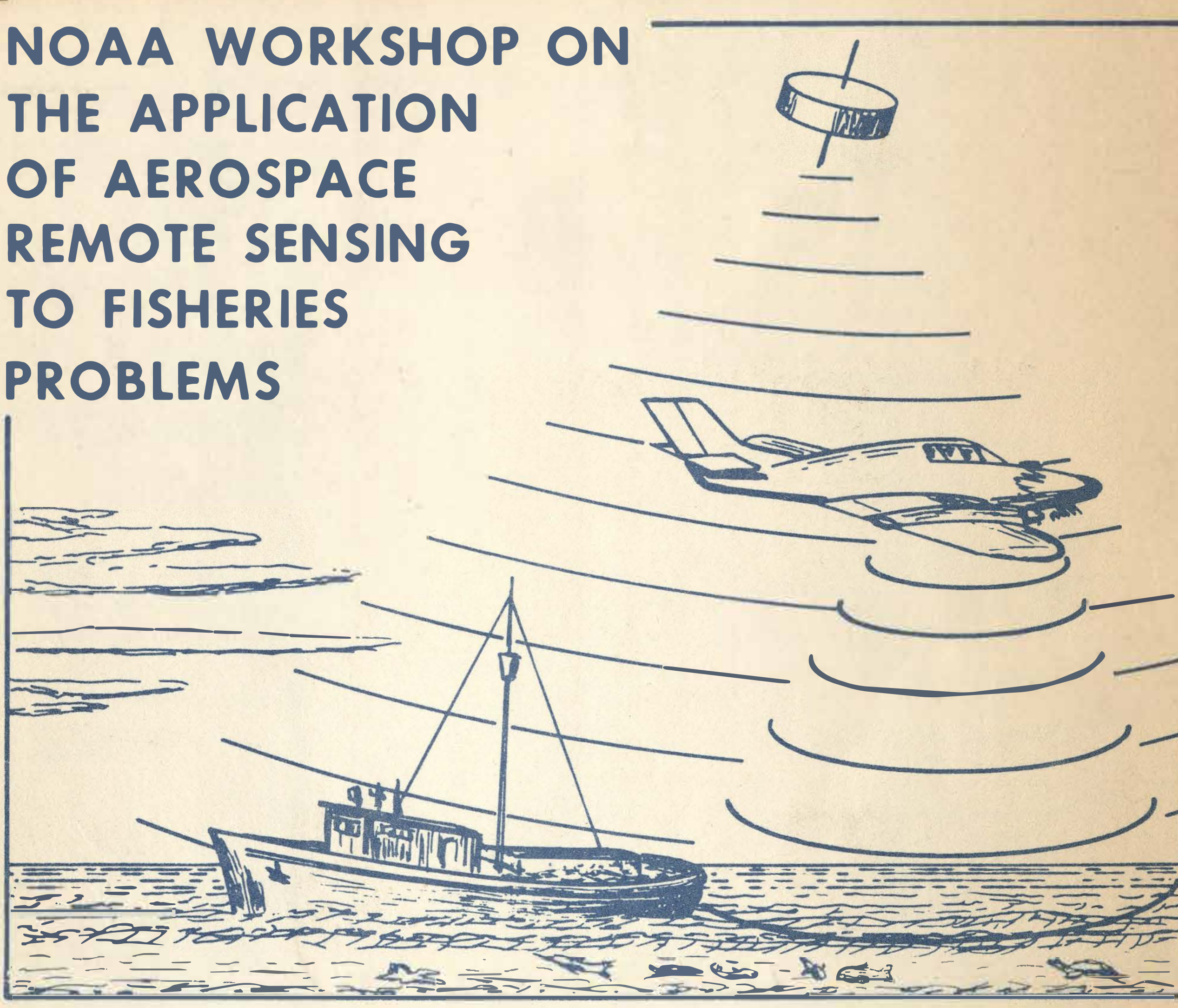
NOAA WORKSHOP ON THE APPLICATION OF AEROSPACE REMOTE SENSING TO FISHERIES PROBLEMS



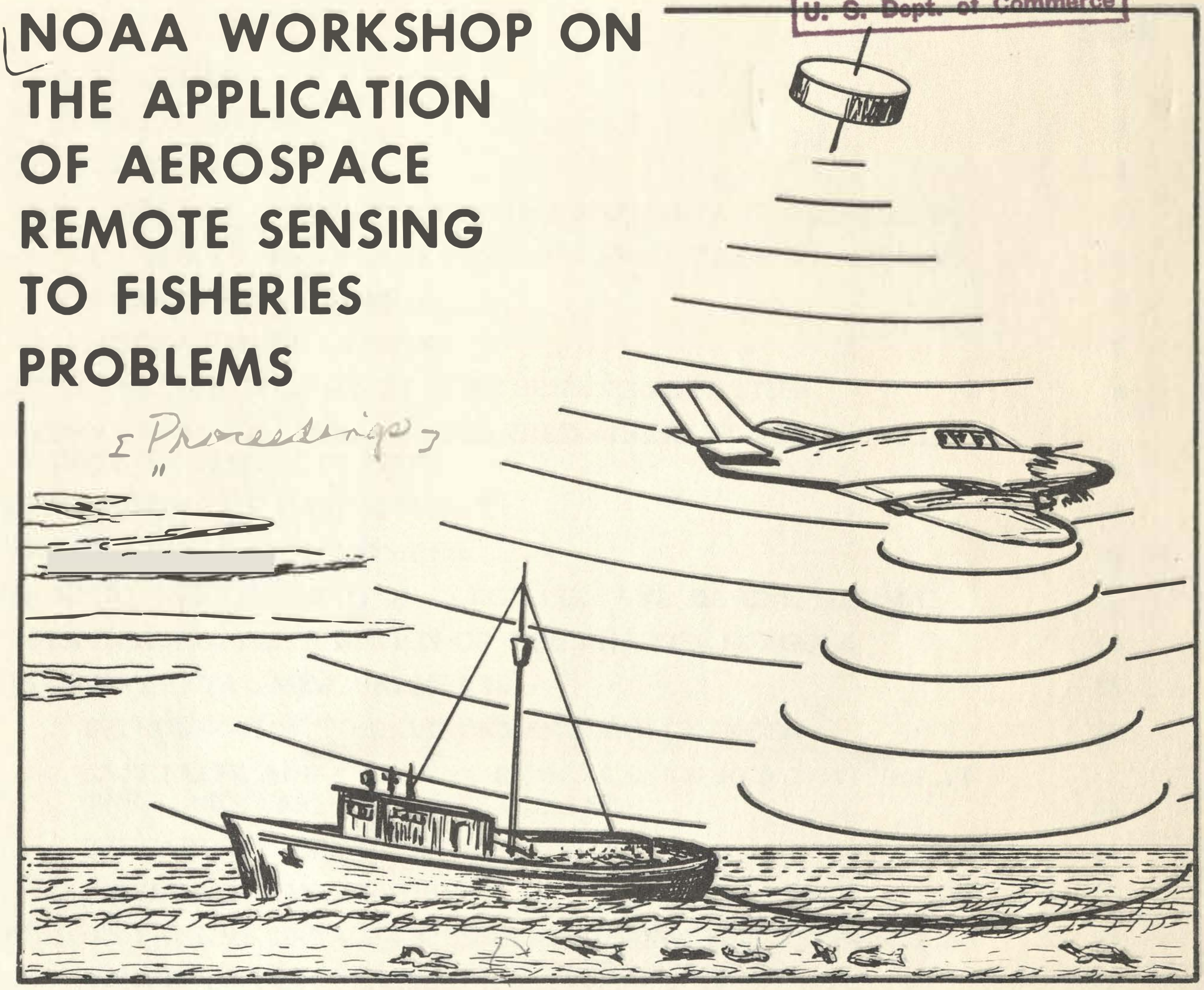
MISSISSIPPI TEST FACILITY

February 28 – March 2, 1973

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

NOAA WORKSHOP ON THE APPLICATION OF AEROSPACE REMOTE SENSING TO FISHERIES PROBLEMS

[Proceedings]



