAPSO terminology, new definitions have been introduced, some have been modified and a few suppressed.

7. DENSITY OF SEAWATER AS A FUNCTION OF SALINITY AND TEMPERATURE

Alain Poisson and Christian Brunet — Laboratoire de Physique et Chimie Marines, Université P. et M. Curie, tour 244, 4, place Jussieu, 75230 Paris Cedex 05, France

Density of seawater has been measured with a high accuracy of temperatures from 0°C to 30°C, and salinity from 0 to 42‰ at atmospheric pressure.

A first set of measurements has been made at 35 ‰ on standard seawater with an hydrostatic balance with an accuracy evaluated to ±2 10^{-6} g/cm^3. These data have been fitted in a polynomial

$$ \rho - \rho_0 = A_0 + A_1 T + A_2 T^2 + A_3 T^3 $$

where standard deviation is 2.7 10^{-6} g/cm^3.

A second set of measurements has been made on diluted or evaporated standard seawater with a vibrating densimeter standardized by standard seawater (and polynomial 1 above) and distilled water (S.M.O.W. equation). All the data have been fitted in a polynomial

$$ 10^3(\rho - \rho_0) = \frac{3}{35} \sum_{i=0}^{j} A_i T^i + S(S-35) \sum_{i=0}^{j} B_i (S-35)^i $$

whose standard deviation is 3.2 10^{-6} g/cm^3.

These data are in good agreement with the data of MILLERO (1976) but show a significant deviation with his polynomial at 35 ‰. Significant deviations also occur with KNUDSEN (1901) and with COX et al. (1970).
PS-8 RADIANT ENERGY IN THE SEA
Convenor: André Morel

SESSION 1: Friday, December 14, A.M. (1)
Chairman: André Morel

1. R. C. Smith and K. S. Baker
Middle-ultraviolet radiation and photoinhibition of photosynthesis in natural waters
(Invited paper)

2. N. K. Højerslev (invited paper)
On the origin of yellow substance in the marine environment

3. A. Bricaud, A. Morel and L. Prieur
Spectral analysis of absorption by "yellow substance"

SESSION 2: Friday, December 14, A.M. (2)
Chairman: J. R. V. Zaneveld

4. K. S. Baker and R. C. Smith
The penetration of middle-ultraviolet radiation into natural waters

5. D. Spitzer and H. R. Wernand
Irradiance and absorption spectra measurements in the tropical East Atlantic

6. A. Morel
Depth of euphotic zone, average pigment concentration and primary production efficiency

SESSION 3: Friday, December 14, P.M. (1)
Chairman: Raymond C. Smith

7. J. R. V. Zaneveld (invited paper)
The influence of size and index of refraction on light scattering and attenuation: A new look using an optical settling tube

8. G. E. B. Kullenberg
Quanta and color index measurement in different oceanic areas

9. J. T. O. Kik
Contribution of the particulate and soluble fractions of light absorption in some Australian waters

10. D. Carpenter
Mapping turbidity and chlorophyll with LANDSAT

SESSION 4: Friday, December 14, P.M. (2)
Chairman: G. E. B. Kullenberg

Particle maxima off the West Coast of South America and their relationship with the chemical and hydrographic structure

12. A. Morel and N. K. Højerslev
Conversion of quasi-monochromatic downward irradiance into downward quanta irradiance (370–700 nm)

The measurement of high frequency subsurface upwelling radiation fluctuations

1. MIDDLE-ULTRAVIOLET RADIATION AND PHOTOINHIBITION OF PHOTOSYNTHESIS IN NATURAL WATERS
Raymond C. Smith and Karen S. Baker – Parvities Laboratory – Scripps Institution of Oceanography, University of California – San Diego, 92093, U.S.A.

A quantitative assessment of the photoinhibition of primary productivity of natural phytoplankton populations as a function of dose rates has been made. We have measured the spectral irradiance (including the middle-ultraviolet 280–340 nm) both above and below the ocean surface, and carried out simulated in situ 14C productivity measurements, by both excluding and enhancing middle-ultraviolet (MUV) radiation. Photoinhibition, and debilitating effect of high intensities upon the photosynthetic capacity of chloroplasts, has three aspects: the intensity, the duration of irradiance, and the spectral composition. Qualitative results of several investigators suggest that exposure to MUV has the effect of increasing the degree of photo-inhibition. A spectral weighting function, the relative biological efficiency for photo-inhibition, has been shown to be consistent with these results and indicates the relative spectral efficiency of photo-inhibiting radiation. The significance of these results for global assessment of primary productivity are discussed.

2. ON THE ORIGIN OF YELLOW SUBSTANCE IN THE MARINE ENVIRONMENT
N. K. Højerslev – Institute of Physical Oceanography, University of Copenhagen, Haraldsgade 6, 2200 Copenhagen N., Denmark

Spectral downward and upward irradiance in the range 310–675 nm, spectral absorptance and transmittance within the visible part of the spectrum have been measured in the Baltic, Danish, and Norwegian coastal waters, the North Sea, the waters around the Orneby Islands, the Skelbo Islands, the Faroe Islands, Iceland and, finally, off Western Greenland.

The Baltic is a moderate turbid yellow-green water mass characterized by salinities below 10‰ for very high concentration of yellow substance throughout the year because there is a considerable river discharge to the Baltic combined with a restricted water exchange with the more open Danish sea waters. The Danish and Norwegian coastal greenish waters are generally as productive as the Baltic, salinities are typically between 10–12‰ and the concentration of yellow substance is moderately high throughout the year. The river discharge to these waters has the same magnitude as for the Baltic but the water exchange with the neighboring open sea is free. The water mass between the North Sea and off Western Greenland are all very productive when plankton blooms take place. Their salinities are close to 35‰ except near the coast of Western Greenland where 32‰ is encountered. Although all these waters are green (maximum daytime transmittance around 500 nm) the concentration of yellow substance is strikingly low almost being comparable to the concentrations found in the clearest blue- oceanic waters. The concentration of yellow substance is highest in day-time transmittance around 310 nm expressed as %, the following is valid: The Baltic 3, the Kattegat (a sea area in which Baltic and oceanic water meet) 10–30, the Skelbo Islands 65 and for the waters around the Faroe Islands, Iceland and off Western Greenland 80–85. These high transmission values were observed in temperature ranges from 0–10°C in all areas.

Accordingly, it is unlikely that significant amounts of yellow substance are formed in the sea by chemical breakdown processes of organic matter as earlier believed since they are strongly temperature dependent. Instead, the yellow substance is brought to the sea by river discharge. Consequently, the absorption due to yellow substance is approximately the same in both oligotrophic and eutrophic major open oceanic areas. This is fortunate for remote ocean studies of the open sea because existing algorithms for the retrieval of Chl concentrations cannot separate yellow substance and chlorophyll.

3. SPECTRAL ANALYSIS OF ABSORPTION BY "YELLOW SUBSTANCE"
A. Bricaud, A. Morel and L. Prieur – Laboratoire de Physique et Chimie Marines, Université Paris et Marie Curie (Paris 6) F 75005, 75005, France

Spectral variations of absorption in the 300–700 nm wavelength domain by dissolved organic matter have been measured on 105 filtered sea water samples. They originate from diverse parts of the ocean and are quite different with respect to algae pigments and particle content. Use of 110 cm cells, two of 10 cm cells with a highly sensitive spectrophotometer allowed measurements to be made throughout the UV-visible range, even for low concentrations of dissolved "yellow substance" (YS), as encountered in the open sea, not influenced by land drainage. In open sea, the rather low amount of YA, which supposedly results from biological activity, gives typical absorption at 375 nm ranging from 0.1 to 0.3, or 0.04 to 0.08 at 440 nm. However, these values, at least of the same order as the absorption values by phytoplankton if its concentration is around 1 mg Chl a m–3. The amount of YA seems poorly correlated to phytoplankton as well as non-living particles contents.

High absorption were observed in some coastal areas when influenced by natural land run-off, by eutrophication and also by industrial and anthropogenic discharges. In all cases, the approximate exponential decrease in absorption from 280 nm to 700 nm appeared to be a semi-circle. The best fit for the spectral domain 310–700 nm leads to the relationship: a(λ) = a0(λ) - exp(λ-S) where S, the slope coefficient varies only in a restricted range between 0.0145 and 0.0025. This expression allows absorption coefficients to be extrapolated with a reasonable accuracy, throughout the visible part of the spectrum, from a single measurement.
made in the near UV (between 350 and 400 nm), where the absorption is higher and thus more easily measured. A rapid estimate of the VS content can be made on board by this method, which avoids storage problems and makes routine measurements feasible, in view of optical-biological studies or of obtaining "sea-truth" values in remote sensing programs.

4. THE PENETRATION OF MIDDLE ULTRAVIOLET RADIATION INTO NATURAL WATERS

Karen S. Baker and Raymond C. Smith — Vlittl Library, Scripta Institution of Oceanography, University of California, San Diego, La Jolla, California 92033, U.S.A.

Present-day levels of middle-ultraviolet radiation (MUV), the spectral region from 300 to 340 nm, have ecological importance because surface waters in oceans and lakes permit the penetration of MUV to depths allowing damage to near surface organisms. There is concern that an increase in the incidence of solar UV radiation upon these natural waters, as a consequence of anthropogenic modification of the ozone layer in the stratosphere, might well have an additional effect upon primary producers and other aquatic organisms. We have measured the penetration of MUV radiation into natural waters, as a function of the concentrations of chlorophyll and dissolved organic material, and present our results in a form that is useful for assessing the potential impact of increased MUV radiation.

5. IRRADIANCE AND ABSORPTION SPECTRA MEASUREMENTS IN THE TROPICAL EAST ATLANTIC

D. Spitzer and H. R. Wernand — Netherlands Institute for Sea Research, P. O. Box 59, Texel, The Netherlands

Apart from the measurements of the photosynthetic available radiation (PAR), measurements of the ambient irradiances and distributions at diurnal and local scales are necessary for the study of marine photosynthesis. Also, important differences about vertical and horizontal distribution and composition of suspended particles and dissolved organic matter can be drawn when spectral data and particularly absorption spectra in situ are available.

Optical and radiometric measurements of refracted and reflected irradiances and solar and scalar irradiances at different depths. Using the integrated radiative transfer equation, the absorption coefficients can be then calculated. The instrument employs spherical integrators interlinked by an integrating sphere, and a monochromator with 20 interference filters between 350 and 700 nm. Because of its moderate dimensions and weight (55 cm length, 20 cm diameter, 8 kg), the instrument can be easily handled and operated even when the sea-state conditions are not very favorable. Solar and vector irradiance and hence the absorption spectra can be recorded within a few minutes.

Extensive error analysis of both the instrument and the method has been performed. Total error was estimated to be less than 20%.

Spectral irradiance measurements together with photon scalar irradiance (PAR) measurements were performed in regions of the eastern Tropical Ocean with various concentrations of suspended biological particles. By both methods evident vertical stratification in the photosynthetically active material was demonstrated and confirmed by fluorometric measurements. Also, variations of the absorbing properties of the suspensions were found. The absorption coefficients calculated from the spectra of the acetone extracts of filtered particulate matter collected at different stations and depths. Relationship between irradiance attenuation and absorption coefficients and chlorophyll concentration is discussed. A large number of collected optical data allows optical classification of the euphotic zone of the investigated regions.

6. DEPTH OF EUHOTIC ZONE, AVERAGE PIGMENT CONCENTRATION AND PRIMARY PRODUCTION EFFICIENCY

A. Morel — Laboratoire de Physique et Chimie Marines, Université Pierre et Marie Curie, U.E.R., 96, Promenade des Planches-sur-Mer, Fréjus, France

The depth of the euphotic layer, Z (%)—where the photosynthetic available radiation, in quanta and for the 370 to 700 nm wavelength domain is reduced to 1% of its surface value—varies from 5 to 130 meters in the data set used in the present study. The average pigment (Chl a + Phaeo a) concentration is computed within this layer. The values obtained, [Pg], which vary over more than 2 orders of magnitude, are plotted versus Z (%). On such a plot, the coastal waters, when attenuation

mainly results from suspended sediment and/or yellow substance, are clearly separated from the open ocean. A partial second axis for which attenuation is governed by the algal blooms and its associated biogenous by-products.

By considering the oceanic waters only, a highly significant relationship between the log-transformed Z (%) and [Pg] is found. The existence of such a spectral attenuation coefficient for photosynthetic quanta and for the whole euphotic zone—is not linearly correlated with pigment concentration. At least, two main causes may be invoked to account for this nonlinear effect: i) the variation in the effective absorption coefficient of phytoplankton with the spectral composition of the underwater light field; and ii) the variation in the relative proportions of living and detrital material.

The energy storage by primary production within the euphotic zone is described by the biogeochemical class efficiency, ε, a ratio of the photosynthetic stored radiant energy per day and total incident radiation also per day. For oceanic waters, ε increases over 2 orders of magnitude when Z (%) decreases from 110 to 10 meters. However, the scatter of the points in the ε - Z (%) diagram (even if disregarding the coastal anomalous waters) prevents obtaining a significant relationship. Nevertheless, an upper limit, which would correspond to favorable nutritional and physiological conditions, can be established.

7. THE INFLUENCE OF SIZE AND INDEX OF REFRACTION ON LIGHT SCATTERING AND ATTENUATION: A NEW LOOK USING AN OPTICAL SETTLING TUBE

J. Ronald V. Zaneveld — School of Oceanography, Oregon State University, Corvallis, Oregon 97331, U.S.A.

An optical settling tube has been constructed that measures the increase in transmission as the various particle sizes in a well-mixed sample settle out. By assuming an attenuation efficiency of two (the asymptotic value for particles much larger than the wavelength of light) the particle settling rate distribution can be determined. Conversely, if the particle size distribution is known (by means of a Coulter Counter and Stokes' settling is assumed, the attenuation efficiency curve can be reconstituted. The attenuation efficiency curve permits one to study the complex index of refraction of particulate matter. The inverse scattering problem, that is, the determination of the index of refraction distribution of a collection of suspended particles when their scattering characteristics are known, has been shown to be difficult as the minimum is not well defined. The settling tube method bypasses many of these problems by permitting study of a small size class of particles. Preliminary results will be shown for latex spheres, a phytoplankton bloom, and resuspended sediments.

8. QUANTA AND COLOR INDEX MEASUREMENT IN DIFFERENT OCEANIC AREAS

G. E. B. Kullenberg — Institute for Physical Oceanography, University of Copenhagen, Hørsholmvej 5, 2200 Copenhagen N., Denmark

Thin light conditions have been studied by means of quanta and color index measurements in the northwest Atlantic and Peru upwelling areas, in the Drake Passage, especially in the Antarctic Polar Front zone and in the Southern Ocean between New Zealand and Antarctica. The same techniques have been used for all the observations, with a Jenoptek quantum meter integrating between 400 (350) and 700 nm and the color index defined as the ratio between the upwelling light, at about 1 m depth, around the wavelengths 450 and 520 nm. The results show large differences between the various areas. In the upwelling areas the 1% quanta depths were typically between 30 and 20 m, occasionally even shallower. The color index varied between 0.1 and 1.0, typical of high productive areas. In the Peru area, a fairly well-defined relationship between the index and the chlorophyll a concentration in the surface layer was indicated. In the Southern Ocean section from New Zealand the index varied between 0.5 and 2.0, generally with the lowest values in the northern area. The 1% quanta depths were found between 60 and 80 m. These appeared to be a general decrease of quanta levels from north and south, in the interval 46°S to 64°S latitudes.

In the Drake Passage the 1% quanta depths were found between 65 and 80 m. The color index was in the interval 2.5 to 3.0, with some exceptions as low as 1.5.
9. CONTRIBUTION OF THE PARTICULATE AND SOLUBLE FRACTIONS TO LIGHT ABSORPTION IN SOME AUSTRALIAN WATERS

T. O. Kirk - Division of Plant Industry, CSIRO, P. O. Box 1600, Canberra, A.C.T. 2601, Australia

A method has been developed for measuring the absorption spectra, and calculating the in situ absorption coefficients, of the particulate fraction (trichoplankton) and the soluble fraction of natural waters. The procedure involves concentrating the particulate fraction by filtration followed by resuspension in a smaller volume, and measurement of the absorption in a large integrating sphere, to minimize the effects of light scattering. The method has been applied to seven inland water bodies in the southern tablelands of New South Wales and the Australian Capital Territory. The in situ absorption coefficients, and the soluble colouring material (gluvin, gelbstoff) have also been measured. The absorption coefficients have been used to calculate what part of the total absorbed photosynthetically active radiation (PAR) is captured by each of the three major absorbing components. In clear, rather colourless waters, the major PAR absorber is the soluble material. In slightly more turbid waters, the inorganic particulate fraction (trichoplankton) is the greatest absorber. In highly turbid waters the particulate fraction (consisting mainly of trichoplankton) is the dominant light absorber, in addition to being the most important light scatterer.

10. MAPPING TURBIDITY AND CHLOROPHYLL WITH LANDSAT

David J. Carpenter - School of Applied Sciences, Canberra College of Advanced Education, and Department of Engineering Physics, Australian National University, Australia; and Susan M. Carpenter - CSIRO Division of Mathematics and Statistics, Canberra, Australia

Recent LANDSAT MSS data acquisitions of the Canberra region have been accompanied by the collection of water quality data at several sampling sites on four lakes; the variables measured being chlorophyll a, turbidity and water quality characteristics. In general the LANDSAT bands represent a wide variety of water types, from shallow to turbid well. The data have been used to map the distribution of water quality characteristics. These data have been used in the study of the spatial and temporal variation of water quality characteristics.