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NOAA WORKSHOP ON THE APPLICATION OF AEROSPACE REMOTE SENSING TO FISHERIES PROBLEMS

INTRODUCTION

The NOAA Workshop on the Application of Aerospace Remote Sensing to Fisheries Problems was held at the Mississippi Test Facility, Bay St. Louis, Mississippi, on February 28, March 1, and March 2, 1973 with Dr. William F. Royce of National Marine Fisheries Service, Washington, D. C. as Chairman and Mr. William H. Stevenson of National Marine Fisheries Service, Fisheries Engineering Laboratory at the Mississippi Test Facility as Program Chairman.

The purpose of the workshop was:

- To familiarize key NMFS personnel with the current and impending state-of-the-art in remote sensing systems and techniques, including biological and environmental indicators used in remote sensing, and types of data resulting from remote sensing.
- To identify data requirements for the successful solution of specific problems related to the various facets of the National Marine Fisheries Service sphere of responsibility and to define opportunities for data acquisition utilizing remote sensing techniques.
- To develop preliminary recommendations for solutions of fishery problems using remote sensing techniques, and to develop priority assignments for future fisheries remote sensing research and development programs.

The workshop was initiated by the Program Chairman, Mr. Stevenson, with opening and logistics remarks after which he introduced Mr. Jackson M. Balch, Director, National Aeronautics and Space Administration, Mississippi Test Facility who welcomed the participants to MTF.

WELCOME ADDRESS

Mr. Jackson M. Balch, Director
National Aeronautics and Space Administration
Mississippi Test Facility

In his welcoming statement, Mr. Balch gave a background of the type of work being done by enumerating those agencies now involved in programs at MTF with a brief description of the work of each. Agencies which are now located at MTF include:

1. Department of Interior
   a. U.S. Geological Survey
      - Water Resources Division - Gulf Coast Hydroscience Center
      - First field experimental analysis of the EROS program
   b. National Park Service
      - Regional Ecosystems Laboratory has two functions: (1) to provide laboratory support, and (2) data modeling function.
   c. Environmental Protection Administration
      - Analysis and categorical programs
      - National Soil Monitoring Laboratory
      - Regional Pesticide Chemical Regulation Laboratory
2. Department of Transportation
   a. U.S. Coast Guard - identifies spillages and seepages of oils and hazardous materials and makes arrangements for clean up.
3. Department of Army
   a. Environmental and hazardous operations research and development function.
4. NASA
   a. Johnson Space Flight Center - Earth Resources Laboratory is heavily involved in application techniques of remote sensing as it applies in a local environment or need.
   b. Marshall Space Flight Center - Shuttle testing operation which provides for the development and proof testing of the new high performance liquid engine and the solid rocket engine.

5. Institutional headquarters of the Gulf Universities Research Consortium includes the University of Miami, Florida State University, University of Texas, and Southern Methodist University.

6. Staff office of the Governor's Office/Governor's Council of Science and Technology of the State of Mississippi. This Council consists of the heads of all line state agencies which have environmental and resource problems. Arrangements are being made for the same type office for the State of Louisiana.

7. Department of Commerce

   a. National Oceanic and Atmospheric Administration

      - NOAA Data Buoy Office
      - NOIC Resident Office - Major instrumentation, calibration, and repair facility for marine world. Details of utilization have not been worked out yet with NOIC.
      - National Marine Fisheries Service - Fisheries Engineering Laboratory.

Due to NASA programming and funding overall site readiness and support for rocket test and development assignments (already decided in the case of the Space Shuttle program), it is possible for other agencies resident at MTF to purchase a wide variety of technical services at reimbursable cost rates based only on those agency peculiar costs that are additive to the overall site rocket readiness posture. This results in very attractive support costs--perhaps as low as fifty to sixty percent of those normally expected at home installations or through vendor sources. Site institutional services costs are even more favorable--perhaps as low as ten cents on the dollar.

KEYNOTE ADDRESS

Mr. David H. Wallace
Associate Administrator for Marine Resources
National Oceanic & Atmospheric Administration

Following the welcome address by Mr. Balch, the Chairmanship was turned over to Dr. William F. Royce, who introduced Mr. David H. Wallace, Associate Administrator for Marine Resources, National Oceanic and Atmospheric Administration, who delivered the keynote address. In his keynote address Mr. Wallace stated that the reason for the workshop was to determine the opportunities thay may exist for advancing the solutions to some of the problems relating to fisheries through applications of aerospace technology, particularly that relating to remote sensing. The White House, in its last budget review, emphasized that Federal Research and Development should be relevant to the needs of the nation. In this area, economic problems of some commercial fisheries; growing demands of recreational fisheries; conservation of marine fish, shellfish, and mammals; and protection of the marine habitat from natural and man induced adverse environmental alterations certainly fall into the "relevance" category; internationally, nationally, and locally. This workshop can be considered as a broader effort than prior discussions on remote sensing to determine fisheries user requirements as they relate to current research and development in aerospace sensing. Questions posed by Mr. Wallace as available items for consideration included:

- Can we reduce the hunting efforts of commercial fishermen in locating fish schools such as menhaden or tuna?
- Can we enhance the opportunities available to the public for sportsfishing by identifying sportsfish locations or habitats such fish would normally seek?
- Can we predict the formation of red tides, with their disastrous economic results, such as those which recently occurred off the New England coast?
- Can we improve our conservation efforts on the large marine mammals, such as whales, by aerospace sensors capable of providing census or tracks?
- Can we identify ocean pollutants in sufficient detail to prevent or assess destruction of fishing grounds?
- Can our MARMAP Program be strengthened by selective aerospace data?

STATEMENT OF WORKSHOP MEETING PURPOSE AND OBJECTIVES

Dr. William F. Royce
Associate Director for Resource Research
National Marine Fisheries Service

In his statement of workshop meeting purpose and objectives, Dr. Royce called attention to the formal objectives listed on the agenda and noted earlier in this report. Rather than reiterate these objectives, Dr. Royce provided a brief overview of fishery problems in the resource research area of the National Marine Fisheries Service by:

- Giving a review of the Conference on Fisheries Management which was just concluded in Vancouver, British Columbia.
- Indicating in a general way, the areas in which money is now being spent in resource assessment.
- Covering mechanics of the meeting.

REVIEW OF THE CONFERENCE ON FISHERIES MANAGEMENT

The Conference was called by the Food and Agriculture Organization of the United Nations and was attended by 300 representatives from 55 countries and a dozen international commissions. They undertook to review the status of fisheries stocks around the world, methods of managing them, economic and institutional bases for dealing with them, and evaluated the status of fisheries management and development in different parts of the world. Full documentation will be published by the Fisheries Research Board of Canada in its Journal scheduled for August, 1973.

The outstanding feature of the conference was the general consensus with respect to the limit of production of conventional species of living marine resources. At present, approximately 70 million tons of conventional species are being produced annually and the consensus is that only about 30 million additional tons could be produced. In the near future we will be searching for new stock, hunting new means of harvesting present stock, and upgrading species we now take by marketing them in a more valuable form.