11. PARTICLE MAXIMA OFF THE WEST COAST OF SOUTH AMERICA AND THEIR RELATIONSHIP WITH THE CHEMICAL AND HYDROGRAPHIC STRUCTURE

Haonung Pak and Ronald Y. Zaneveld - School of Oceanography, Oregon State University, Corvallis, Oregon 97331, U.S.A.; and L. A. Copley - Department of Oceanography, University of Washington, Seattle, Washington 98195, U.S.A.

The distribution of suspended particulate matter was measured during May 21–June 18, 1977, at approximately 4°S, 5°S, and 21°S from the coast of Peru to about 400 nm offshore. A well-defined particle maxima was observed over the continental shelf at depths of about 200 m between about 5°S and 23°S. At 4°S, the main particle maximum was found at approximately 400 m, but in the nearshore zone the maximum extended upwards to approximately 200 m. A comparison of the particle data with the chemical data shows that the particle maximum is found at approximately the same location as the oxygen minimum zone, at about 200 m. The nitrate and nitroge maximum were concurrently observed at the core depth in the area south of 10°S. North of 10°S, weak nitrate maximum were observed with the oxygen minimum layer at some stations, but this feature and the nitrate maximum were frequently absent. The protein distribution near the coast, which has a maximum in the nearshore, is characterized by a zone of high chlorophyll a concentration. In the region of the particle maximum, chlorophyll a concentration was also found to be high, indicating a probable source of suspended particulate matter and protein, and a sink for dissolved oxygen and nitrate. The offshore transport is more extensive than the nearshore transport and is probably supported by a westward current that is present off northern Peru between 15°S and 20°S, and may contribute to the extension of the Equatorial Undercurrent and the Subsurface South Equatorial Countercurrent.

12. CONVERSION OF QUASI-MONOCROMATIC DOWNWARD IRRADIANCE INTO DOWNWARD QUANTA IRRADIANCE (370–700 nm)

A. Morel - Laboratoire de Physique et Chimi Marine, Université Pierre et Marie Curie (Paris 6), F. 75230 Villeneuve-le-Mont, France; and N. K. Højerslev - Institute of Physical Oceanography, University of Copenhagen, Hørsholmvej 12, 2200 Copenhagen N, Denmark

582 daysight spectra of the downward irradiance have been recorded by means of a French irradiance meter in various seas. On the basis of this data set, statistical relations between the downward irradiance at different wavelengths and with different halfwidths and the downward quanta irradiance (370–700 nm) have been established. They are expressed as: $E_d(\lambda) = P(\lambda)F(\lambda)$, where $E_d(\lambda)$ is the relative quanta irradiance and the relative quasi-monochromatic irradiance at the wavelength $\lambda$ (with 100% above the surface). The factors $P(\lambda)$ and $F(\lambda)$ are tabulated as depth-dependent parameters for the best fit analysis. The optical relations (highest correlation coefficients) are found for $\lambda = 500$ nm (with half width being set equal to 25 nm). Furthermore, a similar but less accurate conversion of downward irradiance into downward quanta irradiance is feasible. This analysis allows one to convert the longwave radiation into downward quanta irradiance (350–700 nm).

Independently of the above statistical investigation based solely on French data, a Danish data set, involving both spectral and monochromatic irradiance as well as downward quanta irradiance (350–700 nm), has been established for different areas in the Caribbean Sea. The Danish data set has been applied to the Danish data set to obtain the relative quanta irradiance at the wavelength $\lambda$ (with 100% above the surface). The factors $P(\lambda)$ and $F(\lambda)$ are tabulated as depth-dependent parameters for the best fit analysis. The optical relations (highest correlation coefficients) are found for $\lambda = 500$ nm (with half width being set equal to 25 nm). This conversion gives sufficiently accurate values for most conversion of marine photosynthesis. The data have been used to map the distribution of upward quanta irradiances in the region of the particle maximum. In the region of the particle maximum, chlorophyll a concentration was also found to be high, indicating a probable source of suspended particulate matter and protein, and a sink for dissolved oxygen and nitrate. The offshore transport is more extensive than the nearshore transport and is probably supported by a westward current that is present off northern Peru between 15°S and 20°S, and may contribute to the extension of the Equatorial Undercurrent and the Subsurface South Equatorial Countercurrent.

13. THE MEASUREMENT OF HIGH FREQUENCY SUBSURFACE UPWELLING RADIANCE FLUCTUATIONS


Upwelling spectral radiance is a function of both the total amount and the vertical distribution of chlorophyll-a in the ocean. Vertical and horizontal displacements of the local chlorophyll-a distribution due to internal waves and current shear, produce rapid fluctuations in the upwelling radiance. Understanding the relationship between upwelling radiance and such displacements allows one to more accurately predict the local surface and subsurface physical oceanographic state.

A subsurface instrument array was constructed consisting of three spectroradiometers and three vertically distributed thermostate sensors. Supporting instrumentation included a photometric integrating sphere, a spectroradiometer, fluorometer, transmissometer, current meter, and conductivity/temperature/depth probe.
Two spar buoys and a ship formed a fixed triangle supporting the instruments in a position fixed relative to the water column by use of an 85-foot diameter sea anchor. One spar held two spectroradiometers at different depths in positions above the chlorophyll layer and an 18-element thermistor string. The second spar buoy held the third spectroradiometer and a similar thermistor chain. The third thermistor chain was suspended from the ship as was the other subsurface instrumentation.

The spectroradiometers each contain a 5-filter wheel which is scanned upon control by a linked subsurface and shipboard microprocessor. The filter wavelengths used were 430, 450, 490, and 550 nm with the fifth position used to monitor dark current. Both up and down mirror positions allowed the upwelling radiance (10º P0V) and downwelling irradiance to be scanned. Full spectral scans were made in approximately 1 minute. All data were recorded on magnetic tape with HP-2100 minicomputer system.

Two sea trips were made in May and June 1979 off the Southern California coast. Both intermittent profile and time series data were taken with all instrumentation. A chlorophyll layer was found at a depth of approximately 20 m, which peaked between 3 and 5 times the surface concentration of approximately 0.5 mg/m³.

Upwelling spectral radiance measurements are compared with model calculations based on measured chlorophyll profiles. Power spectral density and cross correlation analyses of the vertical displacement and spectral radiance time series data are discussed. Adaptive filtering techniques are described which reduce surface wave and cloud input downwelling radiance noise. Correlations of the above with fluorometer and transmissiometer data are also made to infer the horizontal spatial chlorophyll variance.

PS-9 MARINE POLLUTION TRANSFER PROCESSES
Convener: G. B. Kullenberg

SESSION 1: AIR-SEA EXCHANGE
Tuesday, December 4, A.M. (2)
Chairman: G. B. Kullenberg

1. P. S. Liss
   Air-sea exchange of gaseous pollutants and processes generating this exchange

2. R. A. Duce, B. J. Ray, C. K. Usui, P. J. Harder and J. L. Fasching
   The atmospheric concentration of heavy metals over the Pacific and their exchange with the ocean

SESSION 2:
Tuesday, December 4, P.M. (1)
Chairman: R. Cheselet

   The BIMS—an in situ device for measuring material fluxes from the ocean to the atmosphere

   Global cycling of mercury in the marine atmosphere and its exchange with the oceans

   Sources and transport characteristics of some anthropogenic organics in the marine atmosphere

SESSION 3:
Tuesday, December 4, P.M. (2)
Chairman: R. Duce

6. O. C. Zaia, R. B. Gagosian and E. T. Peltier
   Preliminary measurements of organic compounds in the marine atmosphere and their exchange with the ocean

   R. Duce
   Preliminary data from electron microscopy and carbon isotopes mass spectrometry related to the air-sea exchange processes

SESSION 4: COASTAL ZONE PROBLEMS
Wednesday, December 5, A.M. (1)
Chairman: M. J. Orren

8. M. Waldichuk
   The transfer of metals from mine tailings to seawater and biota in the marine environment

9. G. Han and D. V. Hansen
   The effects of dissolved oxygen and water transport on oxygen depletion in the New York Bight

10. H. Nakata and T. Hirano
    Physical processes of pollutant transport in the inland seas

SESSIONS 5 and 6: OCEAN
Wednesday, December 5, P.M. (1)
Chairman: M. Mork

11. M. Mork
    Transport in coastal areas with special reference to the Norwegian coastal current

12. G. E. B. Kullenberg
    Physical transport processes and mixing

13. Y. Sugimura, Y. Miyake and Y. Suzuki
    A study of dissolved metallic elements in the Southern Ocean waters

SESSION 7:
Wednesday, December 5, P.M. (2)
Chairman: P. S. Liss

14. M. J. Orren
    Chemical processes and interaction influencing pollutant transfer

15. P. Buit-Mérard and R. Cheselet
    A comparative study of particulate trace metal chemistry in the open ocean and western Mediterranean

    Content of 137Cs, plutonium and americium isotopes in the Southern Ocean waters

SESSION 8:
Thursday, December 6, A.M. (2)
Chairman: M. Waldichuk

17. J. Farrington, J. Teal and B. Tripp
    Experimental studies of hydrocarbons in benthic animals and sediments

18. R. V. Zawelch
    Processes influencing the distribution of suspended matter in the ocean

    M. Waldichuk
    General discussion and summing up
1. AIR-SEA EXCHANGE OF GASEOUS POLLUTANTS AND PROCESSES
GENERATING THIS EXCHANGE
P. S. Liss — School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ, U. K.
Perhaps the most important objective for studies of the behavior of gases at the air-sea interface is to be able to calculate gas fluxes between the atmospheric and oceanic reservoirs. The flux of any gas across the sea surface will be given by the product of the air-water concentration difference driving the flux and a transfer function (often called the transfer velocity) which quantifies the rate at which the exchange will occur. An important way of calculating fluxes is thus to try to specify these two parameters.
For gases of high solubility in water and/or undergoing rapid chemical reactions in the aqueous phase it can be easily shown that processes in the air near the interface control the rate of exchange, and to specify the transfer velocity for gases of this type a rather large body of micro- and mesoscale meteorological knowledge is available. The situation for gases of low aqueous phase solubility and which are unsaturated in water, for which processes in the near-surface water are rate controlling, is less satisfactory. For example, wind tunnel experiments have shown that for these gases the transfer velocity increases either as a linear function of wind speed, whereas field studies using the Radon Deficiency Method show little or no relationship between these variables. Although such difficulties cannot presently be resolved, it turns out that the greatest uncertainty in air-sea gas exchange calculations arises from the inadequacy of gas concentration measurements in the two phases. Despite their shortcomings, the calculated fluxes appear to have important implications for the cycling of both natural and pollutant gases in the atmosphere and in the oceans.

2. THE ATMOSPHERIC CONCENTRATION OF HEAVY METALS OVER THE PACIFIC AND THEIR EXCHANGE WITH THE OCEAN
As part of the Sea/ Air Exchange (SEAREX) Program, the atmospheric particulate concentrations of the metals Fe, Al, Sc, Mn, Pb, Se, Sb, V, Cu, Zn, Cd, Ag, Co, Ni, Ca, Mg, and K have been determined in samples collected from a 20-meter high walk-up tower located on the windward coast of Bokandretok Island, Eniwetok Atoll, Marshall Islands, 11°11', 162°4'. These samples, along with a limited number of rain and dry deposition samples, were collected during March-May 1979, part of the long dry season. Additional samples were collected during June-August 1979, part of the wet season. These samples were taken until a combination of instrumental neutron activation analysis and atomic absorption spectrophotometry. Some of these tracer elements present in the Eniwetok atmosphere are clearly derived primarily from the ocean surface (e.g., Na, Mg, K, Ca) and others primarily from crustal weathering processes in continental areas (e.g., Al, Fe, Sc). The sources for some other elements are not as clear, with possibilities including pollution, volcanoes, and various marine and terrestrial biological processes. Atmospheric concentrations of the non-marine derived elements at Eniwetok are in general several times lower than those observed on windward Oahu, Hawaii, 21°15', 158°W. Rain samples were collected at Eniwetok using a scavenging cloudly closed polystyrene collector exposed only during rainfall. Dry deposition samples were collected with a similarly cleaned cloudly closed polystyrene plate which was covered during rainfall. A first approximation of the relative importance of gross dry versus wet deposition for these metals from the atmosphere to the ocean surface has been determined. Washout factors and dry deposition velocities have been determined from these data. From this information estimates can be made of the significance of atmospheric input as a source for metals in the surface waters of this region of the mid-Pacific Ocean.

3. THE BIMS - AN IN SITU DEVICE FOR MEASURING MATERIAL FLUXES FROM THE OCEAN TO THE ATMOSPHERE
There is evidence that the trace metal composition of atmospheric sea-salt particles produced by oceanic sources may be significantly different from bulk seawater. The magnitude of the ocean-to-atmosphere flux of trace metals is unknown. However, it must be evaluated to assess accurately the input of continentally derived trace metals to the atmosphere to the ocean—a major objective of the Sea/ Air Exchange (SEAREX) Program. The Bubble Impingement Multiple Sampling (BIMS) was designed and constructed to evaluate these upward fluxes and the apparent chemical fractionation processes occurring during bubble bursting. The BIMS is a one meter square truncated pyramid suspended between the bulbs of a 5-meter long cantilever. The in-situ generation of atmospheric sea-salt particles is accomplished by pressurizing six 1.50 nm (2.3) sea-salt aerosols that are adjustable for bubbling depth down to one meter. The sea-salt aerosols are collected at the top of the pyramid on a high volume Whattman 41 filter. The atmosphere of the pyramid is isolated from the ambient atmosphere and a new water surface (microlayer) continuously flows over the glass filter. The BIMS was used on a SEAREX Cruise on R/V ENDEAVOR in July, 1979 to collect artificially generated aerosol samples from the Sargasso Sea at ~35°N, ~65°W. The samples were immediately preserved by freezing until subsequent analysis by atomic absorption spectrophotometry and neutron activation analysis. The results of these analyses can be best understood by calculating enrichment factors (EF Na) where:

\[ EF_{Na}(X) = \frac{(X)_{\text{Na}}}{(X)_{\text{Na}}} \times 100 \]

where X is any given element. EF Na values have been determined for Mg, Fe, Al, Cu, Zn, Cd, Se, and Pb. The importance of the Sargasso Sea as a source for atmospheric trace metals can be estimated using the EF Na values and estimates of the atmospheric sea-salt production in this area. The implications of these estimated fluxes from the ocean to the atmosphere will be discussed.

4. GLOBAL CYCLING OF MERCURY IN THE MARINE ATMOSPHERE AND ITS EXCHANGE WITH THE OCEAN
This year, investigations of Hg in the near surface atmosphere and in rainwater have been conducted during the dry (April-May) and wet (June-August) seasons at the SEAREX tower facility on Eniwetok Atoll, Marshall Islands. Shipboard determinations of Hg in marine air are also underway and also were made in the northeast Atlantic Ocean on a SEAREX cruise of the R/V Endeavor (July 7-27, 1979). The distribution and chemical composition of atmospheric Hg were examined using both Au amalgamation and carbon monoxide trapping agents. Mercury (Hg) was determined by an Au amalgamation flameless atomic absorption technique (4% precision ± 0.5 ng). Mercury determinations in rainwater were made by the Au amalgamation procedure after reduction and addition.
"In summary: (1) Most of the near-surface atmosphere Hg species over the open ocean regions investigated are in the vapor phase (≈99%). At Eniwetok, for example, during the dry season, vapor phase Hg varied between 0.5-12.4 x 10^-6 g/m^3, while the particulate Hg concentration was between 0.4-0.7 x 10^-3 g/m^3. (2) Diurnal cycling of Hg in the marine atmosphere was generally evident with the highest Hg concentrations occurring during the daylight hours. The mean background concentrations of Hg were found in the air over both ocean regions. (3) Selective adsorption experiments indicate the presence of the marine atmosphere of gaseous organic Hg compounds. (4) Preliminary rainwater Hg analysis indicate that the concentrations of Hg in open ocean rain will be higher than expected (>10 ng/L)."
5. SOURCES AND TRANSPORT CHARACTERISTICS OF SOME ANTHROPOGENIC ORGANIC COMPOUNDS IN THE ATMOSPHERE

C. S. Gian, E. L. Atlas, R. J. Leonard, K. S. Sullivan and G. S. Niel -- Department of Chemistry, Texas A&M University, College Station, Texas 77843, U.S.A.

Samples of air have been collected from urban, coastal and remote marine sites. Analyses of these samples for dialkyl phthalate plasticizers and chlorinated hydrocarbons were performed. Generally, organics were found in two seasonal cycles: one in the spring and the other in late autumn.

The air samples were collected using a special collection system designed to minimize contamination. The samples were analyzed using gas chromatography and mass spectrometry.

6. PRELIMINARY MEASUREMENTS OF ORGANIC COMPOUNDS IN THE MARINE ATMOSPHERE AND THEIR EXCHANGE WITH THE OCEAN

Oliver C. E. Ashby, Robert R. L. Gage, and Edward T. Peltier -- Department of Chemistry, Wood Hole Oceanographic Institution, Wood Hole, Massachusetts 02545, U.S.A.

As part of the sea-air exchange program (SEAREX), we have collected two suites of air and precipitation samples from the remote waters of the North Atlantic. The samples were collected in order to study the exchange of organic compounds between the atmosphere and the ocean.

The samples were analyzed using gas chromatography and mass spectrometry. The results show that there is a significant exchange of organic compounds between the atmosphere and the ocean.

7. PRELIMINARY DATA FROM ELECTRON MICROSCOPY AND CARBON ISOTOPE SAMPLING RELATING TO THE SEA-AIR EXCHANGE PROCESSES


Preliminary results obtained during the SEAREX field experiments in 1979 in the tropical North Pacific Ocean suggest that

The transport of continental source aerosols is concluded by measurement of the 13C/12C isotope ratio of particulate organic carbon (POC) as a function of particle size. The isotope ratios show that the large particle component of POC has a marine origin, while the small particle component has a continental origin.

8. THE TRANSFER OF METALS FROM MINE TAILINGS TO SEAWATER AND BIOTA IN THE MARINE ENVIRONMENT

Michael Waldichuk -- Department of Fisheries and Oceans, 4160 Marine Drive, West Vancouver, B.C. V7V 1N6, Canada

The effects of disposal of 60,000 tonnes per day of tailings from a copper-molybdenum mine into Rupert Inlet, on the west coast of the site of a large scale discharge of 6,000 tonnes per day of tailings from a zinc-lead mine into Agfardvikavatn fjord on the central west coast of Greenland. Both bodies of water are quite well oxygenated from top to bottom. They differ somewhat in salinity and temperature, Agfardvikavatn fjord having a higher salinity and lower temperature, being frozen over for at least half a year. Agfardvikavatn becomes vertically mixed in winter when it freezes over, and surface water becomes dense because of salt rejection from the ice. There is an intrusion of dense outside water over the sill at this time of year.

An increase in dissolved Zn, Pb, and Cu in the water of Agfardvikavatn, and in the seaward fjord Qvarnarvik, with a corresponding increase of these metals in fish, mussels and seaweeds have occurred since the mine went into operation. Water runoff from the mine is mixed vertically at the entrance by intense tidal turbulence in Qvarnarvik. Tidal currents, mixing and upwelling in this region cause a resuspension of tailings into the water column. No increase in dissolved heavy metals, however, has been found in the water of Rupert Inlet, comparable to that in Agfardvikavatn. Only a slight increase in the copper content of certain invertebrates has been noticed in areas of Rupert Inlet over where the impact of the mine tailings can be seen.

The various characteristics of the mine waste and of the receiving waters, which may have an effect on release of metals from the tailings into the water, are discussed. It appears that the chemical composition and the physical binding of the metal in the crystal lattice of the material in which the metals are associated in the mill are the most significant in determining the leachability of the metals from the tailings. The physical and chemical characteristics of the seawater are secondary.

9. THE EFFECTS OF DISSOLVED OXYGEN AND WATER TRANSFER ON OXYGEN SATURATION IN THE NEW YORK BIGHT

Gregory Han and Donald V. Hansen -- National Oceanographic and Atmospheric Administration, Atlantic Oceanographic and Meteorological Laboratory, Miami, Florida 33149, U.S.A.

In 1976, a condition of oxygen depletion occurred in a region of the open continental shelf off New York. A region with oxygen concentrations of less than 1 mg/l extended over 100 km from the New Jersey coast. The condition was due to the condition, as described by McRoy and Silverman in (1976), a large bloom of Ceratium tripos over the entire shelf, a warm spring with high river runoff, and strong, persistent southwest winds.

The transport of oxygen to the shelf was computed by a diagnostic model using observed current velocity and density data. The model is a steady-state solution of the linearized momentum equations with a linear bottom friction component using a finite element technique. Four patterns were used to approximate the transport over a 25-day interval spanning the period of the event. Two of the patterns were determined as being the best. The first pattern was used to compute the transport from the shelf to the ocean and the second pattern onshore. The transport from the shelf to the ocean was estimated to be 200 kg/m²/s.

The oxygen utilization, calculated from the observed oxygen decrease and the convergence of oxygen flux, was 0.17 mg/l/day. The respiration of the observed Ceratium tripos, with concentrations over 100 cells/ml, was the only oxygen sink of sufficient strength (0.40 mg/l/day) to utilize the available oxygen supply. The low oxygen condition was thus apparently caused by a large input of carbon from outside the region rather than from anthropogenic sources.
10. PHYSICAL PROCESSES OF POLLUTANT TRANSPORT IN THE INLAND SEAS—A REVIEW OF THE RESEARCHES IN THE SETO INLAND SEA, JAPAN

Hideki Nakata and Toshiyuki Hirano — Ocean Research Institute, University of Tokyo 15-1, 1-chome, Minamidai, Nakano-Ku, Tokyo 164, Japan

The dispersion of pollutants are generally governed by the processes of advection and diffusion in the sea. In the coastal regions, particularly, the influences of several elementary processes like tidal currents, density currents, wind driven currents, etc., become important in the spreading and dilution of the pollutants.

In this paper, we discuss our recent research activities on the transport and diffusion of sea water mass in the Seto Inland Sea using plastic drift cards, current drogues and uranin dyes and also review the present status of the researches on this problem in this area.

The Seto Inland Sea is very important for fisheries in Japan. But the problem of environmental pollution has affected this sea recently due to the tremendous industrial development.

Inlet researches on the mixing processes in the Seto Inland Sea have mainly been continued by experimental studies using hydraulic models and mathematical simulations. The first contribution to these model studies was made by Hayamizu et al., in 1970, and they found that the Seto Inland Sea water is being transported toward the east through a very long period of time and estimated a horizontal diffusion coefficient of $10^{-3}$ cm$^2$/sec, the most fit to the average distribution of chlorinity.

In further studies, it has been suggested that the mixing processes resulting from the tidal residual circulation and tidal exchange seem to be significant in the transport and distribution of materials in the Seto Inland Sea.

On these circumstances, we made investigations on the actual situation of the movement and exchange of sea water of this area using drifters. About 15,000 plastic drift cards from 30 different points were released, of which 30 to 40% were recovered. Tracking of the current drogues and dye-diffusion experiments were also carried out to obtain detailed information on the dispersion processes.

Some remarkable facts about the advection and dispersion of the surface water, which disagree with the results of the model studies, have been clarified through our investigations. The significant roles of the density currents and wind driven current were also suggested.

12. PHYSICAL TRANSPORT PROCESSES AND MIXING

G. E. B. Kullenberg — Institute for Physical Oceanography, University of Copenhagen, Haraldsgade 6, 2200 Copenhagen N, Denmark

A brief review is given of mixing processes occurring in different zones of the ocean, considering in particular possible energy sources as well as observations of mixing rates. These vary considerably in space and time, and especially the interior mixing rates are compared with those observed in various boundary layers. The mixing along boundaries seems to be considerably stronger than the interior mixing, which nevertheless can be important intermittently. The importance of the small scale features and layered structure often observed in distributions of properties in the sea is considered with reference to the dispersion of contaminants. Examples of persistence and spreading of such layers are given. The rate of deep ocean currents for the transfer of pollutants is briefly considered.

13. A STUDY OF DISSOLVED METALLIC ELEMENTS IN THE SOUTHERN OCEAN WATERS

Yukio Sugimura — Meteorological Research Institute, Kosugi-ku, Sugimura, Tokyo, Japan; and Yosito Miyake and Yoshimi Suzuki — Geochemistry Research Association, Kosugi-ku, Sugimura, Tokyo, Japan

According to our recent study on dissolved metallic elements in sea water, it was found that a considerable part of metallic elements is present in organic form. In order to confirm this latter finding, determination of disolved metallic elements such as Al, Na, Mg, Fe, Co, Ni, Cu, Zn, Se, Mo, Ag, Cd, and U in the Southern Ocean surface and deep waters were carried out. Water samples were collected in 1976–77 with a non-metallic sampler.

In the separation of organic compounds of various metals, a new method using XAD-2 resin was employed. The results of determination for surface water are summarized in Table 1 which shows:

1. In cases of Fe, Co, Cu, Cd, and Ag, more than 60% is organic.
2. In case of Co and Cd, organic compounds prevail near the surface while decrease in the deep.

<table>
<thead>
<tr>
<th>Component</th>
<th>Total (µg/l)</th>
<th>Organic (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>6.0 x 10^{-2}</td>
<td>15</td>
</tr>
<tr>
<td>V</td>
<td>4.3 x 10^{-3}</td>
<td>33</td>
</tr>
<tr>
<td>Mn</td>
<td>7.5 x 10^{-3}</td>
<td>12</td>
</tr>
<tr>
<td>Fe</td>
<td>2.3 x 10^{-3}</td>
<td>70</td>
</tr>
<tr>
<td>Co</td>
<td>6.5 x 10^{-4}</td>
<td>100</td>
</tr>
<tr>
<td>Ni</td>
<td>2.4 x 10^{-4}</td>
<td>22</td>
</tr>
<tr>
<td>Cu</td>
<td>2.1 x 10^{-4}</td>
<td>62</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>Total (µg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>7.4 x 10^{-2}</td>
</tr>
<tr>
<td>V</td>
<td>1.1 x 10^{3}</td>
</tr>
<tr>
<td>Mn</td>
<td>1.1 x 10^{1}</td>
</tr>
<tr>
<td>Fe</td>
<td>1.6 x 10^{3}</td>
</tr>
<tr>
<td>Co</td>
<td>6.2 x 10^{4}</td>
</tr>
<tr>
<td>Ni</td>
<td>1.4 x 10^{2}</td>
</tr>
<tr>
<td>Cu</td>
<td>6.2</td>
</tr>
</tbody>
</table>

3. In case of Al, V, Mn, Ni, Zn, Se, Mo and U, less than 30% is organic. With respect to organic compounds of metals, it is clarified that they are composed mainly of protein or protein carbohydrate complexes with a molecular weight ranging from 10^3 to 10^4.

14. CHEMICAL PROCESSES AND INTERACTION INFLUENCING POLLUTANT TRANSFER

M. J. Green — National Research Institute for Oceanography, P. O. Box 320, Stellenbosch 7600, South Africa

An attempt will be made to provide an overview of the major chemical processes and interactions influencing transfer of important pollutants in the marine environment. Special attention will be paid to the chemical composition of the pollutant material, mode of introduction into the sea, immediate chemical reactions with the seawater and sediments, subsequent reaction and its final repository. Emphasis will be placed on gaps existing in our knowledge of these processes.

15. A COMPARATIVE STUDY OF PARTICULATE TRACE METAL CHEMISTRY IN THE OPEN OCEAN AND THE WESTERN MEDITERRANEAN

P. Buat-Ménard* and R. Cheurlet — Centre des Fables Radioactives, Laboratoire mixte C.N.R.S. — C.E.A. Domaine du C.N.R.S., Place de l’Eglise, 29190 Gif-sur-Yvette, France

*Present address: Graduate School of Oceanography, University of Rhode Island, Kingston, Rhode Island 02881, U.S.A.

We have recently demonstrated that atmospheric fallout is a major primary source of dissolved and particulate trace metals in open ocean surface waters. Active and passive scavenging by suspended particles which subsequently settle was shown to be the single most important mechanism for the rapid transfer of metallic pollutants from the surface layers to the deeper parts of the ocean. We present here a comparison between the trace metal abundances in suspended matter collected over the entire water column in the North and South Atlantic and the Pacific Ocean and recent data from the open Western Mediterranean (Ligurian Sea).

The data for the open ocean waters show a rather uniform pattern:

1. Particulate Al, Sc and Th are entirely associated with suspended alumina-lodiments. Their primary source in the North Atlantic waters is the atmosphere.

2. The elements Ni, Cu, Zn, As, Se, Ag, Cd, Sb, Au, Hg and Pb which are enriched in North Atlantic aerosols, partly because of the presence of an anthropogenic component, are also present in world ocean particles in concentrations at least an order of magnitude too high to be accounted for by terrigenous particles of crustal composition or biogenic particles of planktonic composition.

Except for lead, the enrichments of these trace metals in oceanic suspended matter are shown to be of natural origin and to reflect internal oceanic processes, primarily the formation of biogenic debris in surface waters. Lead, measured only for the atmosphere and waters of the North Atlantic, shows in oceanic particles a strong component of anthropogenic origin.
16. CONTENTS OF $^{137}$Cs, PLUTONIUM AND AMERICIUM ISOTOPES IN THE SOUTHERN OCEAN WATERS


The effect on the Pacific and Indian Oceans of the radioactive fallout has been systematically studied by the present authors for many years. In this study, the content and distribution of $^{137}$Cs, plutonium isotopes ($^{239+240}$Pu, $^{240}$Pu and $^{241}$Pu) and americium ($^{241}$Am), which is a decay product of $^{241}$Pu, on the Southern Ocean surface are reported.

Water samples were collected south of Australia and New Zealand in 1976-77. Above radioactive nuclei were precipitated from a large amount of sea water on board and brought back to the laboratory. $^{137}$Cs was coprecipitated with ammonium phosphomolybdate. Pu and Am were coprecipitated with magnesium hydroxide. The determination of $^{137}$Cs was done by $\gamma$-spectrometry. For Pu and Am, $\alpha$-spectrometry was used after the separation of these nuclei from the bulk of magnesium hydroxide precipitate by using ion exchange resin method.

The ratio of $^{239+240}$Pu to $^{241}$Pu ranged from 0.2 to 0.15 pC/l, 239+240Pu from 0.2 to 3.0 x 10^-6 pC/l, 241Am, from 0.2 to 0.4 x 10^-4 pC/l. The ratio of $^{239+240}$Pu to $^{241}$Pu was 20 to 70%. The comparison between these results and those previously obtained in the Pacific and Indian Oceans will be done.

17. EXPERIMENTAL STUDIES OF HYDROCARBONS IN BENTHIC ANIMALS AND SEDIMENTS

John Farrington, John Teal, and Bruce Trip — Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02545, U.S.A.

We have constructed a chamber which encloses sediment, water, and animals for experimentally studying the roles of animals in the distribution of organic pollutants in and between biota, water and sediments. We have located main at aromatic hydrocarbons between naphthalene and pyrene and at PCBs. We have also examined the distribution of these compounds in coastal environments. In both "clean" and polluted sites there is an approximate distribution between the relative concentration of various aromatics in animals and sediments depending upon molecular weight and isomer, with the heavier compounds in general, more concentrated within the fauna versus the sediment. PCBs, which are metabolized very slowly by organisms, are relatively more concentrated in animals compared to sediments than are the aromatics from petroleum. Though in situ experiments, fauna took up relatively large amounts of spiked, lighter aromatics, in the first few days, these were lost in experiments lasting over two weeks. In a 16-day experiment only 3% of added furane was recovered compared to 32% of added pyrene. The ratio of furane to sediment at the end of the experiment was 825, compared to 80 for pyrene. Current experiments try to separate the roles of currents, diffusion and animal activities in the distribution of organics. Results to date indicate a strong inverse correlation between long-term accumulation of compounds by animals in relation to sediments and the ease with which these compounds are metabolized by organisms.

PS-10 REMOTE SENSING OF OCEANOGRAPHIC VARIABLES

Convenor: J. R. Apel

Chairman: R. E. Stevenson

SESSION 1: Wednesday, December 5, 5 A.M. (1)

1. P. Scully-Power — Integrated active/passive sensing of ocean eddies

2. R. L. Bernstein — Determination of ocean current variability using SEASAT radar altimeter data

3. C. S. Yentsch — Estimation of phytoplankton chlorophyll using a wavelength ratio: Remote sensing by the coastal zone color scanner.

SESSION 2: Wednesday, December 5, 5 A.M. (2)

4. T. D. Allain — Preliminary analysis of SEASAT synthetic aperture radar imagery of selected ocean areas around Europe


SESSION 3: Wednesday, December 5, P.M. (1)

Chairman: P. Scully-Power

7. K. D. Sullivan — The potential for manned earth observations in the shuttle era

8. R. Coleman, C. Rizzo, E. G. Masters and B. Hirsch — The investigation of the sea surface slope along northeastern coast of Australia

9. M. W. Evant, B. L. Weber and T. M. George — Coastal ocean dynamics radar (CODAR): NOAA's surface current mapping system

10. R. G. Lipes — Wind, air and sea results from SEASAT's radiometer

SESSION 4: Wednesday, December 5, P.M. (2)

Chairman: P. Scully-Power

11. R. Legeckis — Satellite observations of long waves in the Equatorial Pacific Ocean

12. R. C. Smith, P. Dustin and K. S. Baker — Remote sensing of chlorophyll in the California Bight

13. E. G. Masters, R. Coleman and K. B. Bretegarr — On regional ocean tide recovery using satellite altimetry

14. T. M. George — Progress in developing a sky wave sea state radar
1. INTEGRATED ACTIVE/PASSIVE SENSING OF OCEAN EDDIES


The ocean eddy field is ubiquitous and interacting, being a manifestation of the underlying dynamical processes; yet the most persistent structures which evolve near circular eddies with a characteristic radius, equivalent to the first internal Rossby Rossby radius of deformation at radius and for which the linear and nonlinear effects are of equal magnitude. Synoptic mapping of these mesoscale inhomogeneities can best be achieved therefore from an orbiting space platform, using either passive remote sensors such as multispectral or active sensors such as SAR-spaceborne, land or radar altimeter. Each of these sensors can detect eddies, but not under all conditions; only by an optimum integration of the sensors can a quantifiable synoptic map be attained. Since design of an optimal configuration will require research in space, the Space Shuttle missions will provide the first opportunity to achieve this, only then can the system configuration be specified for incorporation in an unmanned satellite. Once resolved, this suggests the future possibility of real-time satellite oceanography, a capability that would significantly enhance the conduct of large mesoscale experiments such as acoustic tomography or multivariate observations could provide a procedure for selecting the best combination of source/receiver positions and the optimum choice of a grid partitioning of the area.

2. DETERMINATION OF OCEAN CURRENT VARIABILITY USING SEASAT ALTIMETER DATA

R. L. Bernstein, R. H. Whittaker — Scripps Institution of Oceanography, La Jolla, California 92037, U.S.A. and G. Born — Jet Propulsion Laboratory, Pasadena, California 91107, U.S.A.