One of the major developments in the past few years is the expansion of long range fleets. However, due to economic problems now faced by long range fleets, further expansion is not anticipated; instead, short range fleets will probably be expanded and long range vessels reduced.

Due to increased pressure and activity on the fishing industry, there must be an effective method of controlling fishing intensity and pollution of inshore waters.

The United States at present only produces about 1/3 of the fish it consumes. Yet, there are resources available, some of which are practically untouched and some which are being fished by foreign vessels that could be more economically fished by the United States. In order to produce a larger percentage of national consumption, greater efficiency is required in two areas:

- Better fishing vessels adapted for the job.
- Fishing effort in the right amount must be applied to resources.

Recommendations which emerged from this conference included items on planning, fisheries data, need for early management action, science and development, mobile fleets, participation of industry in the development of fisheries in developing countries, promotion of research and training in fishery resource management and development, multiple uses of applied resources, and the acceleration of aquaculture.

CURRENT PROGRAMS

Comments made by Dr. Royce on the existing programs in the Fisheries Service on resource research included:

- Resource Assessment - Comprises about 60 percent of the budget. Included in this area is stock definition, distribution, migration, and biology. Abundance in terms of number and weight must be determined periodically. The effects of fishing and environmental changes on resources must also be determined.
- Inshore Environmental Studies - Utilizes approximately 20 percent of the budget. This area is concerned primarily with three things: location and movement of pollutants; effects of these on ecology of the area; and the effects of these on organisms.
- Aquaculture Operation - Comprises about 10 percent of the budget. This area is concerned with a scientific base of accelerating commercial aquaculture and dealing with specific problems.
- Marine Mammal Program - Approximately 10 percent of the budget. This program studies marine mammal stocks, their biology, abundance and ways to minimize harm to these animals by fishing operations.

MECHANICS OF MEETING

A committee of three participants was selected by the Chairman for the purpose of drafting recommendations from the workshop. This committee consisted of:

Mr. John Sherman - National Environmental Satellite Service

Mr. Jim Johnson - National Marine Fisheries Service

Mr. Walter Nelson - National Marine Fisheries Service

A question was posed by Mr. Sherman relative to the limit on anchovies on the West Coast resulting in anchovy boats being idle a large part of the time. This condition is not conducive to the improvement of fishing boats or the industry in this area.

Comments were made by both Dr. Royce and Mr. Wallace relative to the problem, expressing a concern about the limits imposed, possibility of foreign vessels fishing the area, of anchovies being utilized for meal in South America, and the necessity for the United States to move ahead in fishery resource utilization.

INTRODUCTION TO NOAA REMOTE SENSING ACTIVITIES

Dr. William Davis, Chief
Upper Atmosphere & Space Services
National Oceanic & Atmospheric Administration

Remote sensing is not new, however, new remote sensing technology has been developed. This technology is being looked at both in terms of whether old jobs can be done better and whether important new jobs that couldn't previously be done at all can be accomplished through the use of this technology.

Considerable investigation has taken place of some applications using experimental sensors flown on aircraft, NOAA environmental satellites, and NASA experimental satellites, such as ERTS and Nimbus. New opportunities are now developing. In particular, there is an immediate need to define requirements for sensors on Nimbus G, which is to be an oceanographic and pollution oriented experimental satellite scheduled to fly about 1977. NOAA has been given the task of defining these requirements by the OMB chartered Interagency Coordinating Committee for Earth Resources Survey Program (ICCERSP), and it is important that we first of all understand our own requirements as well as those of other agencies and sectors of the economy. This meeting thus has the specific purpose of defining such requirements as they relate to fisheries, as well as the more general objective of developing NOAA program objectives in all types of remote sensing for the future. Only by understanding the nature of remote sensing and how it can contribute to our various missions can we perform that task in a meaningful manner. We are thus looking both ways at this Workshop: we have some powerful new technological answers seeking problems which can be solved in a cost effective manner; and at the same time, we have manifold problems for which we seek solutions, which may or may not be soluble using remote sensing techniques. Hopefully we should achieve mutual understanding which will help achieve both kinds of objectives.

Question - J. Johnson - How soon does NOAA have to submit Nimbus G requirements to NASA, and when is it scheduled to fly?

Answer - Dr. Davis - Requirements must be submitted within 1 to 2 months. Nimbus G is scheduled to fly in 1977.

OVERVIEW OF EXISTING AND PLANNED AIRCRAFT AND SATELLITE REMOTE SENSING ACTIVITIES

Mr. John Sherman
Spacecraft Oceanography Group
National Environmental Satellite Service

Mr. Sherman presented a technical review of what remote sensors can measure, what they might acquire in the way of data, and then made the translation into information. A recent paper by Kirby Hanson of Atlantic Oceanographic and Meteorological Laboratories, entitled "Remote Sensing of the Ocean", published in a recent NOAA publication, Remote Sensing of the Troposphere, was recommended by Mr. Sherman as a very good overview of current remote sensing activities.

The entire program of remote sensing in National Environmental Satellite Service is driven by satellite technology. A number of platforms are being talked about for space. Some of the present platforms that are real are:

- NOAA 2 - Sea-surface temperature measuring capability
- SMS/GOES - Synchronous measuring satellite - Supports GATE Program
- ERTS-1 - Launched 1971 - reviewing data
- ERTS-B - Pollution and turbidity
- Nimbus 5 - Microwave Imaging System
- Nimbus F - Follow on to Nimbus 5
- Nimbus G - Dedicated Oceanographic Sensors
- GEOS-C - First Geodetic Satellite with Radar Altimeter
- TIROS-N - Buoy tracking, SST, ocean color radiometer
- Skylab - All basic types of ocean remote sensors that might be deployed to space in the next decade.
- IRDM - International Rendezvous and Docking Mission/Apollo-Soyus Mission may collect ocean data.
- Shuttle - Large payloads.

The objectives that have existed for several years are to:

- Establish the feasibility of techniques.
- Determine how quantitative it can be in relation to water quality.
- Develop and test display techniques for remotely acquired data.
- Develop forecasting techniques that would take advantage of remotely acquired data.

The remote sensing program uses other vehicles as well as satellites. These include:

- Towers and piers
- Buoy systems
- Submersibles
- Research vessels
- NASA aircraft

The properties of the interaction of electromagnetic energy with ocean water establishes some of the constraints and limitations of remotely acquired data. Utilizing a series of charts and pictures of submersibles, the visible region attenuation coefficients versus wave lengths was demonstrated, pointing out that the blue-green area must be utilized.

Sun angle, sea roughness, and manner at which overflight is made must be carefully considered when making surface measurements because of the glitter pattern. Based on a glitter pattern sensor with polarization capability, it is felt that some salinity estimates may be made from space.

Resolution and contrast were defined by utilization of a graph which showed that the contrast of an object being measured is much more critical than the resolution of the measuring instrument.

Areas where feasibility of concepts have been established are:

<u>Ocean Dynamics</u>

- Surface roughness, wind, and temperature
- Ocean tides and storm surge
- Geostrophic currents
- GEOID deflection and sea slope
- Sea-air interaction

Major related NOAA Programs:

- MAREP/OMAP
- GARP/FGGE/GATE

Factors which affect the emission of passive microwaves include salinity at certain frequencies, physical temperature of water at L through C bands, surface roughness, surface winds and foam.

Sea Surface Temperatures

Photographs of the Gulf Stream showed the temperature variation on the ocean surface. In comparisons between satellite and conventional techniques, differences arise due to temporal changes but can be correlated rather closely.