An experiment was performed in the Kuroshio Extension Current 900 km east of Japan, to determine the ability of the SEASAT radar altimeter to measure changes in the sea surface height caused by meanders and eddies in the current. Four flights with NASA F-3C aircraft were conducted on 25 September, and 5, 13 and 19 October 1978, with flight tracks coincident with an ascending SEASAT subtrack. Air expendable bathythermographs (AXBT’s) were deployed to obtain subsurface temperature profiles to 350 m depth, at 20 minute latitude increments along the flight track, between 350°E and 140°E. The AXBT data were converted to sea surface elevation by using the historical hydrographic casts to establish a statistical relationship. The AXBT data resolve the main axis of the Kuroshio, as a 50 cm height change over 35–70 km, plus several eddy-like features of lesser amplitude. The four flights showed the main axis shifted south 70 km, then returned to near its original position. Preliminary SEASAT altimeter data along the track were obtained for 25 September, 1, 7, and 10 October 1978 (SEASAT failed on 10 October). Variations in altimeter data between these dates exhibit the same shifts apparent in the AXBT data.

The altimeter results data to date strongly support efforts to place additional altimeters in orbit to measure ocean current variability on a global, long-term basis. Four separate altimeter spacecraft in carefully selected orbits could provide 50 km–15 day space-time resolution which would match the mesoscale variability which appears to dominate in much of the open ocean.

3. ESTIMATION OF PHYTOPLANKTON CHLOROPHYLL USING A WAVELENGTH RATIO METHOD: REMOTE SENSING BY THE COASTAL ZONE COLOR SCANNER (CZCS)

C. S. Yentsch — Bigelow Laboratory for Ocean Sciences, West Boothbay Harbor, Maine 04575, U.S.A.

The upwelling radiance from the near surface waters of the oceans, when corrected for atmospheric effects, contains spectral information derived from physical and biochemical properties in the water. Within the surface layers, the important absorbers of light are (1) the water, (2) chlorophyll pigments in phytoplankton, (3) nonliving detritus, and (4) dissolved yellow substances.

The coastal zone color scanner (CZCS) housed in the Nimbus-7 satellite attempts to measure phytoplankton chlorophyll in the presence of these other substances (1, 3, 4). The scanner produces an image at five wavelengths in the visible portion of the spectrum. The ratio of wavelengths 530:450 nm is an integral part of the algorithm to determine quantities of phytoplankton chlorophyll. To test the sensitivity and accuracy of this approach, the light attenuation properties of discrete samples of surface water have been measured in a variety of coastal waters containing varying amounts of phytoplankton chlorophyll, detritus and yellow substances. These measurements show that the prediction of chlorophyll concentration by use of the wavelength ratio (3.5:1.0) is not markedly affected by the presence of detritus or the quantity of yellow substance generally found in coastal waters. This appears to be due to the fact that both detritus and yellow substances are short wave length ultra-violet absorbers which, as such, have little influence at the longer wavelengths.

The ratio method tested in coastal waters has a lower limit of detection for 0.10 µg/l and the precision of the technique is ±20% between the range of 0.10 to 10 µg/l chlorophyll.

4. PRELIMINARY ANALYSIS OF SEASAT SYNTHETIC APERTURE RADAR IMAGERY OF SELECTED OCEAN AREAS AROUND EUROPE

T. D. Allen — Institute of Oceanographic Sciences, Wormley, Godalming, United Kingdom

Data from SEASAT’s Synthetic Aperture Radar were received at the European Space Agency’s receiving station located at Oosthanger in Southern England. A total of 55 passes, totalling some 272 minutes of transmission was received in the period 1 August–10 October (the last day of the SEASAT operation). The European SAR imagery has been optically processed by ERIM and is now being distributed to principal investigators. Examples of swell waves, refracted wave fronts, internal wave fields, surface slicks and fronts are discussed.

5. OCEAN SURFACE WAVE DETECTION BY SEASAT-1 SYNTHETIC APERTURE RADAR DURING GOASEX

F. I. Gonzalez — NOAA Pacific Marine Environmental Laboratory, Seattle, Washington; R. A. Schuchman — Environmental Research Institute of Michigan, Ann Arbor, Michigan; D. B. Ross — NOAA Sea Ice Application Laboratory, Miami, Florida; C. L. Rufczen — NOAA/NESDIS/NMRS, Boulder, Colorado; and J. F. R. Gower — Institute of Ocean Sciences, Patricia Bay, Sidney, Vancouver, British Columbia

The Gulf of Alaska Satellite Experiment (GOASEX), sponsored by the National Oceanographic and Atmospheric Administration (NOAA), was a large scale experiment which took place in September, 1977. The goal was to gather surface truth for the analysis of the capabilities of a SAR. Two microwave remote sensors carried on board Seasat-1 were a Synthetic Aperture Radar (SAR), with a nominal resolution of 25 meters. One of the objectives of the GOASEX was to gather data which could be used to assess the wind-detection capabilities of this instrument. Surface wave energy density spectra were computed from direct surface measurements and were coincident with the collection of SAR data by Seasat-1. Two-dimensional spectra were computed from data acquired by a pitch-roll buoy carried aboard the NOAA research vessel OCEANOGRAPH. These two-dimensional spectra were computed from data collected by a Waverider buoy on the weather ship Ocean Station Papa, by a second Waverider located near Tofino, on the western coast of Vancouver Island, B.C., and by accelerometers on board six data buoys operated by the National Data Buoy Office.

Significant waveheights were computed from these spectra and these ranged from about 1 to 3.5 m. Dominant wavenumbers, corresponding to the point of peak energy density for each spectra ranged from about 0.4 to 0.6 m⁻¹ (representing a wavelength range of about 50 to 300 m). Surface wind speed varied from about 10 to 25 knots.

Optical Fourier transforms were performed on Seasat-1 imagery of the ocean and the resulting intensity spectra were compared with the one- and two-dimensional wave energy density spectra computed from in situ data. This intercomparison yielded agreement to within ±15 percent and agreement in direction to within ±20 degrees.

The imagery mechanisms by which SAR detects ocean waves traveling in the range (cross-track) direction seem to differ significantly from the mechanisms by which SAR detects waves traveling in the azimuth (along-track) direction. Unfortunately, as a result of the September surface wave climatology in the Gulf of Alaska, and the inclination of the satellite orbit, most waves in the surface data examined to date were traveling in a direction that was within ±45 degrees of range. Thus the surface truth data examined to date is inadequate to assess the ability of the Seasat-1 SAR to detect azimuth traveling waves. However, indirect evidence, consisting of merchant ship visual observations, weather maps, and a spectral ocean wave model forecast, indicates that azimuth traveling waves were probably present in the area imaged by Seasat-1 SAR in at least one instance.

The intensity spectra obtained from the SAR imagery of this area are somewhat difficult to interpret and are presently under study.
6. SYNTHETIC-APERTURE RADAR OBSERVATIONS OF OCEAN WAVES
R. Stewart — Scripps Institution of Oceanography, La Jolla, California 92039; J. Vesecky — Stanford University, Stanford, California 94305; and J. Webb — Institute of Oceanographic Sciences, Wormley, Godalming, Surrey, England

The experimental oceanographic satellite SEASAT carried a synthetic-aperture radar (SAR) capable of observing a 100 km wide swath of ocean with a resolution of 25 m, using 0.235 m radio waves. This instrument viewed an ocean area near 59° N, 125° W, the site of the Joint Air Sea Interaction (JASIN) Experiment, between Scotland and Iceland, on twenty different occasions. At the same time, ocean wave lengths and directions were independently measured on the sea surface using a pitch-roll buoy on eight separate occasions. Wind speed ranged from calm to 15 m/s, and ocean wave length varied from 25 to 140 m. We expect to compare these two sets of observations to estimate the ability of the radar to measure ocean waves as a function of wind speed, wave steepness, and wave orientation relative to the radar.

The SAR responds not only to surface waves but also to internal waves that produce surface slicks, and to rain that smooths the sea surface. Both phenomena are expected to be most visible in light winds. We expect to test this hypothesis using data from all days, and to determine the optimum conditions for viewing these phenomena.

7. THE POTENTIAL FOR MANNED EARTH OBSERVATIONS IN THE SHUTTLE ERA
K.D. Sullivan — Astronaut Office, Johnson Space Center, Houston, Texas 77058

Routine and large-scale operations in low earth orbit are the current objectives of the U.S. shuttle space effort. To attain these goals, NASA has designed the space shuttle, a reusable, airplane-like spacecraft which may prove to be the covered wagen of the space frontier. The various components of this new Space Transportation System are currently under test at facilities throughout the U.S. and in Europe. For oceanographers, the shuttle offers the possibility of making space-borne experimental and observational programmes as feasible and effective in space as are current ship-borne programmes. To fulfill this potential, we must develop sensors, user interfaces, and data handling systems which fully utilize the unique capabilities of a man-machine system.

8. THE INVESTIGATION OF THE SEA SURFACE SLOP ALONG NORTHERN COAST OF AUSTRALIA
R. Coleman, C. Rivas, E.G. Masters and B. Hirsch — The University of New South Wales, P. O. Box 1, Kensington, New South Wales 2033, Australia

The comparison of the results of geodetic levelling with the mean level of the sea as defined by tide gauge readings, has indicated the apparent existence of widespread departures of sea level from equipotential surface of the earth's gravity field along the northeastern coast of Australia. The magnitude of this coastal sea surface topography (SST) is comparable with both the original levelling and oceanographic estimates. The establishment of the pattern of SST by an independent technique using satellite altimetry data collected by the GEOS-3 spacecraft is of importance for resolving this ambiguity. This paper reviews all the evidence indicating the existence of SST from both geodetic and oceanic levelling results for possible sources of systematic error or unmodelled non-gravitational forces acting on the sea surface. Three-dimensional position determinations from doppler observations at bench marks connected by levelling to tide gauges are analyzed in order to determine the position of MSL on a geocentric cartesian coordinate system. Such information in conjunction with the use of selected passes of GEOS-3 altimetry based on orbit integrations using laser tracking data and the GEM10 gravity field model allows the geometry of the open ocean surface to be established. A comparison is made with a number of geoid models in order to establish the role that the altimetry will play in the evaluation of sea surface topography, expected to have amplitudes of 2 metres.

10. WIND, AIR AND SEA RESULTS FROM SEASAT'S RADARDATEMETER
R. G. Lipes — Jet Propulsion Laboratory, Pasadena, California, U.S.A.

The results from Mission Workshop II of September 1975 show very good performance for a significant subset of the data examined. The SST determinations show a scatter of about 3 K about a cold bias of less than 0.5 K. The wind determinations in both field and spot report comparisons show approximately a 2 m/s standard deviation about a negative bias of less than 0.5 m/s with a slight systematic overestimation of low (less than 7 m/s) winds. Both of these results are within Seastat mission design specifications. The water vapor determinations agree very well with radiosonde data in the GOASEX area, but overestimates precipitable water by about 30% in tropical regions. The preliminary noted in the antenna pattern correction algorithm in previous workshops have apparently been successfully handled, so that brightness temperatures are reliably produced for ocean scenes as close as 2 to 3 resolution cells from land.

Other areas require additional work and understanding. Notably, the conditions for which good geophysical retrievals could not be made remain to be identified and understood. Preliminary work accomplished during the workshop indicates that certain procedures in the radiometric calibration and the brightness temperature bias removal algorithms may give rise to these conditions.

11. SATELLITE OBSERVATIONS OF LONG WAVES IN THE EQUATORIAL PACIFIC OCEAN

During 1975, westward-moving long waves with a period of about 25 days and a wavelength of 1000 kilometers were observed at sea surface temperature front in the equatorial Pacific on infrared images obtained by a geostationary environmental satellite system (GOES). Observations between 1975 and 1976 show that the equatorial front and the waves can only be detected intermittently. The most frequent satellite observations occur between May and November. Starting in 1979, the data from the TIROS-N satellite will be evaluated to determine if improvements in data quality will allow this new polar orbiting satellite to be used for monitoring the equatorial sea surface temperature fronts.

12. SATELLITE OBSERVATIONS OF LONG WAVES IN THE EQUATORIAL PACIFIC OCEAN
Raymond C. Smith, Phillip Dustin, and Karen S. Baker — Victorville Laboratory, Scripps Institution of Oceanography, University of California-San Diego, La Jolla, California 92039, U.S.A.

Complementary ship and satellite data (NMMB/S-ZCS) from the California Bight are used to provide a quantitative assessment of the optical and temporal variability (patchiness) of chlorophyll in these waters. These data will be used to study the physical and biological processes leading to this variability, to map and estimate regional productivity, its seasonal variability and to compare and validate estimates of this regional productivity. Preliminary analyses of these data will be discussed.

13. ON REGIONAL OCEAN TIDE RECOVERY USING SATELLITE ALTIMETRY
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Radar altimeter ranges from the GEOS-3 spacecraft, collected over a 12-month period between May, 1975 and May, 1976 were analyzed in an attempt to obtain regional ocean tide models in the Sargasso Sea. Two methods were investigated, being spectral analysis techniques on altimetry sea surface height and at crossover points, Fourier solutions on crossover points, and solutions based on overlapping passes. The methods used are either discrete subsets of the data or the complete data set extended. The resultant ocean tide models for the M2 tide were compared against the Medfield empirical model for the area. The effect of systematic orbital errors on the altimetry ranges was also investigated.
The particulate influx to the ocean quickly contributes to the concentration of many dissolved elements in surface waters. Most of these elements, however, take part in the biologic cycle, quickly return to the particulate form, and may leave the water surface through sinking. Much more than the adsorption onto active surfaces such as clay particles, it is the ligand-association of trace elements in organic coatings and fecal aggregates which is the driving force controlling the solid/solid alterations of the trace elements as bound or suspended particles. The enrichment factors (relative to average crustal material) of many heavy metals up to several orders of magnitude, can be entirely explained by these latter processes.

In the process of sinking, the particulate material becomes that of the deep oceanic water column. Most of the particulate material is very fine and remains in the water column for very long periods without much change in their elemental composition. A small number of the particles, mainly fecal products, sinks much more rapidly and provide the flux of trace elements to the bottom sediments. Particulate chemistry of Mn, Cu, Zn, S, C, Hg, Sn is closely tied to the particulate organic carbon cycle. These particles are re-mobilized at the sediment-water interface and can, through upwelling be reintroduced into the water column.

In the particulate matter, these trace elements have a conservative behaviour in deep waters, and are reemphasized at the sediment-water interface and can, through upwelling be reintroduced into the water column. Particulate bacteria, the form of barite, undergoes partial dissolution within the water column and exhibits a non-conservative behaviour everywhere. Regardless of the pathways, all the elements noted, including barite, can be demonstrated to have a self-sustaining cycle in the ocean.

1. MODEL OF FLUX AND DISSOLUTION OF MARINE PARTICLES

J. C. Brun-Cottan** and R. Chesset
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An updated model of vertical flux and regeneration rate of suspended particles in the ocean water is presented.

The observed distribution of particle sizes, the dissolution coefficient and the decrease of particle density with their size decreases, are introduced in this model. The fact that the particle size distribution is nearly constant in the world ocean water column, is taken as a boundary condition of major importance. It implies that the distribution of chemical components in the whole suspended matter is not related to the size parameter.

The regeneration rate for a given coefficient of dissolution hardly depends on the particle size distribution function.

It has been recently shown that the particle size measurements down to 0.2 μm obtained with an electron microscope, fit very well the Log-normal distribution function. The use of this function in the model gives quite different values for the regeneration rate than the ones obtained with the usual power law (Iong function). Indeed for a given dissolution coefficient, the Lognormal distribution implies a regeneration rate 10 or 100 times smaller than when using a power law function.

With the proposed model, it is relevant to calculate the vertical flux (in terms of mass), and the vertical mean velocity of the suspended matter. The computed values are in the order of 10^{-6} and 10^{-3} cm/s (30 to 250 m/years). These values are smaller than the ones generally given. The case of non-steady-state situations is introduced.

2. CONSERVATIVE AND NON-CONSERVATIVE PROPERTIES IN FLUXES AND CHEMISTRY OF OCEANIC SUSPENDED MATTER

R. Chesset - Centre des Fables d'Activités, Laboratoire Mixte CNRS-CEA, Gif-sur-Yvette, F 91190, France

The distribution between the dissolved and particulate forms of many trace elements in oceanic waters are not controlled by thermodynamics but by biogenic-driven kinetic processes.

Using multi-element analytical techniques, as well as electron microscope-microprobe work, our group, mostly during the GEOSECS Program (1972–1978), has studied the fate of a series of about 20 trace elements. These were mainly transient and heavy metals in their particulate forms.
concentrations of total suspended matter. Thus, at GEOSecs station 3 (51°00′N, 42°05′W), the influence extends to 1800 m above the bottom, while increases in total suspended matter can only be detected below a height of 800 m.

The fact that the nepheloid layer material is of a different composition than that found higher in the water column implies that the observed gradients of FeP and MgP in the nepheloid can only be explained by dissolution of FeP and MgP at the water-sediment interface. Vertebrate planktonic grazers, based upon excess 222Rn gas production, determined for GEOSecs station 3. The vertical eddy diffusion coefficient, k, calculated from a variance of 170 m above the bottom, was sufficient to explain the shape of the extended Alp profile (up to 1600 m). At station 67 (44°55′S, 51°06′W) the 222Rn data (up to a height of 170 m) and the Alp profile imply a vertical advection term, w, as well as a k term.

4. PARTICULATE FLUXES IN THE NORTHEAST PACIFIC AS DETERMINED BY SEDIMENT TRAPS AND URANIUM/THIURUM SERIES RADIONUCLES

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Detailed profiles of dissolved (<4 μm) and particulate (<4 μm) 234Th have been determined in the California current off Central California during March and again in July 1978. The initial study was characterized biologically by intense primary productivity with intense zooplankton grazing by salts; the second period showed evidence of upwelling, high primary productivity, and development of copepods as the grazing herbivores. Marked deficiencies of both dissolved and total 234Th (with respect to 228Ra) exist in the surface waters during both periods. This disequilibrium is used to derive 1) estimates of the residence times of dissolved 234Th in the surface waters with respect to particle scavenging, 2) the residence time of the particles carrying the 234Th, and 3) the vertical particulate flux required to sustain the observed disequilibrium. Soutar-type, paired funnel, sediment traps were also deployed during the study period to determine the magnitude of the particles in the euphotic zone.

The 234Th/238U and 234U/238U water column disequilibria yielded surface-based layer residence times for dissolved 234Th of 47 and 25 days and particulate residence times of 2.4 and 2.4 days, respectively, between the intense saltwater swells and 7.3 days during the March and July cruises. The required particulate 234Th fluxes are 1.3 x 10−14 and 1.3 x 10−14 dpm/m/day, respectively. These values are in good agreement with independent observations of particle fluxes from bottom trap experiments in the California Current. The fluxes of 234Th are lower than the corresponding 238U fluxes, 1.3 x 10−14 and 1.3 x 10−14 dpm/m/day, respectively. Thus, 234Th, with a half-life of 24.1 days, and (large) non-complex source function, is demonstrated to be an optimal tracer to elucidate removal processes occurring over times scales of 1 to 10 days.

5. VERTICAL VERSUS HORIZONTAL PARTICULATE FLUX IN THE BOTTOM NEPHELOID LAYER

I. N. McCave — School of Environmental Sciences, University of East Anglia, Norwich, U.K.

The horizontal particulate flux is much greater than the vertical flux in almost all situations with some current because the current velocities (££) are far greater than the particle settling velocities (££). The dominant terms in the expression for the flux are ££w and ££w, horizonal. The latter terms also have a much greater horizontal than vertical extents, and taking a vertical/horizontal ratio of ~105 it is not too different from the ratio of effective vertical particle speed of 5.10−4 cm/s in a current of 10 cm/s. Despite the dominance of horizontal flux, material is not dispersed far and wide because of relatively vast lateral extent of oceans. Before entering the ocean, the size and shape of the ocean becomes part of the oceanic boundary layer. The flux to the bed (Fb) is controlled by the same term as the vertical flux (££w) modified by the fluid shear stress at the bed (££). The critical shear stress, ££c, is 0.01 cm/s. ££c is 0.01 cm/s. ££c > ££ for ££ > ££. Clearly if ££ > ££ there is no flux to the bed and any input to the nepheloid layer from above results in increased concentration. Deposition would be prevented for all but the fastest settling particles by ££ > 0.7 dynes/cm2, corresponding to ££ of 200 cm/s at 1 metre above the bed and 28 cm/s at 10 metres above the bed, a speed not commonly encountered in the deep sea. Thus, the larger, rapid settling particles contributing much of the vertical particulate flux are unlikely to be significantly prevented from depositing or being transported far laterally before being deposited. Finer material, on the other hand, with ££ < 0.1 cm/s, is likely to be prevented from depositing by speeds (at 10 m) of > 7 cm/s. These are at least more commonly found in western boundary areas. It may be that deposition of material settling from the surface and interior of the ocean is like rain falling through a mist. I will also refer to residence times of particulates in layers.

6. COMMENTS ON SOME ASPECTS OF PARTICULATE TRANSPORT IN THE OCEANS

D. Lai — Physical Research Laboratory, Ahmedabad 380 009, India

Recent studies on dissolved and particulate concentrations of trace elements and radionuclides have brought to light an increasing importance of particulate transport in the oceans. The chemical change in seawater due to in situ addition or removal of U-based radionuclides is significant in the case of a number of elements. However, to date, it is not clear how the particulate processes are related to the processes of the water mass. Some of the problems are outlined briefly.

It is shown that whereas a substantial flux in the case of some elements is due to transport by consolidated fecal pellets, this transport does not generally lead to any substantial in situ transport to deep waters. Changes, if any, in the dissolved concentrations of elements within the oceans occur due to small particles (<10 μm) which sink stoichiometrically with a mean speed of ~10−0.1 m/s. The larger particles acting by Stokes' velocities impact and carry along the small particles. The smaller particles, ~1 μm, are thus transported down rapidly by the larger particles by a biotic mechanism.

Simple theoretical calculations are consistent with the measured vertical transport rates based on studies of radionuclides.

8. URANIUM ISOTOPES IN SOME INDIAN RIVERS AND ESTUARIES

D. V. Borole, S. Khanazarian, and B. L. K. Somayajulu — Physical Research Laboratory, Ahmedabad 380 009, India

The 238U concentrations and the 234U/238U activity ratios of the riverine and estuarine waters of the west coast rivers, Narbada and Tapti were measured extensively during the different seasons. A one-season sampling of the estuarine regions of the west-coast rivers, Godavari and Mahanadi was also carried out.

The distribution of uranium and major ions in the 1300 km stretch of the Narbada river and its tributaries show that the uranium concentration in the water is in the range of 1 to 5 × 10−4 μg/L. The activity ratios of 234U/238U in the riverine and estuarine waters were low and showed no significant variability with time. The 234U/238U activity ratios were 0.01 to 0.02 in the riverine waters and 0.001 to 0.005 in the estuarine waters. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concentration in the riverine waters was found to be lower than the background level of 10 μg/L. The uranium concentration in the estuarine waters was found to be higher than the background level of 10 μg/L. The uranium concent
groups were found: carboxyl (COOH) with intrinsic Pk's in the range 3.6 to 4.0, and phenol (aromatic-OH) of pK 9 to 10. Similar results were obtained using quite different solid particles, showing that adsorbed films dominate the final surface chemistry of the particles, apparently suppressing ionic interaction between the solid and the aqueous phase. This has important implications for the various mineral phases introduced to seawater as well as the solubility of their associated trace elements. In addition, adsorbed organics are expected to themselves assimilate dissolved trace elements with a selectivity substantially different from inorganic adsorbates.

10. THE ROLE OF THE ARAGONITE PARTICLE FLUX IN DEEPENING THE CALCITE LYSOCLINE
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Although dissolution experiments show that calcite dissolves very quickly, the calcite lysocline lies deeper in the ocean than the level at which calcite becomes undersaturated. The flux of aragonite to the sea floor—principally as pteropod shells or fragments—is partly responsible. Aragonite is more soluble than calcite: dissolving at the sea floor it will tend to supersaturate pore waters with respect to calcite. The diffusive sublayer at the sediment-water interface may also become saturated or supersaturated, depending upon the relative balance between dissolution rates and diffusion.

Under these conditions, the high concentrations of dissolved carbonate which occur in the boundary layer will protect the calcite sediments from dissolution. At greater depths in the ocean, where calcite is even more undersaturated, the dissolution process cannot maintain a saturated boundary layer, and the protection does not occur.

The combined dissolution of calcite and aragonite can be modeled if the appropriate parameters are known or can be estimated. These include thickness of the diffusive sublayer, rates of calcite, aragonite, and insoluble material, bioturbation rates, aqueous diffusion coefficients, dissolution rates, near-bottom carbonate concentration, and field Ksp of calcite and aragonite. Calculations using the best available parameters indicate that the aragonite flux plays a significant role in depressing the level of calcite dissolution in sediments below the level where sea water becomes undersaturated.

PS-11D OCEAN CRUST AND SEAWATER INTERACTION
Chairman: David S. Cronan

SESSION 1: Saturday, 8 December, P.M. (1)
Chairman: David S. Cronan

1. D. S. Cronan Metalliferous sediments formed by basalt/seawater interaction in the Southwestern Pacific
2. J. H. Johnston and K. E. Knepler A study of selected crustal metalliferous sediments from the East Pacific Rise
3. J. R. Lawrence and J. Drever Cold seawater circulation and alteration at DSDP 395

SESSION 2: Saturday, 8 December, P.M. (2)
Chairman: David S. Cronan

4. J. Gieskes, et al. (DSDP Leg 64 Scientific Party) Intrusion of basaltic tills into highly porous sediments—resulting hydrothermal activity—Guaymas Basin—Gulf of California
5. K. Knepler Geochemistry of sediments from the Yawasa Trough, N. W. Fiji
6. J. R. Lawrence Oxygen-18 flux into the oceanic crust: Sea floor spreading and continental growth

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1. METALLIFEROUS SEDIMENTS FORMED BY BASALT/SEAWATER INTERACTION IN THE SOUTHWESTERN PACIFIC
D. S. Cronan — Department of Geology, Imperial College, London, SW7 2AZ, England

Active submarine volcanism associated with the island arc/trench system in the southwestern Pacific region has given rise to a number of examples of hydrothermal metalliferous sediments formed by basalt/seawater interaction. Seawater circulates within the freshly cooled lava, leaches metals and precipitates them when the solutions discharge on the sea floor. This process normally results in the precipitation of iron or manganese oxides, or mixed ferromanganese oxide deposits, thought to be the end products of a sub-sea-floor hydrothermal fractionation sequence. Examples found to date include iron-rich sediments in the Lau Basin, ferromanganese oxides in the Indonesian archipelago, and mixed iron and manganese oxide deposits off New Britain. However, the hydrothermal solutions also have the capacity to precipitate silicates or silica, as has been noted in the Lau Basin and in the Indonesian archipelago, and silicates. Examples of the latter have not been found on the sea floor in the southwestern Pacific, to the writer's knowledge, but young sulphide deposits of massive origin do occur on land in the region. Recent data from the East Pacific Rise show that sulphide mineralization can take place on the sea floor in association with submarine volcanic activity, and further research in the southwestern Pacific will probably locate examples of it. The most likely areas would be associated with back arc basalt spreading centres, or in transform faults.

2. A STUDY OF SELECTED CRESTAL METALLIFEROUS SEDIMENTS FROM THE EAST PACIFIC RISE
J. H. Johnston and K. E. Knepler — Chemistry Department, Victoria University of Wellington, Private Bag, Wellington, New Zealand

X-ray diffraction, chemical analyses and 57Fe Mössbauer spectroscopy have been used to characterize the metalliferous sediments of six crestal sediment samples from the East Pacific Rise. The X-ray diffraction studies on the untreated, air-dried sediments showed that all six samples contained significant amounts of calcite and trace amounts of baryte. Minor amounts of oligoclase-plagioclase feldspars were identified in four of the untreated samples, whereas in the buffered acetate-leached, carbonate-free fractions, these were identified in five samples, together with montmorillonite, in all six. No crystalline oxides/oxide-hydroxides of iron were detected in either the bulk or leached sediment samples.

Chemical analyses show these sediments are similar to other metalliferous sediments. Compared to other reported analyses of East Pacific Rise sediments, they tend to have lower Mn and higher Al, Si and Ba contents, but are significantly more enriched in Fe and Mn than Mid-Atlantic Ridge sediments.

The use of Fe/Si ratios and element-partitioning calculations, suggests much of the iron is present as amorphous iron oxide/oxide-hydroxide phases. Hence 57Fe Mössbauer spectroscopy and associated computer-based curve-fitting procedures have been used to further elucidate such phases. This suggests that for samples near the seawater/sediment interface, the iron phase is predominantly an amorphous ferric gel or ferric hydroxide, with relatively small increases in core depth (approx. 1 metre) and hence age of the sediment, this gel type phase has transformed as a result of diagenetic changes to superparamagnetic goethite with a slightly larger particle size, as shown by the partial magnetic relaxation of the Mössbauer spectra.

3. COLD SEAWATER CIRCULATION AND ALTERATION AT DSDP 395

A variety of low temperature alteration products occur in the 575-meter-thick section of basaltic rock from Site 395. Carbonate veins, smectites (predominantly montmorillonite), zeolites, goethite, opal and glass, listed in order of decreasing abundance, are present. The only higher temperature mineral found was clinochlore, and it occurs only in veins in two massive flows and a dolerite intrusive unit. Values of δ18O (SMOW) of calcite veins range from +11.8 to +13.8 ‰, and δ18O (FDI) ranges from +1.5 to +1.7 ‰. The calcite veins were formed at 0°C in equilibrium with deep ocean water. Some veins may have formed during glacial periods when δ18O of the deep water was higher. Some veins have also formed in the temperature range of 8–15°C. Smectite veins associated with an intrusive dolerite sill (δ18O = +11.6 to +16.0 ‰) are estimated to have formed in the temperature range 20 to 160°C. Phosphates (δ18O = +11.6 to +13.6 ‰,
SMOW) are estimated to have formed in the temperature range 30 to 100°C. The Ca²⁺, Mg²⁺, Si⁴⁺ (≥ 89%), Ba²⁺ (≥ 94.5%), Na⁺ (≥ 99%), and Mg²⁺ compositions of the pore fluids in the overlying sediments are in between those of present-day and glacial deep ocean waters. Very extensive circulation (i.e., large water masses) dominated during alteration of the basalt samples by the cold temperatures of abundant calcite veins and carbon, magnesium and sulfur mass balance considerations. In one fracture of the dolerite sill, circulation became very restricted as the temperature dropped below approximately 60°C. Halite was formed as anhydrite converted to gypsum and consumed water.

4. INTRUSION OF BASALTIC SILLS INTO HIGHLY POROUS SEDIMENTS—RESULTING HYDROTHERMAL ACTIVITY—GUAYMAS BASIN, GULF OF CALIFORNIA

J. Gieskes and DSIP Leg 64 Scientific Party — Scripps Institution of Oceanography, University of California—San Diego, La Jolla, California 92037, U.S.A.

Sill intrusions into highly porous sediments in the Guaymas Basin, Gulf of California, lead to low-grade metamorphism, thermal alteration and migration of organic compounds, marked changes in interstitial water chemistry, and large-scale expulsion of heated pore fluids. The latter process creates space for the intruding magma and initiates a hydrothermal system, which can explain the observed hydrothermal deposits around fault scarps on the basin floor.

5. GEOCHEMISTRY OF SEDIMENTS FROM NORTHWEST OF FIJI

Karin Knudsen — Chemistry Department, Victoria University of Wellington, Wellington, New Zealand

Sediment samples from the base of eleven gravity cores NW of Fij were chemically and mineralogically examined to determine their nature. Chemically, the sediments may be divided into two groups: (i) those recovered from the Yasawa Trough, and (ii) those recovered in the vicinity of the Bremner Ridge (northern group). The former has significantly lower Mo, Pt, Sr, Ba, Pb and higher Ni, Cr than the northern group. Mineralogically, the trough sediments contain a more diverse suite of minerals and are richer in clay minerals. Clay mineral analysis of the 2y and 2-8y fraction of selected sediments reveals that chlorite predominates over smectite in the coarser fraction of the trough sediments but smectite becomes more important in the finer fraction. The relative chlorite content of the northern group of sediments appears to decrease with increasing distance from Fiji. ²⁵Fe Mössbauer studies show a significantly lower ferric/ferrous ratio in the trough sediments when compared to the northern group and that this ratio is highest in the finest fraction of the sediment. The "amorphous" iron component increases with increasing distance from Fiji. These results reflect the influence of the Fiji Islands upon the sediments and the efficacy of the Yasawa Trough as a barrier to sediment dispersal. Elemental ratios do not support a hydrothermal origin for the sediments but do indicate that they are enriched in Fe and Mn relative to Pacific pelagic clay.

6. OXYGEN-18 FLUX INTO THE OCEANIC CRUST: SEA FLOOR SPREADING AND CONTINENTAL GROWTH

J. R. Lawrence — Lamont-Doherty Geological Observatory, Palisades, New York 10964, U.S.A.

The flux of ¹⁸O is 2.2 x 10⁻¹⁵ mol e⁻/m²/yr in the pore fluids from Deep Sea Drilling Projects cores. If the daily values are extrapolated to a year, the quantity of hydrous volcanic material indicated by this flux the continents have grown substantially.
1. NUTRIENT FLUSHING AND CIRCULATION IN PEEL INLET, WESTERN AUSTRALIA

Tom Beer — Centre for Resource and Environmental Studies, Australian National University, Canberra, ACT. 2600, Australia

The physical, chemical, and biological parameters of Peel Inlet were sampled at seven sites over a 55-week period. The salinity was treated as a conservative tracer and the readings used to estimate a weekly flushing time for each site in its saline exchange with the oceans.

By using assumptions and neglecting the differences between $\lambda$ and $\Lambda$, K. P. PARK (1964) had estimated partial molal conductance of major ions of seawater. The disagreement between these data and our results shows that the assumptions made by PARK are not valid.

2. PARTIAL MOHAL CONDUCTANCE OF MAJOR IONS OF SEAWATER IN SEAWATER

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Partial molal conductance of an ion can be defined in two different ways: either as a thermodynamical quantity ($\lambda$) which can be determined by experiment; or as a thermodynamical quantity ($\lambda$) which is a mathematical concept and follows the GIBBS-DEHEM relation.

Thermodynamical partial molal conductance $\lambda$ of the 8 major ions of seawater have been estimated at 5°, 15°, and 25°C in seawater of salinity 10, 20, 30, 35, and 38.4/00. These quantities cannot be obtained directly from experiment. They have been determined from the measurement of the thermodynamical partial molal conductances of salts and from measurement of electrochemical partial molal conductance of the ions. The latter quantities have been determined from the measurement, by a radioactive tracer method, of transference numbers of the 8 major ions in a seawater of salinity 38.4/00 at 20°C. This measurement is very delicate, so that the result of the most transference values at 25°C have been measured by the electrochemical method using a radioactive tracer. The two sets of data are in good agreement. $\lambda$ of K$^+$ can be determined at each temperature and salinity by using some properties of the particular ion. $\lambda$ of all other ions are then calculated by the additively principle. $\lambda$ of each ion at several temperatures and salinities have been finally combined into an empirical relation against temperature and salinity.