Ocean Color

Ocean color includes water mass identification; surface current and circulation systems; transport studies; and chlorophyll detection, monitoring, and productivity. The ocean is distinguished by its color due primarily to the presence of chlorophyll and the absorption of these and other organisms. Through a series of flights over the San Francisco Bay area and the West Coast of Africa, in particular, a close relationship was shown between the amount of chlorophyll, temperature changes, and the presence of fishing vessels. Where chlorophyll increased, the temperature changed rather sharply, and there fishing vessels were found.

There is presently in use an imaging system, a multi-channel ocean color system, with pictures in twenty separate channels, each with about 150 angstroms of spectral resolution. The instantaneous field of view from 37,000 feet altitude is about 50 feet. This instrument has been flown at high altitude and the data reduced, showing in some detail the variation in chlorophyll in ocean water. This system is an electronic system with data recorded on digital tape. In shallow water care must be taken in determination of chlorophyll due to bottom reflection.

Fisheries Environment Assessment

Items to be considered relative to Fisheries Environment Assessment include:

- Life in the sea
- Direct fish detection
- Forecast of seasonal catch
- Estimate of maximum sustainable yield

- International agreements
- Fish kills

Coastal Processes

Coastal processes is a very important program in National Environmental Satellite Service with circulation type studies within the coastal regions being emphasized.

Included in the area of coastal processes are:

- Shore and coastal mapping
- Bathymetry and hydrography
- Current and circulation systems
- Wetland mapping
- Bay, delta, and estuarine dynamics
- Catastrophic events

In all measurements, a measurement of energy is being made. It can be reflectance by suspended sediment, absorption by chlorophyll, surface anomalies, difference change due to oil, and color. (An observation by Mr. Bill Glidden pointed out that a key element mentioned which affects energy is spectral distribution. Multi-spectral techniques can be used to sort out the items and effects referred to previously.) (Comments made by Mr. Stevenson emphasized that a transfer of the understanding of the energy by putting it into spectral signature, and relating the signature to a phenomena that is related to fisheries or fishery significant oceanography, would afford a logical step.)

Conclusion

Dr. Al Strong was to have discussed some of the sea-surface temperature measurements in which he has been involved.

Dr. Vernon Derr has a laser, radar-type instrument which is being used in conjunction with Raman's spectra, which may be able to measure the temperature profile in the ocean remotely.

Dr. George Maul has done considerable work in the area of interaction effects of the atmosphere and ocean surface and how these things modify the signals being used.

(Dr. John Proni advised that he had been sent by Dr. Appel to make a short presentation on the Coupling of Satellite Observations within the Body of the Ocean.)

All of the above named participants made presentations at a later time. These presentations are summarized in this report in the relative positions in which they were delivered.

DISTRIBUTION OF FISHING CRAFT

Dr. Robert F. Hutton
Associate Director for Resource Management
National Marine Fisheries Service

Dr. Hutton presented The Distribution of Fishing Craft, along with the Fisheries Enforcement and Surveillance Program, and the specific needs for information which might be met through aerospace technology.

The need for surveillance and enforcement has increased tremendously over the past few years, due in part to the vast increase in foreign fishing vessels off the coast of the United States. Agreements and recommendations of various international commissions are becoming more complex in design and enforcement. Compliance with adopted conservation measures is mandatory by all nations if the fishing industry is to survive.

In the Northwest area of the United States, the protection of salmon resources from foreign fishing vessels is a grave concern. Other species such as ocean perch and Pacific hake are also important to the economy of the Northwest. Increased surveillance is needed to insure that traditional resources are protected under the terms of international agreements.

Along the California coast problems presently exist with anchovies, yellow fin tuna, etc.

In the Gulf and South Atlantic, an increase in foreign activity has been noted, although in the past these areas have been relatively free of foreign fishing vessels.

In the North and Middle Atlantic, foreign fishing has been extensive; so that at present, under international agreement, haddock, cod, yellowtail flounder, herring, and silver and red hake resources are under an annual quota system.

In Alaska, almost constant surveillance of foreign activity is required to protect our fishing areas.

The thirty (30) National Marine and Fisheries Service Agents provide the following services:

- Accompany ships and aircraft, primarily Coast Guard, on fishery patrols.
- Serve as specialists in vessel identification.
- Identify fishing methods and fishing gear.

- Identify species.
- Law enforcement.

Aircraft have proved to be the most effective and economical means of surveillance of fishing waters over large areas despite the following limitations:

- Daylight operation only
- Weather condition
- Speed and altitude often greater than optimum for detailed identification

Although aircraft appearance over fishing areas may be anticipated due to daytime only operation, the knowledge that they may appear with minimum advance warning serves as an effective deterrent to violations of fishing agreements in territorial zones.

During a fisheries patrol, if vessels are encountered, their location is recorded in latitude and longitude and if weather permits, a pass is made over each vessel at an altitude of 200 feet and a speed of 120 knots per hour. During the flyover the vessels are identified by name or number, vessel class, and nationality. The types of fishing gear and use are recorded and photographs taken at the discretion of the agent. The amount of fish on deck or visible in trawl nets is described. Species observed are identified by the agents as closely as possible.

Fish and sea patrols are used for direct enforcement of regulations within closed areas, protection of contiguous zones, and boardings under international agreement.

The kinds of information required to protect fisheries resources include:

- Need to monitor on a continuous basis the location of all fishing vessels in inshore and offshore waters.
- Need to monitor fishing vessels with regard to conservation regulations.

Specific surveillance and enforcement needs which are only partially being met with present techniques are:

- Need to improve aerial photographs
- Identification of fishing gear in use or on deck
- Mapping and reporting of fixed gear
- Monitoring of foreign vessel activities within authorized loading zones
- Information on encroachment of contiguous fishing zones by foreign fishing vessels

- Information to differentiate between innocent passage and fishing activities by foreign vessels
- Current knowledge of total fishing effort in a given area

Additional techniques for surveillance and enforcement are needed immediately. Aerospace remote sensing is one possibility that may be helpful and should be explored.

RECREATIONAL SPORT FISHING

Mr. David Deuel
National Marine Fisheries Service

Recreational Sport Fishing was presented by Mr. Dave Deuel, Division of Statistics and Market News. This organization has the responsibility of collecting marine sport fish catch and effort statistics for the nation. A survey through the Bureau of Census in 1970 showed that at that time there were approximately 10,000,000 salt water anglers in the United States. The question "How could remote sensing be used in sport fishing to get an estimate of the total fishing effort?" was posed along with possible types of information required. This type of work has been done by some states, on a limited basis, in the past through the utilization of low flying aircraft.

Types of information required include:

- Enumeration and seasonal distribution of vessels by:
  - Size
  - Geographical area
  - Time of day
  - Weekday versus weekend or holiday
- Number of anglers per vessel

Considerable discussion related to possibilities that remote sensing offers in the enforcement/surveillance and sports fishing areas followed the formal presentations in the form of questions and answers.

TAGGING AND TRACKING OF LARGE FISH AND MARINE MAMMALS

Mr. Heeny Yuen
Honolulu Laboratory
National Marine Fisheries Service

Within the past two decades many aquatic animals have been tracked electronically. The electronic systems used for tracking primarily have used underwater propagation of acoustic waves although a few have used radio waves. Basically, a transmitter is placed in or on an animal, the animal is released, and tracking is done by receiving systems either on a boat or shore station.