No data of transference numbers of ions in seawater exist in literature to our knowledge. Previously, by using some assumptions and neglecting the difference between $\lambda$ and $\Lambda$, K. P. PARK (1964) had estimated partial molal conductance of major ions of seawater. The disagreement between these data and our results shows that the assumptions made by PARK are not valid.
4. AIR AND WATER EXCHANGE OF A NON-ESTUARINE GULF

Rainer Rodl — Horace Lamb Institute of Oceanography, Box 167, Kinsgood 5062, South Australia

Salinity and water temperature distributions along bays and gulfs penetrating Australia from the Southern Ocean exhibit profiles and seasonal variations which throw light on their exchange processes. Measurements of currents, water and air temperatures and winds along the longest of these gulfs—Spencer Gulf—are examined with a view to understanding the heat, and hence the salinity and water exchange processes in such an environment.

5. OBSERVATIONS OF MESOSCALE WINDS IN AN OROGRAPHICALLY DOMINATED ESTUARY: COOK INLET, ALASKA


Orographic and thermal forces in an estuary interact with the atmospheric pressure field to produce surface winds which are unique to the region. Over a large part of the estuary the wind aligns itself into only a few persistent and classifiable patterns. Each of these local patterns relates to several synoptic-scale regimes and are thus predictable. In the interest of improving coastal forecasts, surface wind data were collected and analyzed from lower Cook Inlet, Alaska, in 1978.

From these data, surface wind patterns were developed and classified according to several synoptic-scale meteorological regimes. The dominant surface air circulation is controlled by the imposed pressure gradient along two nearly orthogonal orographic channels. The direction of the resulting surface flow is largely dependent on the relative position of passing extratropical cyclonic disturbances in the Gulf of Alaska. Some isolated sites in Cook Inlet exhibit local circulations that are nearly independent of the synoptic scale. These are generally categorized as drainage or land sea circulations.

6. SUBTIDAL FLOW IN THE LOWER COOK INLET—SHELLIKOF STRAIT SYSTEM


Current data obtained during October 1977—March 1978 (winter) and May—October 1978 (summer) show that mean flow through lower Cook Inlet and Shellikof Strait, Alaska, was toward the southwest. During winter, the mean current speed was of order 20 cm/s. In summer, it was of order 10 cm/sec. The current was topographically steered in lower Cook Inlet by arcuate bottom topography which prevented the flow from penetrating into the shallower region to the north. In Shellikof Strait, it was deeper and formed a nearly straight flow. The mean current was largely barotropic although in summer the baroclinic contribution was appreciable due to coastal freshwater input from runoff. The barotropic component of mean flow may have been driven by an alongshore slope in the surface water level associated with the Alaskan Stream, a southwesterly flowing current off the shelf. Estimates of the slope for winter, obtained from current measurements and frictional arguments are of the same order (10°) as those proposed for the North Atlantic Right area by Winant and Beardsley (1979).

Superposed on the mean flow were strong, subtidal current fluctuations with periods from 4 to 8 days. In summer, these fluctuations had amplitudes of 40—50 cm/sec while in winter they were a factor of two stronger, about 80—100 cm/sec. In general, they were stronger in the western part of the lower inlet, and were generated and exited via Shellikof Strait. For the most part, the fluctuations were barotropic along the axis of the topographically steered mean flow. A phase analysis obtained from the coherences was incoherent.

The origin of these subtidal current fluctuations coincided with those of the regional weather which is dominated by low pressure systems travelling westward through the region. Available wind records were inadequate for a rigorous statistical analysis of wind-current coherency. However, a case-by-case comparison of these winds, geostrophic winds and currents suggests that coherency between local winds and currents was negligible. The subtidal fluctuations may have been generated by regional weather forcing on the shelf which has been hypothesized for other large estuarine systems such as Chesapeake Bay (Wang, 1978; Wang and Elliott, 1978) and the Strait of Juan de Fuca (Holbrook, Muench and Cannom, 1980). They may also have been caused in part by weather-induced fluctuations in the Alaskan Stream.

7. OCEANOGRAPHIC CHARACTERISTICS AND WATER MOVEMENTS IN THE ST. LAWRENCE ESTUARY

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From observations made at a number of oceanographic stations established in the St. Lawrence Estuary, data for the freshwater budget, ice conditions, salinity, temperature distribution and water circulation are presented and discussed. The main water structure is a two-layered system. In winter, a cold upper layer with a depth between 75 and 100 m with temperatures below 0°C and salinities between 20 and 25 °/oo overlies a deep warm layer with temperatures less than 4°C. The more variable characteristics of the two layers are the upper one. In late spring and summer, the upper layer is developed and a warm water mass, -10 m thick, with temperatures as high as 12°C appears at the surface.

This is overlain by cold water with a minimum temperature at about 75 m overlying the deep warm layer. During the time of the upper (25 m) layer in the lower estuary was found to vary between 11 and 24 days. A value of 22+ day has been estimated as the average residence time of oceanic water.

The complex character of the residual circulation is demonstrated by the main features of the surface expression pattern as an outflow of warm, less dense, surface water from the Bay of Fundy which sets southward to join the eastward intermediate deep, cold, saline water. This alongshore current is clockwise gyre between Pointe-des-Monts and Rimouski and frequent northward transverse currents observed near Rimouski with a mean residual velocity of 0.6 knots. The data have been analyzed in terms of a stratification circulation diagram and the characteristics of the St. Lawrence estuary have been compared with those of other estuaries. In the lower part, the density current circulation is highly developed and the advective mode accounts for more than 90% of the upstream salt transfer. In the upper part of the estuary, both advection and diffusion contribute importantly to the upstream salt flux.

8. COASTAL WATER MOVEMENT AT KORI POINT, SOUTHEASTERN PART OF KOREA

Sangbok D. Hahn — Physical Oceanography Laboratory, Korean Ocean Research and Development Institute, F.G. Box 121, Dong Dae Mun, Seoul 130, Korea

Coastal water movements around Kori Point, southeastern part of Korea was measured by Aanderaas Recording Current Meters (RCM4) from September 1979 to August 1979 to examine influences of bottom topography and local wind system. Drogue study and long-term dye study were also carried out to understand detailed water circulation system in this area.

There is dominant reversing current system in the study area. Dominant current direction is north-eastward at ebb current and south-westward at flood current. Mean current speed is 20 cm/sec. Mean ebb current speed is 22 cm/sec and mean flood current speed is 17 cm/sec in general. Because of oceanic current which flows north-eastward with speed about 5 cm/sec, ebb current is stronger than flood current.

Main current axes show parallel to bottom topography contour lines in normal weather conditions. The surface water level system is governed by wind system in storm warning condition in general. According to progressive vector diagram if water movement, current flow direction varies from south-westward to south-eastward in this coastal zone.

9. OCEANOGRAPHIC STRUCTURE AND CIRCULATION PATTERNS IN LAKE MENGELZAL AND THE NORTHERN PART OF SUEZ CANAL AREA

S. H. Sharaf El-Din — Oceanography Department, Faculty of Science, Alexandria University, Alexandria, Egypt

During the period of July to October 1978, 37 hydrographic stations were taken, 16 in the Suez Canal and 21 in Lake Menzelzah. At these stations, temperature, salinity and dissolved oxygen were taken at different depths. Besides, two current meters were moored at two depths for 2 days every week during the period (July to September) at Kometer 10 in the Suez Canal. Another 3 current meters were moored at 3 locations in Lake Menzelzah for more than two weeks. The salinity of the surface area in the Northern Part of the Canal is affected by the brackish water of Lake Menzelzah coming through Kohobi Junction. The dissolved oxygen is usually lower in the polluted area of the lake. Menzelzah area in the clean area. The general remark is that the current in the Canal is in the southward direction in the upper layer, while in the lower layer it is sometimes northward and other times southward. At El Gamil outlet the water flows from Lake Menzelzah to the
10. BEHAVIORS OF THE TSUNAMI AND ASSOCIATED SEICHE IN OTSUCHI BAY

Nobuyuki Shikama - Ocean Research Institute, The University of Tokyo, Tokyo, Japan

The Tsumani and seiches generated in association with 1978 Miyakine-oki Earthquake were recorded by current meters at four depths of an array which had been moored at almost central part of the bay. The bottom pressure change was also recorded in the vicinity of the array. Otuchii Bay is on the Pacific coast of the northeastern Japan and can be very roughly delineated as a rectangle of 8 km in length and 1.5 km in width and 40 m in average depth. The records show an initial rise of the tsunami which was followed by a train of waves of 1000 s, of 30 minutes. From a phase relation of the pressure record to the current records, it is suggested that the initial wave is a nature of progressive waves and in contrast to this the successive waves a nature of standing waves. The latter waves have a period of several hours and lasted for about two days with their amplitude being damped gradually. An attenuation and a relation of current to bottom pressure are discussed in more detail.

11. TIDAL MODELLING USING FINITE ELEMENT METHODS

Frank D. Malose and John T. Kuo - Columbia University, New York, New York 10027, U.S.A.

A limited area finite element numerical model has been developed for the calculation of the barotropic tides and their effects on arbitrary continental shelves and in marginal seas as a function of the depth of the ocean tides impinging on it. The model has also been used to study the effect of the bathymetry and the coastal boundaries on the tide generating potential and the surface wind stress. The shallow water equations are time integrated using a semi-implicit formulation based on that proposed by Appendix (1967) and applied in atmospheric modelling by Herring et al. (1968). The model has allowed the study of time steps 50 to 40 times longer than would be permissible in explicit schemes under 'CFL' type constraints. Element sizes may vary widely within the computational grid so that a high density of computational nodes need only be present near areas of high resolution is required such as in regions of rapidly changing bathymetry. In the discretization for the New York Eight test area, 100:1 have been achieved between the size of the largest elements on the outer shelf and the smallest elements located in the East River. The frontal method of element assembly, pioneered by Ionescu (1970) and further developed by Boyd (1976), has been adopted so that the computational grid can be efficiently and effectively varied without the cumbersome nodal remapping and for bandwidth minimization that would be necessary with standard finite element assembly techniques. For meso-scale ocean dynamic problems, a closely spaced grid is still being used due to the mesh and computer power limitations that would be necessary with standard finite element assembly techniques. For meso-scale ocean dynamic problems, a closely spaced grid is still being used due to the mesh and computer power limitations that would be necessary with standard finite element assembly techniques.

12. DIURNAL VARIATION OF PRECIPITATION IN EAST AFRICA

G. C. Amat - Department of Meteorology, University of Nairobi, P.O. Box 30197, Nairobi, Kenya, and J. R. Knecha - Kenya Meteorological Department, Government, Kenya

Annual and monthly patterns of diurnal variation of precipitation have been examined for fifty stations in Kenya, Uganda and Tanzania between latitudes of 5N and 11S. The area has a variety of topographic features including Lake Victoria which is the largest lake in the tropics with an equatorial passage through it. Based on the patterns of diurnal variation, the region is divided into ten zones, each with a distinct pattern of its own. It is found that the pattern of diurnal variation is largely determined by interaction between the synoptic scale flow in the lower layers and the meso- and synoptic scale topographic features. This is clearly seen for the coast of Lake Victoria and also for the eastern slopes of East African highlands. The classical concept of continental and maritime/coastal types of diurnal precipitation patterns need to be revised. A by-product of this study is to estimate the period of diurnal variation of circulation over Lake Victoria and its surroundings. It is found that the depth of the lake is slightly more than that of the sea breeze along the Indian Ocean coast of Kenya. Also, in the afternoon, something like a lake breeze front forms on the eastern side of Lake Victoria about one hundred kilometres from the lake shore, sloping towards the lake as we go up. The slope of the front is of the order of 1:50. Surprisingly, the diurnal cycle of precipitation on the eastern and the western sides of the Victoria has opposite phase. This is attributed to interaction between the synoptic scale seasonal flow and the mesoscale circulation associated with Lake Victoria.

This fact of observation highlights the limitation of symmetric models of horizontal velocity convergence and vertical motions in the neighbourhood of Lake Victoria.

13. NORSEX: THE NORWEGIAN REMOTE SENSING EXPERIMENT

O. M. Johannessen - Geophysical Institute, University of Bergen, Norway

The NORSEX program aims to build up national expertise in remote sensing methods and apply these to the solution of real geophysical problems in the Norwegian Waters. Three surface-truth experiments have been and will be carried out, where the SMRR and CZCS sensors in Nimbus 7 and the IR sensor in TIROS N are used. The first surface-truth program was an evaluation of the SMRR in Nimbus 7 and was carried out in the Barents Sea three days after the Nimbus 7 was launched in November 1978. The surface-truth consisted of flights with the NASA CV 990, a Norwegian F3 airplane and two research craft. The second experiment was carried out in the coastal area between Stavanger and Bergen in March/April with 5 researchvessels and 3 U.S. airplanes with IR, passive microwave and SAR sensors took part. The boundary between the Atlantic and Coastal water was well established, and this coastal front had typical wavelength of 100 km with amplitude of 50 km. The outflow from the fjords was also well demonstrated. The third experiment is to take place in September/October this year, in the marginal ice zone north of Spitsbergen. The aim is to study the ice-ocean dynamics of the marginal ice zone. A Norwagian icebreaker will be used to carry out an interdisciplinary "surface truth" program on oceanography, ice physics, biology and optics and "ice buoy" will be purchased for deformation studies. Preliminary results from these experiments will be presented.

14. SURFACE CIRCULATION PATTERN AT HIGH TIDE IN THE NORTHEAST MONSOON SEASON FROM LANDSAT CCT DATA AND IN SOUTHWEST MONSOON SEASON FROM THE FIELD DATA AT THE PANGA-BAY, SOUTHERN THAILAND

A. Siripong and S. Dharmavvanth - Marine Science Department, Faculty of Science, Chulalongkorn University, Bangkok 5, Thailand, T. Chaneesee and S. Tapansond - Hydrographic Department, Royal Thai Navy, Bangkok, Thailand; S. Muri and R. Matsuoka - Institute of Industrial Science, University of Tokyo, 22-1 Roppongi 7 Chome, Minato-ku, Tokyo 106, Japan

Landsat MSS CCT data on 2 March 1973, NASA ID No. F 1220-3143 was used in this analysis. The selected test site covered about 5,625 square kilometers. The surface circulation pattern at high tide in the northeast monsoon season was deduced from the surface suspended sediment classification from the classified by satellite, medium concentration, medium concentration to clear. At highest tide, the tidal current velocity equalled zero, so the sediment plume showed strong river influx into the upper part of the bay. The wind-current seemed to develop into two clockwise gyres in the eastern and western part of the water area which was divided by the two small islands at the middle of the bay. This current changed from the outflow from the Pang-a Bay passing Chome (inset) Pak Phra to the Andaman Sea. Since we have time to collect the field data in southwest monsoon season only in this year after analyzing the Landst data in northeast monsoon season, we have used that pattern as a guideline to select the hydrographic stations. We found the pattern was also greatly by the wind.

15. DETERMINING WIND FIELDS FOR SEASAT MEASUREMENT VERIFICATION

R. A. Brown - Department of Atmospheric Sciences/Polar Science Center, University of Washington, Seattle, Washington, U.S.A.

The ability of satellite microwave instruments to measure surface winds or stress must be verified against surface measurements. The procedure for determining such comparison fields, their accuracy and some comparisons with SEASAT data are given.
17. FINE STRUCTURES OF WIND WAVES AND REMOTE SENSING OF SURFACE WIND

J. Wu – College of Marine Studies, University of Delaware, Newark, Delaware 19711, U.S.A.

Recent results on fine structures of the wind-disturbed water surface in a laboratory tank are summarized.

The slope and curvature distributions of wind waves along upwind-downwind and crosswind directions have been measured. In both directions, the slope distributions are very closely Gaussian. The mean slope of the mean-square surface slope varies logarithmically with the wind velocity of the waves. As the wind velocity increases, the ratio between the crosswind and upwind-downwind components increases and lies between 0.5 and 0.6 at high wind velocities. The spatial structure curve is generally greater at a larger incidence angle. The average radius of the wave curvature varies inversely with the wind-fraction velocity. The ratio of the crosswind and upwind-downwind components of the average radius of curvature is unity at all wind velocities, indicating that the wind-disturbed water surface is isotropic on the smallest scale.

Both the laboratory-determined and the field-measured mean-square slopes of wind waves vary similarly with the wind-fraction velocity, but the former with short dominant waves is considerably higher than the latter with long dominant waves. Measurements of the ripples were then conducted with preexisting regular surface waves. Under the same wind-fraction velocity, with preexisting waves the mean-square slope was found to be smaller than that without preexisting waves, indicating the suppression of ripple growth by long waves.

Again with wind following preexisting waves, the results include the appportionment and the slope distributions of ripples located on various portions of the carrier-wave profile were obtained. At low wind velocities, the leeward face of the carrier wave was found to contain more ripples than the windward face. The periodic capillaries are concentrated near the crest, and move toward the trough of carrier waves as the wind velocity increases. At high wind velocities, the ripples become more evenly distributed on the leeward end and on the windward faces. However, the ripples on the windward face are concentrated near the carrier-wave crest and ripples on the leeward face are concentrated near the trough. At wind velocities the root-mean-square slope of ripples on the windward face of the carrier waves is greater than that on the leeward face.

Growth and decay rates of water-surface slopes and wave heights approaching and departing an equilibrium state were measured under suddenly started and stopped winds, respectively. The measured slopes and dispersive wave heights are found to grow and decay exponentially with time in each case, the growth rate is faster than the decay rate. The growth time of slope statistics is only about fractions of a second and is much shorter than that of height statistics, suggesting that the rippling process is nearly directly and effectively by the wind, and that wave-wave interaction and wind gusts are important to wave generation by wind.

These results are believed to be helpful for interpreting data obtained by microwave radar measurements of the ocean surface.

18. CALIBRATION FOR AN OCEAN COLOUR SCANNER FLOWN OVER A POLLUTED AREA – A PREAMBULATORY EXERCISE FOR THE USE OF NEW DATA

R. Fanetto and L. Giannini – C.N.R., 1564 San Polo, Venice, Italy

Sea truth measurements have been correlated with the data from a 10 channels OCS flown 11,000 m above the Northern Adriatic coastal zone in September 1977. Differential spectroscopy, comparing the optical density from two bands, as well as several band ratios, have been tested to establish a complete data flow for suspended matter after correction for atmospheric noise and geometric distortion. Results are discussed.

19. SOLID STATE ARRAY RADIOMETER OF THE OCEAN SURFACE


A NASA-developed Solid State Array Spectroradiometer (SAS) has been flown in studies of the ocean upwelling radiation off the Southern California Coast. These flights were coordinated with simultaneous oceanographic and meteorological observations to make remote sensing measurements using newly developed underwater spectroradiometers. Accompanying measurements included chlorophyll fluorescence and total attenuation coefficient profiles, isoterm and chlorophyll layer displacement from thermistor strings and conductivity/temperature depth profiles. The SAS uses a 4 by 342 element Charge Injection Device (CID) array detector. The array is used in a pushbroade mode with the 342 elements oriented perpendicular to the aircraft flight path. Each element has a 0.7 x 0.7 microradian instantaneous FOV. Twenty-one of the 42 channels are allocated to a grating to give spectral data between 400 nm and 688 nm. The detector array has been cooled so that the noise equivalent radiance (NER) is determined primarily by the 1 x 1 A-D. Without filters the digitization Least Significant Bit (LSB) in the blue to blue-green part of the spectrum is 300 and 350 mW·cm⁻²·sr⁻¹·μm⁻¹. The subsurface radiometers contain a photomultiplier to measure the upwelling radiance or downwelling irradiance as selected through linked subsurface and surface microprocessors. Five spectral filter positions between 430 nm and 550 nm were employed in the microprocessors controlled to allow a spectral scan in approximately one minute. Ten-bit digitization of the photomultiplier output from the subsurface unit is recorded on an HP 2100 microcomputer as is all other data.

A total photon inventory for the incident irradiance and the upwelling radiance spectra between 430 nm and 688 nm has been made and compared with the models based on measured subsurface chlorophyll profiles. Spatial characteristics of the upwelling radiance are further obtained from two-dimensional SAS imagery and the ability to predict the subsurface horizontal chlorophyll distribution is discussed. Techniques to reduce surface reflection and atmospheric scatter contributions to the total upwelling radiance are also discussed.

20. IR SEA SURFACE TEMPERATURE MEASUREMENTS AND ATMOSPHERIC CORRECTIONS

H. J. Bolle – Institut für Meteorologie und Geophysik, Universität Innsbruck, Innsbruck, Austria

The SST's can be computed from radiance in the 0.12 μm region with absolute accuracy only if the vertical distribution of the water vapor above the surface is known. In coastal areas and, sometimes also over the open ocean atmospheric aerosol can strongly interfere with the SST measurement. The magnitudes of the corrections to be applied are determined by means of METEOROSAT and SMS image. The possibilities to improve these corrections by means of simultaneous measurements of the water vapor and aerosol amount is discussed.

21. SEA SURFACE TEMPERATURE CHANGES IN KOREAN WATERS

Sangbok D. Hahn – Physical Oceanography Laboratory, Korea Ocean Research and Development Institute, KIST, P. O. Box 131, Dong Daemun, Seoul 130, Korea

Sea surface temperature (SST) changes in Korean Waters was examined with four sets of data: mean sea surface temperatures during 1982–1991, those of 1911–1925, those of 1926–1940 and those of 1961–1975. Area studied in Korean Waters is enclosed by 33°N–37°N and 129°E–131°E. There was an SST warming trend during 1982–1975, and this phenomenon was clear in winter. In February, mean SST during 1961–1975 was warmer than that of 1926–1940, that of 1911–1925 and that of 1882–1911, with temperature changes 0.5°C, 1.4°C and 2.0°C, respectively. In the South China Sea (34°N, 128°E) mean SST was 29°C during 1961–1925, 30°C during 1926–1940 and 31°C during 1961–1975. In August, mean SST during 1961–1975 was also warmer than that of 1911–1925 and that of 1882–1911, with temperature changes 0.5°C and 0.8°C, respectively. In the Southern Sea of Korea (34°N, 128°E), mean SST was 25°C during 1882–1911, 25°C during 1911–1925, 26°C during 1926–1940 and 37°C during 1961–1975.

22. AN INVESTIGATION OF A WATER-LEVEL OSCILLATION OBSERVED IN MORETON BAY, QUEENSLAND

F. E. Harding and S. N. Milford – Department of Physics, University of Queensland, St. Lucia, Queensland 4067, Australia.

Moreton Bay is a semi-enclosed bay, 50 km long by 30 km wide, to the east of Brisbane. Irregular water-level oscillations superimposed on the semi-diurnal tide have been measured at several locations in the bay along with oscillations in the water velocity. Typical water-level oscillations range from 0.5 to 1 m with periods of 10 to 30 minutes, and a duration of up to 8 hours. Subsequently measurements of atmospheric pressure and wind suggest that the oscillations are mainly due to travelling atmospheric pressure patterns rather than due to forcing by the wind. The atmospheric pressure patterns have an amplitude of 0.5 to 1 mb and vary in speed from 5 to 40 m/s at various directions across the bay.
A two-dimensional finite-difference model of the bay is driven by travelling atmospheric pressure waves. A radiation boundary condition allows outwardly propagating waves to go through the open boundaries to the north, east, and south. The uncertainty in the atmospheric pressure parameters is allowed by varying the wave pressure at the seaward ends of the bay, and the resulting changes from those predicted with a constant wave pressure are shown to the sensitivity of the bay's response to varying the parameters of the pressure waves. Calculations show that the sensitivity of the bay is orders of magnitude greater than that of the model compared with those observed.

23. ON THE TRANSVERSAL SEICHE MOTION INDUCED BY THE NEMURO-HANTOKI-EARTHQUAKE ON JUNE 17, 1973

Nobuo Moritani - Tokyo Center, Japan Weather Association, Chiyoda-ku, Tokyo, Japan; and Tomosaburo Abe - Department of Physics, Science University of Tokyo, Shinjuku-ku, Tokyo, Japan.

The Usukagomehori moat, one of the moats surrounding the ancient Edo Castle, is roughly rectangular with a dimension of approximately 610 x 69 x 1 m. The observed period of the seiche is 6.67 min which agrees fairly well with the value calculated from Moritani’s formula. Present observations of the seiche were obtained by the authors observed a remarkable oscillatory motion of the water level in the moat by the Nemuoro-Hantoki Earthquake (it occurred off the Nemuoro Peninsula, Hokkaido, Japan) on June 17, 1973. Its bi-amplitude is grown up rapidly and reaches 4.28 cm after about 100 seconds. They discussed on the data of the water level changes and the seismic records based on the one-dimensional linear model. The observed results are able to be favorably explained theoretically assuming that the oscillatory motion is induced by the selected resonance with the seismic disturbances. The amplitude of the transversal seiche motion, induced by the earthquake, decreases gradually, accompanying with the decrease of the external force coincides with that of transversal monomodal seiche. It is estimated that the seiche may be easily induced by the seismic disturbances to the transversal direction of the moat.

24. ON THE BEHAVIOR OF SLICK IN OPEN SEAS AND MOAT WATERS

Tomosaburo Abe and Harunotou Takayama - Department of Physics, Science University of Tokyo, Shinjuku-ku, Tokyo, Japan.

The following fundamental problems have been researched in order to study on behavior of the slick in open sea and moat waters. Ripple-damping effect can be considered at one of the causes of slicks. This effect is related to surface films of surfactants and it varies with the degree of composition of the film molecules. Such a compaction can be considered to be caused by horizontally propagated flow in the water or by horizontal convergence of the wind stress. As surface molecules are compacted, the film pressure and the damping coefficient are calculated by measuring the capillary wave length and height at a water surface adding small amounts of the following substances: oleic acid, stearic acid, palmitic acid, and synthetic detergents. On the other hand, the film pressure is calculated by measuring the capillary wave length, while the film molecules are influenced by the flow in the water or by the wind stress. The experiments have been carried out in small scale channels. The wave is measured by the most stable method. The method is available to measure the instantaneous horizontal distribution of the small scale wave heights. In every form of this film, the damping coefficient increases rapidly to the maximum value at a low pressure (5-10 dyn/cm²), then decreases from its maximum value due to the nearly value of 0.13 cm² after that, the damping coefficient increases gradually according to increasing of the film pressures. The following table describes the result of the latter experiment.

<table>
<thead>
<tr>
<th>Velocity of flow in 3 cm water depth (cm/sec)</th>
<th>Wind speed at the height of 3 cm above the water surface (cm/s)</th>
<th>Film pressure (dyn/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>170</td>
<td>1.5</td>
</tr>
<tr>
<td>2.5</td>
<td>250</td>
<td>11</td>
</tr>
<tr>
<td>290</td>
<td></td>
<td>7</td>
</tr>
</tbody>
</table>

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The author of this paper has attempted an interregional corollary of well data and where such data is not available, seismic reflection data with the aim of identifying inter-regional unconformities and overlaps. The sedimentary basins studied include Cambay Basin and Bombay Offshore Basin, in the West Coast, Cauvery Basin and Bengal Basin in the East Coast. In the Cambay Basin, a hinterland basin connected to the Arabian Sea is intermittently, have at least seven unconformities, whereas in the Bombay Offshore Basin there are five. In the Cauvery Basin more than seven and in Bengal Basin at least five unconformities are discernible. All these represent regression or fall of sea level. Of these unconformities a few are of regional nature—these are in the Upper Eocene, Late Oligocene, Upper Miocene and Pliocene. The unconformities are suggestive of sea level falls and the geological sequences enclosed by the unconformities represent transgressions and high sea level rises.

PS12B SEASONAL SEA ICE, ICE SURVEILLANCE AND ICEBERGS
Convener: D. F. Paskausky
SESSION 1: Monday, December 10, A.M. (2)
Chairman: D. F. Paskausky
1. D. F. Paskausky
   - The seasonal sea ice zone—a new frontier for marine science
2. R. O. Ramsayer, O. M. Johannesen, E. Swenod, and W. J. Campbell
   - Variation of the sea ice pack in the Norwegian, Greenland and
   - Barents Sea via satellite passive microwave observations: September 1973 to December 1974
3. T. A. Gossink and J. J. Kelly
   - Air-sea gas transfer through annual sea ice
4. W. Mitchell
   - Seasonal sea ice studies

1. THE SEASONAL SEA ICE ZONE—A NEW FRONTIER FOR MARINE SCIENCE
David F. Paskausky — U. S. Coast Guard Research & Development Center, and The University of Connecticut, Groton, Connecticut 06340, U.S.A.

The Seasonal Sea Ice Zone (SSIZ) is defined as the area delineated by the maximum and minimum contemporary extent of ice cover plus a region inward and outward from the ice boundary that is significantly influenced by the boundary. Due to seasonal migration of the ice boundary, this geographically significant area encompasses large expanses of deep ocean as well as most of the polar shelves in both the Arctic and Antarctic.

Growth of resource utilization and navigation to these resources in Arctic regions creates a new economic base to support an accelerated effort in ice-infested region research. Concurrent with the generation of need for research has been the development of technology, such as new icebreakers and satellite-linked remote sensing devices, capable of satisfying the logistics of research operations in the harsh environment of the SSIZ.

The growing energy requirements of the world necessitate tapping the oil, mineral and foodstock resources of the polar regions; thus in the next decade polar research represents a new frontier for marine science. Some major problem areas that must be addressed are:

1. Platforms—Development of new platforms such as lighter-than-air (LTA) craft and air cushion vehicles (ACV) as well as improving the usefulness of planes, satellites, helicopters, icebreakers and icebreakers and icebreakers is required.
2. Ice Prediction and Surveillance—With increasing vessel traffic methods of surveillance and ice region and for response to oil spills. Detection of pressure ridges and leads may be accomplished by using forward-looking sonar mounted on the bow of surface or submarine vessels and permanent bottom-mounted inverted echo sounders on (or) from the air using visual, laser and pulsed-radar scanners mounted on aircraft, satellites or space stations. Some type of numerical simulation will be necessary to smooth data gaps.
3. Biology—The ecological chain is poorly understood in polar regions. What affects would an oil spill under the ice have on the biota and how is this linked to the world ecological chain?
THE SI, A UNIVERSAL LANGUAGE

P. Giacomo — Directeur du Bureau International des Poids et Mesures

THE SYSTÈME MÉTRIQUE

To apprehend the philosophy of the SI, it is worth looking back at its father, the Système Métrique (SM), born in 1795. The goals of the SM were universality, simplicity and coherence.

Universality. There was one unit for each quantity, independent of the object to be measured, with a few common prefixes, one expressed multiples or submultiples of any unit, standards, chosen in nature, could easily be agreed by all nations, and kept forever.

Simplicity. It was systematically decimal; its universal units and prefixes were also a major contribution to simplicity.

Coherence. Simple relations allowed derived units to be established for derived quantities, such as square-meter for area or cubic-meter for volume, without introducing arbitrary numerical factors. Even the mass unit was derived from the length unit, using a cubic decimeter of water.

Coherence was the real innovation. From our present point of view, the SM failed to fulfill strictly the coherence rule: the litre and the kilogramme were based on a sub-multiple of the metre. The coherence principle was, however, clearly included in the philosophy of the SM.

THE EVOLUTION

Initially the SM was intended to solve only the problem of units for commerce. It was established by length, mass, volume, and area, these quantities being essential for the exchange of goods.

The extension of its use in various countries increased steadily and still continues. It is a matter of the definitions, and as such it is exposed to various political pressures.

A common feature in the early stages of development of new fields is the use of "temporary new field and its relations with the other parts of science. Then the need and possibility of defining new units for the sake of coherence, simplicity and university, becomes obvious. However, the change to new units always gives rise to problems.

In any case, the evolution will allow us the type of difficulties which the SM had to overcome and which we must try to avoid in the future.

NEW FIELDS FOR THE SM

Mechanics. Starting from the SM, the "natural" units for force, pressure, work, power were first established based upon the obvious force of gravity acting on a kilogramme, the so-called kilogramme-force. Units for pressure (kg/cm²), work (kg·m), power (kg·m²/s) were derived from this force unit, they have not yet completely disappeared, contributing to the popular confusion of force and mass.

The development of the mechanical sciences led to a more fundamental approach. In this field the force unit is linked to the mass unit through the fundamental law of dynamics, rather than the earth's gravity field which is subject to changes with time and place.

The "cgs" unit dyne was used for derived units like, etc., were still temporary units. They were partly replaced by the present coherent SI units: newton, pascal, joule, watt, etc.

Electricity. The development of the use of electricity in science and industry gave rise to a new problem of units.

In an attempt to create a convenient system of electrical units, people tried to derive them from the mechanical units. This appeared the "cgs electronstatic units" and the "cgs electromag- netic units" incoherent with respect to each other, and they were replaced in technical uses of electricity preferred "practical units" including the watt and the amper.

These units were derived from metric units, however, the incoherence was obvious when one had to match electrotactic and magnetic machinery.

The main ground for trying to establish a unique coherent system was the system known as MKSA was thought out in 1901 by Giorgi. It took 50 years of passionate discussions before reaching the agreement which led to the SI, along Giorgi's lines.

Thermodynamics. This field had to develop with the coming of steam engines, refrigeration and the use of liquefied gases, etc. The calorie and centesimal degree played an essential role in the development. For the sake of coherence and simplicity, we must now use the joule for all forms of energy, including heat. For temperature, the Kelvin instead of the centigrade was chosen as the basis of defining temperature as a physically measurable quantity, the key for coherence between thermodynamics and thermodynamics.

Photometry. The need of units to measure light became obvious with the development of the lighting industry. Initially, these units were based upon specified light sources, cans or oil lamps, which are linked with other physical quantities. Until recently, the candela was defined in terms of a specified light source, a black-body at the temperature of the standard platinum lamp. It is now defined in terms of the power transported by light, specified in watts. This latter definition is a definite step towards linking photometry to the other areas of physics.

The mole has long been used in chemistry, sometimes without being named. Its definition has been based on various amounts of various elements, such as hydrogen or oxygen. Recently, it became clear that the mole, now defined in terms of a specified amount of carbon twelve, had to be included in the SI. Chemistry makes more and more use of thermodynamics.

Statistical thermodynamics has long made implicit use of the mole. The step of including the mole in the SI is typical of the present concern for maintaining universality and coherence.

IMPROVEMENT OF THE ACCURACY

The other need for the SI to evolve has been and still is for the SI, the steady improvement of accuracy. There is a continuous improvement in the accuracy offered by the basic standards. The standards for the base units of the measurement system cannot be secondary to any other. Thus the stability of the base units and the standards upon which they are based must be updated from time to time.

This up-dating is performed without losing continuity in the results of measurements provided, so the size of the unit is kept unchanged.

For instance, the metre has been defined successively in terms of the terrestrial meridian; a platinum-iridium metre-bar; and a wavelength of krypton 86; in the near future, it will very likely be defined in terms of the speed of light.