The purpose of tracking the animals is:

- To determine migration routes. So far this effort has been of short duration, consisting of a small fraction of the total migratory route due to logistic problems and the boring nature of the task.
- To study behavior. Environmental data have been collected in connection with behavior studies to determine their effects on behavior. Pressure and temperature sensors have been incorporated into the tags to facilitate the measuring of behavioral and environmental attributes.
- To measure physiological variables.

In considering data requirements, precision and frequency of measurements must be considered. Satellite tracking provides a much greater duration of tracking than conventional means. With a satellite tracking system, tracking times and distances can be thought of in terms of years and thousands of miles while with conventional methods, weeks and a few miles are more appropriate tracking probabilities.

Possible systems for getting data requirements from remote sensing techniques may be based upon:

- Nimbus F - scheduled for 1974 launch - One of the primary missions is an experiment called Tropical Wind Energy Conversion and Reference Level Experiment. The tropical wind part of the experiment will seek a description for motion systems of the troposphere above the tropics through the release of 300 special balloons and the tracking of these by the Nimbus F satellite.

Transmissions from each balloon will be in digital format with the balloon's identity included in the transmission. A Random Access Measurement System aboard the satellite will receive the transmissions from the balloons, determine its position, and relay this information to earth.

Utilizing the above approach, possible schemes were discussed which might provide tracking data from large fish. These are described below:

- Tag fish with an acoustic transmitter and track fish with a robot boat with automatic tracking capability. The boat would contain equipment for communication with the satellite and its position would indicate the location of the tagged fish.

- Attach tags to a number of fish with breakaway links to release transmitters periodically which, when released, would surface and transmit data for a given time. This would prevent the hazard of a robot boat and would eliminate the problem of porpoises imitating the signal from tags described above. Primary concerns of this scheme are the size of package required, environmental data would be eliminated, tag would necessarily be externally placed and a large number of tags would be required.

- Photo-sensing might be used with dye dispensers being used instead of transmitters.

A general discussion period relating to tracking problems and possibilities followed the formal presentation with numerous pertinent questions asked and comments made, with many of the participants taking part. One area covered during the discussion period which had not been discussed was that of tracking whales, and the peculiar problems encountered including packaging, tagging, growth of whales, rubbing off of packages, and pressure encountered.

LOCATION AND DISTRIBUTION OF FISH AND FISH SCHOOLS

Dr. Andrew Kemmerer
MARMAP III Program Manager
National Marine Fisheries Service

Dr. Kemmerer addressed, in addition to the topic listed, the data needs of the recreational fisherman and the commercial fishermen. The National Marine Fisheries Service is interested in providing the data needs of all users of Marine Fishery resources. These users and their data needs may be discussed in five categories:

- Commercial - Fishermen and Industry
- Recreational - Amateur and Professional
- Resource Managers
- Scientists
- Naturalists

The commercial fisherman's data needs basically are:

- What fish are there?
- Where are they?
- When are they there?
- How many are there?

  Availability

  Abundance

The commercial industry's data needs are:

- Supply
- Seasonal distribution
- Spatial distribution
- Average expected catch
- Fishing strategy

The amateur fisherman needs the following types of data:

- What ?
- Where?

- Fishing tactics
- Indicators

The resource manager's data needs are:

- Effort - Distribution and total
- Catch - Distribution, total, and species
- Age comparison of stocks
- Status of stocks
- Life history of stocks
- Ecological relationships
- Comparative resources

The scientist's data needs are more related to specific species and include:

- Seasonal distribution
- Temporal distribution
- Abundance
- Population dynamics

The naturalist needs to know basically:

- What is there?
- Where is it?
- When can it be enjoyed?

The most important difference in the data needs of different groups is the time or frequency of the data needed.

The types of sensors that are presently available may be defined as follows:

Environmental Sensors

- Surface temperature
- Surface chlorophyll
- Water color

- Surface salinity
- Sea-state
- Weather
- Tides
- Water mass boundaries

Fish Sensors

- Surface schooling fish
- Large individual fish near the surface
- Most of marine mammals
- Fish - both day and night

Fishing Vessels

Ways we can use these sensors to provide data that users need include:

- Detect fish
- Qualify fish
- Quantify fish
- Develop predictive equations
- Look at indictors

The capability for detection of fish and providing indicators is presently available. Capability for qualification and quantification of fish is quite limited while no predictive equations exist that will predict where fish exist.

The direction that remote sensing should go in fisheries work may be identified in four groups:

- Need to identify fish
- Need to qualify fish
- Need to work on predictive equations
- Need to further develop indicators

In the discussion period which followed Dr. Kemmerer's presentation some discussion was directed toward a clarification of what was meant by "indicators" and "predictive equations" with a discussion of predictive equations particularly related to quantification. A short discussion evolved in answer to a question about the status of work on identification of fish through their signatures. The remaining discussion was devoted to acoustical water sensing techniques and a discussion of internal waves.

ENVIRONMENTAL MEASUREMENTS

Mr. Jim Johnson, Director
Pacific Environmental Group
National Marine Fisheries Service

Environmental Measurements was presented in four parts:

1) Introduction to Environment and Changes was presented by Mr. Jim Johnson.

2) Satellite and Airborne Remote Sensing Activities at the SWFC was presented by Mr. Heeny Yuen of the Honolulu Laboratory, SWFC, National Marine Fisheries Service from a presentation prepared by Dr. R. Michael Laurs of SWFC, La Jolla.

3) Estuarine Conditions was presented by Mr. Walter Nelson of SEFC, National Marine Fisheries Service.

4) Fishery Oceanography was presented by Dr. Merton C. Ingham of National Marine Fisheries Service, Washington, D. C.

INTRODUCTION TO ENVIRONMENT AND CHANGES - Mr. Jim Johnson

Prior to this meeting, considerable thought has been given on how the environment affects fisheries. Recent studies on environmental data needs of fisheries include but are certainly not limited to:

- Travelers Coast Guard Buoy Report
- MARMAP TRW Report
- NMFS Oceanographic List of Requirements from Buoys

Both the fisherman and the scientist are interested in how the environment affects the abundance, distribution and behavior of particular species of fish. The fisherman is also interested in the state of the sea and weather on the fishing grounds.

Abundance

One of the difficult problems of the Fisheries Service today is to determine what the unit stock size should be to ensure the maximum sustainable yield and then to determine what the allocation of this yield should be among several users both domestic and foreign. The unit stock and factors affecting its size is determined by:

- Recruits
- Growth

- Natural mortality
- Fishing mortality

It is critical to have knowledge of the number of recruits that enter the unit stock each year. In the past recruitment has been estimated from samples of eggs, larvae and juveniles. Obtaining samples is often time consuming and expensive especially when a large research vessel is required.

A critical point in the cycle of fish reproduction is the larval stage. The environment plays an important role in this stage due to larval drift. If the drift is favorable, survival and thus recruitment will be high and vice versa. What we should like to be able to do is to first determine what factors in the environment, such as larval drift, are controlling the survival of larvae and from this understanding through monitoring of key environmental factors, predict recruitment into the yield model perhaps as much as two to three years before. Perhaps remote sensing could provide information on currents.

Distribution

Distribution of some species is greatly affected by environment, particularly temperature and available food supply. This was shown by albacore location in warm areas in particular years as compared to cold years. Remote sensing is already useful here in providing sea temperature information.

Behavior

A slide showing a catch of tuna in relation to thermocline demonstrated the behavior of tuna reacting to a temperature change in the thermocline.

Other environmental processes affect abundance, distribution and behavior of fish but time constraints prevent full discussion of these. One of the most important is upwelling. It may be that remote sensing could provide much useful information here. Air sea interaction processes are also important in affecting the abundance and distribution of fish.