Each of these standards defines a metre of the same size. The aim of each change is to improve the ultimate accuracy that can be reached when implementing the definition. The new definition is always chosen so as to be compatible with the old, taking into account the poorer accuracy with which the latter could be implemented. Since this accuracy must be the highest attainable in the field of length measurement, the change will not introduce any incoherence in practice.

Further, the base quantities and base units are chosen in the fields where measurements can be performed with the highest accuracy. The measurements of derived quantities in terms of derived units are usually based upon methods involving the measurements of these units. Thus derived units benefit automatically from the change in definition of the base units, through improvement in the accuracy of measurement of the base quantities.

For the present, the preparation of the electrical capacitance now uses, at the highest level of accuracy, of interferometric measurements of length.

LIMITS

The SI is powerful, but not all-mighty. For instance, as I said before, its geographical extension depends upon Governments. There are some other limitations which frequently lead to misunderstandings and endless arguments.

Natural Units. We all know a few units, stemming from daily experience, which were in use everywhere for as long as people. Any measurement system could be conceived. I mean the day (and to some extent week, month, year, century) for time, and feet for angle. These units are part of the common language in all countries and civilizations, with various names but clearly and accurately the same meaning, without the need of any conventional agreement.

Their exceptional ubiquity originates from the simple ways of dividing the circle into four or six equal parts; this natural fact seems to have been known in the earliest historical times. It would be unrealistic to imagine that we could get rid of these units.
Can you imagine, for instance, your garage mechanic adjusting the speed of your car engine at 100 radian per second? . . . and promising that it will be ready within one megasecond?

On the other hand, temporary units such as the calorie or erg units have been created, with more or less good luck, to fulfill an urgent need. They matter only for scientists and engineers.

Further, if we observe many old-fashioned units, we find the same name in one language to designate different units, and its usual translation is another language to designate further different units (see for instance pound, inch, foot, barrel and their "equivalent" in French : livre, pouce, pied, baril). Such units are arbitrary and confusing. They cannot pretend to the same precision or the same natural units.

It has been decided to maintain, with the SI, a few non-coherent time and angle units. The main drawback to this unavoidable tolerance is that it encourages undue support for some other non-coherent units to be maintained with the SI.

Conclusions. In all discussions related to units, convenience in size is the most frequent argument used to support some incoherent units. We cannot hope to get the benefits of universality and at the same time satisfy everybody's needs of convenience: what is convenient for land area measurements cannot be convenient for cross sections of high energy particles, and so on.

Prefixes to designate multiples and sub-multiples have been invented for just such occasion. From atto (10^-18) to exa (10^18) they cover a range of 10^36 which is likely to satisfy most needs. Further, for scientific uses, powers of ten should generally be preferred to prefixes as they are easier to deal with, they are also more universal than prefixes, the latter alphabet being less universal than the so-called "metric" figures.

ADVANTAGES OF THE SI

The SI having kept and even systematized the basic principles of the SM, its advantages stem from the same qualities: universality, simplicity and coherence.

If you have learnt seven base units and two supplementary units, you can express any physical quantity. So, far, sixteen prefixes and twenty special names of derived units are added for your convenience.

With this vocabulary of 45 words, you can readily get acquainted with any field of measurement.

You can convert yourself from mechanics to electricity, nuclear science, photometry, thermometry, energetics, vacuum technique, etc., without any problem regarding measurement units.

The SI is a universal language with respect to all fields of science and technology. It is also universal with respect to the various languages used by scientists in different countries. In that respect, it is an ideal choice for the international understanding between men.

From the scientist's point of view, it also ensures clarity and continuity. Clarity because each part of the SI is carefully and uniquely defined. Continuity because all the necessary changes in the definitions of the units maintain the same meaning for the same word. The changes do not alter the site of the unit, they just recognize the changes of the accuracy with which the same unit can be realized and used at successive epochs.

DUTIES

To take full advantage of these qualities of the SI, some rules must be kept in mind.

Coherence must be taken seriously. In all fields of science and technology, people would like to maintain old or even introduce new incoherent units for various good reasons such as traditional use or convenience in size. Each lobby has one or two "special units" so convenient that they cannot discard them. But the number of lobbies is incredibly large, and it increases with the variety and sophistication of new techniques. This is the respect which would quickly lead to a state very similar to, if not worse than, that prevailing before the advent of the SI.

A dozen incoherent units, mainly of time and angle, are admitted for use with the SI. Another dozen are temporarily admitted. If the use of some other incoherent units cannot be by now abolished, at least mixing them with the SI units must be strongly discouraged.

Never introduce an incoherent unit where it is not already (traditionally) in use. The advantages of the SI are almost universally agreed. However, because it is very difficult, and sometimes hopeless, to convince some people that the change to the SI is worthwhile. For the sake of liberty of judgment and behaviour, a compulsory change is sometimes considered as unfair. But, in my opinion, it is still fair to forbid a backward move. This is at least a way to be sure that coherence will finally win.

Never expect the unit to specify the quantity. It is a common habit, in loose language, to forget to mention the quantity. It is not obvious that "one kilogram of beans" means a mass of one kilogramme. Scientific language cannot rely upon such statements. On the other hand, if the quantity is clearly stated, the unit is redundant. It is, however, necessary to express the unit: redundancy is necessary in any information process.

This last rule is the price we must pay for universality of units with respect to the objects or quantities having the same dimensional equation.

It is indeed one of the rules which is the most frequently violated. One frequently diverts units from their task thereby creating "jargon-units" unworthy to express clear scientific thoughts.

Just compare the two sentences: "The power is 100 W, 50 W Mech and 25 Wpj" or "The power is 100 W, the mechanical power is 50 W and the electrical power is 25 W". Even worse: "The voltage is 15 Vcc" or "The peak to peak voltage is 15 Vcc" (of course, if 1 am French, Vcc is supposed to mean "voltage de crête à crête").

If I write 15 Vcc, I expect that the reader knows what this "unit" means. If I write 15 V, I know that I am obliged to specify what I mean by Vcc.

This last rule will in fact help to enhance clarity. Each time I am tempted to use a "jargon-unit," I must ask myself: "Have I clearly stated the quantity I want to express?" I am sure that the current answer will be "no."

The effort required to observe these few rules is definitely worthwhile, compared with the universal understanding that a proper and widespread use of SI will bring.

THE SUN COMMITTEE AND SI UNITS

R. W. Stewart — Chief Executive Officer, Ministry of Universities, Science and Communications, Victoria, Canada

I recall with some pleasure that the Committee on Symbols, Units and Nomenclature was put in place at the Berlin IUGG Assembly at my own instigation. In the dozen years since, the Committee has made an important contribution. The decision, reported at the Grenoble Assembly, that oceanographers should adopt SI units was a natural one, but one with very important implications for our science. It has led to a fuller examination of all of the units employed, particularly in physical oceanography. The recommendations of the Committee go far beyond a simple adoption of SI units, to the sweeping away of a lot of baggage which has been accumulated over the years by the science, but which is now a serious encumbrance if not regarded as principally of historical interest and subject to cataloguing in a museum of science. Despite the energetic work of a very powerful committee, and despite the adoption of SI units throughout virtually all areas of science, the rationale of this system is not yet fully appreciated by all oceanographers. It was therefore agreed to invite Dr. Giacomo to present a lecture on the System Internationale. Since this paper is important to oceanographers, and since there seems no ready place for it in the ordinary oceanographic literature, it has been decided to publish it in these proceedings.
IUGG SYMPOSIA (IA P S O LEAD ASSOCIATION)

IUGG-4 PROBLEMS OF COASTAL AND ESTUARINE ZONES
Sponsors: IAPSO, IAG, IAMAP, IAHS, ICG(CMG)
Convenor: J. B. Matthews
Co-Convenors: B. J. Noye and N. S. Heaps

SESSION 1: DYNAMICAL INTERACTION OF THE SEA BREEZE WITH COASTAL WATERS
Monday, December 10, A.M. (2)
Chairman: R. H. Clarke
1. R. H. Clarke
   Introductory talk
   An overview of our current understanding of the physical interactions between the sea and land-breeze and the coastal waters
2. R. A. Pielke
   A numerical study of the thermocline induced by sea breeze
   Simulation of the thermocline oscillation in Lake Kinneret (Sea of Galilee) as induced by the inland penetration of the Mediterranean sea breeze
4. Y. Maher and J. Neumann
   Horizontal heat-flux variations and the sea breeze

SESSION 2: LARGE LAKES
Monday, December 10, P.M. (1)
Chairman: C. H. Mortimer
6. C. H. Mortimer
5. C. R. Morphy
   Characteristics of internal waves of Kelvin and Polincare type coastal observed during IFVGL (Lake Ontario, 1972)
6. G. T. Canady
   Frictional and inertial coastal boundary layers in the Great Lakes
7. J. Saylor
   Rotational waves in the Great Lakes and their significance in large-scale mixing processes

SESSION 3: ESTUARIES 1
Monday, December 10, P.M. (2)
Chairman: B. J. Noye
9. K. P. Bowden
10. B. Kjerfve
   Turbulent mixing in estuaries
   Variability of material transport in a well-mixed estuary: synoptic cross-correlation measurements in North Inlet, South Carolina
11. J. Stroanch
12. M. A. Gerges
    The Fraser River Plume, British Columbia, Canada
    Recent observations of currents from moorings in the Egyptian waters off Sinal Coast
13. J. B. Matthews
    Circulation in a seasonally ice-covered Arctic lagoon estuary

SESSION 4: ESTUARIES 2
Tuesday, December 11, A.M. (1)
Chairman: N. S. Heaps
14. J. Sundemarss
15. R. A. Denton
    Migration and deformation of tidal dunes in an estuary
    The role of bed slope in determining length and stability of density wedges
16. G. Krause
17. D. M. Farmer
    Long term mixing processes in tidal estuaries
    Hydraulic control in a sill fjord

IUGG-4 (continued)

SESSION 5: COASTAL SEAS
Tuesday, December 11, A.M. (2)
Chairman: J. B. Matthews
18. T. Takahashi
    Seasonal differences of the circulation processes in a coastal basin nearly closed by land
19. A. Alcamo
    On the scales of variability and the structure of waters of the Baltic Sea
20. K. A. Elahi and K. Rashid
    A mathematical model of the Northern Arabian Sea
21. B. J. Noye
    A three-dimensional tidal model for shallow seas

IUGG-5 THE ORIGIN AND NATURE OF THE SOUTHERN OCEAN
Sponsors: IAPSO, IASPEI, IAVCEI, IAMAP, ICG(CMG)
Convenor: Sir George Deacon
Co-Convenor: D. E. Hayes

SESSION 1: Wednesday, 12 December, A.M. (2)
1. G. J. Johnson and J. R. Vannay
   Bathymetry of the circumpolar ocean
2. J. P. Kennett
   Paleo-oceanography of the circumpolar ocean
   The nature of the climatic evolution of the Southern Hemisphere
   New ideas on the early separation of Australia and New Zealand

SESSION 2: Wednesday, 12 December, P.M. (1)
5. K. Schlich and J. Grothe
   Plateaus and seamount ridges in the Southwest Indian-Antarctic sector
6. L. A. Frakes
   Physical and biological influences on sediment distribution

SESSION 3: Wednesday, 12 December, P.M. (2)
7. E. Bertkowskoy
   The influence of Pacific surface waters on the sediments of the Malvin Plateau
8. P. F. Barker and I. A. Hill
   Scotia Sea evolution and the growth of the Antarctic circumpolar current
   A joint Australian/U.S. Aeromagnetic survey of the Australia-Antarctic discordance
IUGG-13 OCEAN AND ATMOSPHERIC BOUNDARY LAYERS
Sponsors: IAPSO, IAMAP

SESSION 1: Wednesday, December 12, A.M. (1)
Chairman: Henry Charnock
1. J. A. Businger Review of turbulent transfer of momentum at the air-sea interface
2. D. Hess The impact of the WANGARA experiment
3. R. R. Long A new theory of the neutral planetary boundary layer
4. Tatsuh Iyashi and Yasushi Mitsuta Air-sea heat exchanges associated with mesoscale phenomena during AMTEX
5. R. A. Antonia and A. J. Chambers Wave-induced effect on the similarity of Reynolds shear stress and heat flux in the marine surface layer
6. A. Weil Studying atmospheric mixed layer evolution using a triple monostatic Doppler sodar

SESSION 2: Wednesday, December 12, P.M. (1)
Chairman: J. Imberger
7. R. A. de Stoeckel Mixing in the upper ocean
8. F. Schott Near-surface horizontal scales and mixing under varying stratification as determined from FLEX’76

SESSION 3: Wednesday, December 12, P.M. (2)
Chairman: J. Imberger
10. J. C. Gascard, J. Gouella and H. Lacombe Response de la mediterranee aux flux d’eau et d’energie a travers au surface aux echelles sidereennes inter-annuelle et climatique
11. E. Augustin The influence of cloud convection and radiation on the boundary layer development in ocean and atmosphere
12. P. K. Taylor Observations of the atmospheric boundary layer during JASIN

SESSION 4: Thursday, December 13, P.M. (1)
Chairman: Roland De Stoeckel
13. W. G. Large and S. Pond High wind speed flux measurements
14. J. D. Woods Diurnal variation of convection in the ocean mixed layer
15. D. Cadet, G. Reverdin and G. Sommeria Lagrangian investigation of the tropical boundary layer within the monsoonal flow
16. R. H. Spigel and J. Imberger Mixed layer dynamics in lakes of small to medium size
17. C. A. Jacobs and A. Satern An examination and model simulations of an observed large diurnal amplitude event in the sea-surface temperature during GATE
18. P. Kundu Similarity and other dynamical considerations of one-dimensional mixed layers

IUGG-5 (continued)
SESSION 4: Thursday, December, P.M. (1)
10. H. L. Bryden Effect of eddies on the circumpolar current
11. T. M. Joyce, J. M. Toole and E. P. W. Home Mixing and poleward fluxes across the Antarctic polar front
12. D. J. Baker and R. B. Hearst Low-frequency fluctuations in the circumpolar current from deep-sea pressure gauge measurements
13. M. Davey The role of mixing in the dynamics of the circumpolar current

SESSION 5: Thursday, December, P.M. (2)
14. T. D. Foster The thermohaline structure of the Weddell Sea
15. A. Foldvik Current and tidal measurements in the Weddell Sea
16. A. L. Gordon Weddell-Gyre circulation

SESSION 6: Friday, December, A.M. (1)
17. W. F. Budd Sea-ice variation and climate
18. H. van Loon The effect of the Southern Ocean on the vertical structure of, and poleward heat transfer by, the quasi-stationary waves
19. B. A. Warren Role of the Antarctic in the deep circulation of the world ocean

SESSION 7: Friday, December, A.M. (2)
20. J. R. E. Lutjeharms The influence of the Agulhas Current
21. J. Crease Current measurements and FGGE buoy drifts in 20° to 30° East
22. R. A. Heath Oceanic fronts in the New Zealand region

SESSION 8: Friday, December, P.M. (1)
23. A. P. Treshnikov, E. I. Sarukhanyan and N. P. Smirnov Field observations on the ACC structure and dynamics
24. V. B. Zaleszny and Yu. A. Ivanov Numerical experiments on the analysis of a two-dimensional model of thermohaline and wind circulation in the ocean
25. V. V. Goretsky, V. O. Ivchenko and E. I. Sarukhanyan Numerical simulation of the Southern Ocean circulation

SESSION 9: Friday, December, P.M. (2)
27. S. P. Hayes The internal wave field near the circumpolar current
28. M. K. Robinson Atlas of surface layer mean monthly temperatures and annual salinity
29. D. J. Tranter Interlinking of physical and biological problems in the Antarctic Ocean
SESSION 5: Thursday, December 13, P.M. (2)

Chairman: M. Biscove

21. Y. Toba and M. Tokuda - Similarity regime for wind waves under strong coupling with the wind
22. E. C. Menahan and K. L. Davidson - Marine aerosol production from whitecaps
23. A. Ramamonjisoa - On crest-pairing and its consequences in gravity wind wave fields

IUGG-20 TIDAL INTERACTIONS

Sponsors: IAPSO, IAG, IASPEI
Convenors: D. E. Cartwright (IAPSO), R. Leoluzet (IAG)
K. Lambeck (Local Representative)

SESSIONS 1, 2 & 3: NUMERICAL AND OTHER MODELS
Tuesday, December 11, A.M. (1) & (2)

Chairman: D. E. Cartwright

1. M. E. Parke (invited paper) - Global open ocean tide modeling
2. E. W. Schwiderski - Detailed ocean tide models of M2, S2, K1 and O1
3. J. T. Kuo and K. H. Chen - Global finite element modeling of the total open ocean tides
4. K. Lambeck - Tidal dissipation, the Q of the oceans, and the acceleration of the moon's longitude
5. J. C. J. Nihoul - Nonlinear tidal interactions, tidal eddies and tidal fronts in the North Sea
6. D. J. Webb - Tides and tidal friction in hemispherical oceans
7. A. E. Gill - A simple model for showing effects of geometry on the ocean tides

SESSION 4: OPEN-SEA MEASUREMENTS AND RELATED THEORY
Tuesday, December 11, P.M. (1) & (2)

Chairman: D. J. Webb

8. D. Dowdle and C. Garrett - Shelf-edge tides off the Gulf of Maine
9. D. Cartwright, R. Spencer and I. Vassie - Pelagic pressure measurements and their role in ocean tidal dynamics
10. J. Filloux - Program of open ocean measurements of sea floor pressure fluctuations and early results
11. A. J. Clarke - The effect of continental shelves on tides
12. F. Schott and A. Sy - On relations between barotropic tides, baroclinic tides and internal waves at the West African continental rise
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