Important data which satellites might provide include:

- Surface winds
- Dynamic heights
- Surface temperatures
- Radiation from sun and sky
- Chlorophyll
- Cloud cover

Data are needed for the most part in numerical and digital form rather than contoured field data. A short discussion of fish catches related to thermocline evolved with primarily Mr. Johnson, Dr. Proni, Dr. Hebard and Dr. Ingham participating.

SATELLITE AND AIRBORNE REMOTE SENSING ACTIVITIES AT THE SOUTHWEST FISHERIES CENTER - Mr. Heeny Yuen

Present satellite and airborne remote sensing activities at the SWFC include use of an APT system for obtaining information used in an experimental daily fishery forecasting project for tropical Pacific tuna fisheries and airborne infrared remote sensing studies involving coastal pelagic marine fish species, notably those which are of concern to sports fishermen, i.e, yellowtail, barracuda, bonito, etc.

APT Satellite Receiver Utilization

For the past 2-1/2 years the Southwest Fisheries Center has used an APT satellite receiver to record timely visual and thermal infrared images of clouds and the sea surface over the fishing grounds of the eastern tropical Pacific. APT photographs depicting visual cloud patterns have been used to locate tropical storms, areas of squally weather along the intertropical convergence zone (ITCZ), and the southern boundaries of the low stratus which lays over the California Current off Baja, California. The thermal infrared photographs have been used together with the visual cloud photographs to determine the types of cloudiness associated with storms along the intertropical convergence zone and thereby infer which areas over the fishing grounds were being subjected to severe winds, squalls and rough seas. These conditions make fishing very difficult and affect the safety of fishermen.

The APT satellite photographs obtained at the La Jolla Laboratory have been used also to locate areas of very little cloudiness or areas of sun glint which usually indicated areas of very little weather activity, relatively light winds and seas less than eight feet. For tactical planning fishermen need to know each day whether conditions over their fishing grounds will be suitable for purse seine and whether the safety of the crew and boat will be affected by weather to follow. In exchange for fishery advisories, fishermen send back each day surface and subsurface observations.

During this past summer very warm seas and deep easterly winds led to the development of a succession of five hurricanes which moved through the fishing gounds in July and August. The development and movement of each tropical storm was followed daily with the APT satellite receiver at the La Jolla Laboratory. With this information it was possible to send fishery advisories to fishermen showing conditions over the fishing grounds within a few hours after the satellite passage.

Airborne Infrared Remote Sensing, Sea Surface Temperature Programs

Coastal airborne sea surface temperature remote sensing surveys were first conducted by J. Squire in 1962. After extensive testing of the airborne infrared radiometer's capability to determine sea surface temperature within desired accuracy limits, coastal remote sensing surveys were conducted of nearshore temperatures from Mexico to Cape Flattery, Washington. In August 1963, a cooperative program was developed with the U.S. Coast Guard to survey once each month three important nearshore coastal fishery areas.

Temperature charts were drawn and distributed for each survey and a summary of data and computation of average temperature conditions and resulting isotherm charts were developed and published for each month of the year.

This remote sensing program was initiated to develop detailed temperature data for comparison with fish catch data, to determine the mean, range and standard deviation in catch temperature for coastal species of importance to both commercial and recreational fisheries.

To better define the relationship of abundance and distribution of important coastal pelagic species of fish with changes in the environment as represented by sea surface temperature, a test area off San Diego was established in April 1972. This area is surveyed weekly from April through October using a twin-engined aircraft on which is mounted a modified infrared radiometer and accessory power supplies and recording equipment. Sea surface temperatures are continuously recorded for a flight track of 165 nautical miles extending from near Torry Pines (north of the La Jolla Laboratory) to 3 miles south of the Los Coronados Island, Mexico, and to 15 nautical miles offshore.

This is a cooperative program with the California Department of Fish and Game and weekly catch data will be furnished by that organization.

Using this data more accurate measures of catch temperature, mean, range, and standard deviation will be obtained for species in this important fishing area, in addition to allowing for a measurement of the effect of environmental change on the abundance of coastal species.

Forecasting Operations for Albacore Tuna

The north Pacific albacore tuna is an exceptionally wide-ranging species which spawns in the subtropical central Pacific, performs trans-Pacific migrations, and is found seasonally in temperate coastal waters of North America and Japan. There is a significant U.S. fishery on the population during summer-fall months of North American coastal waters. In addition to the coastal fishery of North America, the North Pacific albacore population supports Japanese fisheries in the central and western Pacific and in the coastal waters of Japan.

There have been marked geographical variations in the location of the center of the U.S. fishery over the last three decades. Prior NMFS research results indicate that changes in the distribution of albacore tuna and their availability to U.S. fishermen are related to variations in their migration patterns from the central Pacific and changes in environmental conditions.

Results of joint NMFS-AFRF (American Fisherman's Research Foundation) studies indicate (1) that the shoreward migration and early-season distribution of albacore tuna appear strongly related to factors of the marine environment, notably the transition zone waters formed by mixing of subarctic and subtropical waters and the oceanic fronts that form the boundaries of the transition zone waters; (2) that commercial quantities of albacore can be found far offshore and earlier than the usual fishing season; and (3) that a knowledge of the ocean temperature and notably vertical structure is particularly important to fishing strategy in the offshore region.

The oceanic frontal region associated with the transition zone was very complicated in June of 1972. This was especially indicated in the vertical temperature and salinity distributions, but was also apparent in the surface distribution of surface salinity, temperature and circulation.

It is evident that considerable ocean mixing was taking place in this region. This distribution of oceanic properties indicates that a large wave-like feature or a large eddy existed in the frontal region centered very closely about $137^{o}30'$W. These complex distributions had an obvious effect upon the albacore distribution as reflected in the jig-boat catches. During the fishing operations in the offshore waters the largest catches were taken within the Transition waters and were related to the oceanic frontal features associated with the Transition water.

Recoveries from fish tagged in June 800 to 1100 miles offshore indicated that the fish appeared to follow more than one migration route into coastal waters apparently in response to variations in the ocean structure presumably related to the considerable ocean mixing that had taken place.

Proposal

It is proposed that studies be undertaken to evaluate use of high resolution infrared ocean temperature measurements made from orbiting satellites to define oceanic boundaries in the northeast Pacific that appear to influence the large-scale migration patterns of albacore.

High resolution infrared temperature measurements are requested at about weekly intervals for the area 180° to the U.S. Pacific coast between latitudes 30°N to 45°N during the months of April through October. Studies could be conducted to determine if the infrared temperature measurements may be useful in locating oceanic boundaries in the northeast Pacific that appear to influence the large-scale migration patterns of albacore tuna. In part ground truth could be provided from field studies to be conducted during late May to early July by the NMFS R/V David Starr Jordan that will have twelve commercial fishing boats on charter to AFRF working with her. The results of such a study may markedly improve methods used for prediction of albacore distribution.

ESTUARINE CONDITIONS - Mr. Walter Nelson

Much of the environmental sampling of estuaries that has been done in the past has provided extensive unrelated, unrelatable data that has been of little use. A good general understanding of physical factors that operate in estuarine systems has been developed over the years. This includes current patterns; salinity and temperature norms, ranges, seasonal cycles, and fluctuations.

The areas where remote sensing appears to have the most value in estuarine physical factors studies are through:

- Providing a synoptic view of estuary
- Rapid evaluation of estuary for special studies
- Expanding the knowledge of the relationship between the estuarine environment and the resource

The acquisition of surface data in estuaries is not of great benefit in the study of resources without a simultaneous collection of samples of the resource.

An extreme degree of resolution or accuracy in estuaries is not required. This is based on two factors:

- Estuaries are very dynamic systems and measurement values continually change.
- Physical factors measurements are always much more precise than the biological resource sample.

The critical need that the Fisheries now have in the estuarine systems is an improvement in the sampling techniques for the biota in the estuaries. In order to estimate the productivity of an estuary, it is important to know the extent of marsh vegetation, as well as chlorophyll content.

Some critical biological problems in the estuary include:

- Estimating the natural mortality of larvae and juveniles in the estuaries
- Estimating the recruitment of estuarine stocks from the estuaries into the coastal population

The single greatest problem of Fisheries personnel in relation to estuaries is that of estuarine modification, habitat alterations, and pollution. This area seems to be the most promising and most immediate application of remote sensing in the solution of Fisheries problems.

FISHERY OCEANOGRAPHY - Dr. Merton C. Ingham

The needs in fishery oceanography are similar to the needs in oceanography in general. These include knowledge of:

- The properties of water masses
- Direction and speed of movement of water masses
- Potential or real productivity and standing crop of trophic levels in a water mass
- Pollutant loads in near shore areas

Remote measurements which could contribute to these needs include temperature measurements and chlorophyll concentration. However, the most needed item at present is to bring those systems that have been demonstrated as feasible to the operational mode for the acquisition of needed data. Another point that was made was that in Fishery oceanography resolution which will allow observations of things which are tens of kilometers in size and repeatability is more important than absolute accuracy. The systems to be used should be complete systems from sensor to final output with the output being computer compatible.

It is very important at this time, when ships are being tied up and personnel are being laid off; thereby restricting programs of demonstrated capability, that the feasibility of applying remote sensing to fishery oceanography be carefully considered.

REMOTE SENSING DATA PROCESSING AND ANALYSIS TECHNIQUES

Mr. Robert O. Piland, Director
Earth Resources Laboratory
Mississippi Test Facility

Remote Sensing Data Processing and Analysis Techniques was presented by Earth Resources Laboratory (ERL) personnel with Mr. Robert O. Piland, Director - ERL, as Chairman. In his introduction, Mr. Piland described briefly the Earth Resources Laboratory at MTF and defined its mission as follows:

- To conduct research investigations in this area in the application of remote sensing
- To select projects that stress the interests and needs of agencies in the area
- To utilize existing aircraft and satellite programs as the source of data
- To collect and analyze surface data for correlation with the flight data
- To study user requirements of applications on a continuing basis as a guide for program efforts

The work in which ERL is involved at MTF is considered in two ways: technique development and the conduct of demonstration experimental projects. The presentations were related primarily to technique development and directed toward methods of turning remote sensing data into disciplinary information.

This subject was divided into the following areas of presentation:

• General Study Approach - Test Site	Dr. B. H. Atwell
• Water Surface Temperature Measurement	Dr. R. D. Boudreau
• Chlorophyll and Turbidity in Coastal Waters	Mr. J. Weldon
• Salinity-Utilizing L-Band Radiometer	Dr. G. C. Thomann
• Marshland Vegetation	Dr. W. G. Cibula
• Resource Measurements - Cost	Mr. E. L. Tilton

GENERAL STUDY APPROACH - Dr. B. H. Atwell

The plan of ERL in its work in the Mississippi Sound is to look at an entire body of water and transcend the idea of merely trying to relate remote measurements with surface measurements, although this is an integral part of the study. The idea of ERL in its study was to follow the influx of Gulf of Mexico water into the Mississippi Sound on the incoming tide and deduce from this some idea of the circulation within the Sound. It was noted that considerable influence is exerted on the eastern end of the Mississippi Sound by the influx of fresh water from Mobile Bay and the Mobile River. Also, in a shallow system such as the Mississippi Sound, winds exert considerable influence.

The study included four seasonal experiments and included forty surface stations, or boats, and one aircraft. The instrument complement included:

- Multiple frequency microwave radiometers
- Infrared scanner
- Infrared radiometer
- Cameras

Measurements made by the surface vessels included water temperature, salinity, air temperature, relative humidity, wind direction, velocity, visibility, sea-state, and current velocity. These measurements, along with those taken from samples were correlated with remote measurements of these parameters.

In summary, some of the findings of the study were:

- A general increase in salinity from the coast to the Gulf.
- A seasonal variation in salinity of 10 to 15 parts per thousand depending on fresh water inflow.
- Salinity patterns are strongly influenced by tides.
- Outflow from Mobile Bay strongly influences salinity.
- Chlorophyll content decreased from the coast to the Gulf.
- Water clarity is better near the Gulf than close to shore.

Conclusions derived from the remote measurements include:

- It is possible to map surface temperature within $1^{\circ}C$ accuracy over the entire area of the Mississippi Sound with approximately 1000 flight-line nautical miles and one surface measurement.
- The infrared energy provided detailed surface temperature patterns unattainable with any other method.
- In estuary type environments, salinity can be measured with an accuracy of three to five parts per thousand.

A short question and answer period followed the presentation. These questions were directed largely at a clarification of a few points that had been covered and any future plans for experiments in this area.

WATER SURFACE TEMPERATURE MEASUREMENT - Dr. R. D. Boudreau

All remote sensing is done through the earth's atmosphere and, despite the fact that very transparent regions of the atmosphere are chosen for remote measurements, a correction factor must be used in order to arrive at a quantitative value of sea surface temperature utilizing the infrared region.

The classical way of correcting for the atmosphere is to put a boat out under the aircraft being used to measure the surface temperature of the water. The difference between the remote temperature reading in the aircraft and that taken by the boat is due to the atmosphere and, if it can be assumed that the atmosphere is horizontally homogeneous over the entire experiment area, this difference can be used as the atmospheric correction factor for the remote data. A distinct disadvantage of this means of determining the atmospheric correction factor is that one or more boats must be used, the number depending on the variation in atmospheric conditions. In addition, this means does not afford much insight into the cause of the correction.

A technique has been developed by ERL for simulating the way the atmosphere transfers radiation through it; thereby making it possible to calculate the correction factor of the atmosphere. Equations for determination of this correction factor were presented and explained in some detail.

There are four major absorbers in the atmosphere; water vapor, carbon dioxide, ozone, and particulates. As the model is currently being used, three of the above absorbers are accounted for; the only one not accounted for being particulates. The primary reason for particulates not being included is that the distribution and concentration of particulates would have to be known and at present a means of determining this remotely has not been developed.

One technique of determination of water surface temperature employed by ERL is a combination of the model mentioned above and boats, the model being used to determine correction factors in areas remote from the boat in large experiment areas.

Another correction technique, through the utilization of an isothermal patch of water and the model, makes possible the determination of the atmospheric correction factor without the necessity of having a boat deployed. However, if an isothermal patch of water cannot be found, a boat must be used.

In the discussion that followed, a number of comments were made relative to the merits of taking remote measurements without the actual sea-truth data; of putting the entire burden for absolute techniques on the remote sensing aspect, and of the logistic problems encountered in acquiring sea-truth data. It was pointed out that it might be a dangerous mistake to attempt to use satellite data for long term trends of temperature due to instability of satellite data. In addition, considerable discussion developed on the methods and amount of equipment used in the experiment and their possible application to larger areas.

CHLOROPHYLL AND TURBIDITY - Mr. J. Weldon

One aspect of the work being done by ERL is the use of a spectrometer in the Mississippi Sound in an effort to develop a quantitative method of determining chlorophyll and turbidity values. The data was gathered in the summer of 1972, and processing was initiated only about a month ago; therefore, some of the results must be considered as preliminary data.

After calibrating the spectrometer in the laboratory, it was necessary to determine a typical spectrum in the Mississippi Sound and whether it is repeatable. Two flight lines, one at 2500 feet and the other at 10,000 feet altitude, were flown over the same area and demonstrated a degree of repeatability, although the flight lines were not identical. The aircraft data from the spectrometer was correlated with the sea-truth data from the boats at various wavelengths.

For chlorophyll, three wavelengths were used, 470, 520, and 620 nanometers. 470 and 620 nanometers were normalized to 520 and the difference was taken between the two normalized values, giving a linear value. This value was then plotted against the ground truth value of chlorophyll concentration.

Chlorophyll water samples were taken at the surface. As a result, spectrometer data were compared to surface chlorophyll measurements and not with chlorophyll distributed through a column of water. This remains a problem.

Correlation of aircraft data and ground-truth data is essentially the extent of the data analysis of spectrometer data at this time. Further statistical analysis of data is expected to provide possibilities for determination of additional relationships.

Much of the discussion following the presentation was directed toward the means of obtaining chlorophyll samples and the utilization of the Secchi disc. It was pointed out that neither a good definition, criteria, nor method of measuring turbidity is available.

SALINITY - Dr. G. C. Thomann

The Earth Resources Laboratory is attempting to determine water surface salinity, with an accuracy of one part per thousand, through the use of a L-Band (1.4 GHz) radiometer to measure surface temperature. This is a low-level aircraft technique which would be used in a coastal environment where there is a wide variation in salinity. A number of factors to be considered in using this technique are:

- For low salinity, there is a low gradient; consequently, low sensitivity.
- For low water temperatures, there are low sensitivities.
- For higher temperatures, there are greater gradients and high sensitivities.

The final accuracy of the measurement depends on the sensitivity of the radiometer and the ability to correct other sources of noise, which includes deep space radiation, sun radiation, cloud reflections, the atmosphere, and radiometer inaccuracies. In conjunction with this program, an L-Band radiometer has been ordered for use on a boat for more extensive and carefully controlled experiments. Additional studies which are being done by ERL in the Louisiana marsh include circulation measurements, shoreline measurements, open water area measurements, and marsh deterioration measurements.

MARSH VEGETATION - Dr. W. G. Cibula

In his presentation on Marsh Vegetation, Dr. Cibula discussed some of the aspects of vegetation analysis done remotely with a multispectral scanner to be able to get a better concept of what is happening over some of the land masses. When land masses are observed, particularly in this area, what is normally seen is the vegetation covering the land and in most cases this is what is being sensed remotely. As a result, what vegetation means with respect to user requirements, must be understood. As an example, vegetation can be used to define the most likely breeding place for the marsh saltwater mosquito. A breakdown of vegetation species according to the degree of wetness and salinity can be used to define different environments. In the extensive vegetation that normally exists in marsh areas, distinct communities can be defined where there is only a slight difference in elevation. As many as five separate distinct communities can be identified and photographed. Extensive identification and classification of marsh vegetation resulted from marshland ecological studies made by ERL in Louisiana marshes. Plant signatures, or subtle differences in the plants that are caused by innate characteristics of species, allow them to be separated and classified. These distinct signatures may be caused in different ways, such as: pigment in flowering head, aspects of pubescence, thin film of water on plant, and the way light is distributed on the plant.

In the analysis of marsh vegetation a computer character plot can be obtained by assigning letters to represent classifications. This was found to be difficult to work with and as a result colors were assigned and a color presentation was available and much more useful. Through analysis of these multi-color coded presentations, different environments can be easily identified. These color-coded presentations make it possible to easily identify the most likely breeding places of the salt water marsh mosquitoes, which was primarily the reason for these studies.

In answer to a question, it was stated that salt, brackish, and fresh water could possibly be defined through this type of study, strictly on the basis of vegetation. Studies are presently under way by ERL to determine whether this is feasible.

Some discussion evolved which was primarily directed toward the possible utilization of the technique described for identification purposes in other areas, particularly ocean areas.

RESOURCE MEASUREMENTS - COST

Due to a shortage of time at this point, Mr. Tilton was unable to make his presentation at this time. However, time was later allowed and this area was covered in the Thursday afternoon session.

REMOTE SENSING RESEARCH AND DEVELOPMENT

Dr. Vernon E. Derr, Chief
Atmospheric Spectroscopy Program

Dr. Vernon Derr presented Remote Sensing Research and Development, which consisted primarily of a review of the work in remote sensing which is being done at the Wave Propagation Laboratory at the Environmental Research Laboratory of NOAA. Two areas in which the Wave Propagation Laboratory is involved were intentionally omitted from the presentation: radiometry and sea-scatter work.

Most of the work done at the Wave Propagation Laboratory in remote sensing has been done in the atmosphere; however, recently, ocean remote sensing has received some attention. In the atmosphere, parameters measured include wind, temperature, humidity, precipitation, aerosols, and gaseous pollutants. In the oceans, corresponding parameters would be currents, temperature, salinity, chlorophyll content, and other composition.

The three main classes of remote sensing instrumentation which are being dealt with at the Wave Propagation Laboratory are acoustic waves, microwaves, and optical waves. Potential applications and anticipated remote sensing capabilities were presented, as well as specific applications to ocean problems.

A laser may be employed in the atmosphere over a distance up to several tens of kilometers to measure the integrated component of wind perpendicular to the light path. The scintillation pattern, at the end of the path, may be observed by a pair of detectors and the wind velocity may be observed from the cross correlation between the outputs of the two detectors. Indeed, visual observations of the scintillation patterns on a screen reveal the direction and approximate velocity of the wind. Similarly, through the use of acoustic energy under the water, the average current across an inlet may be measured by observing, at the end of the path, the scintillation pattern. Two detectors, in this case hydrophones, are used here just as in the optical case. Plans are underway for the development of such a device for use in Cook Inlet by NOS.

An experiment that used this system employed a three laser triangle to determine the convergence and divergence of the atmosphere. This could be very useful if placed around a city to determine convergence or divergence in pollution measurement and pollution forecast.

Frequency modulated, continuous wave (FM - CW) radar is an important device for ocean meteorology. One distinct advantage of this system is that it provides excellent range resolution.

Doppler radar is the only means presently available for looking inside a severe storm. Multiple doppler radars will provide vector velocities necessary for understanding the dynamics of the storm.

A program of acoustic sounding was instituted at the Wave Propagation Laboratory about 3-1/2 years ago. Due to the strong interaction with the atmosphere and the relatively simple equipment required, this program has progressed faster than any of the other remote sensing programs. Some problems exist in the interpretation of the return when there are mixtures of atmospheres, such as an inversion situation where there is layering, due to the similarity of scattering due to discontinuities in layering and in turbulence.

One of the areas in which the Wave Propagation Laboratory has made the most progress and found the most encouragement to look for methods of measuring ocean remote sensing parameters is in the field of Lidar spectroscopy. Lidar is the use of lasers in the same manner as microwave transmitters are used in radar; that is, a pulse radiation goes out and by measuring the time lapse until reflected energy, the range of the reflecting object can be determined. Although Lidar is a ranging device, something can be determined about the scattering or reflecting object by measuring the intensity and the frequency of the returned energy. The received frequency is not only the transmitted frequency, but also at different frequencies due to two phenomena; fluorescence and the Raman effect.

The advantages of Lidar spectroscopy are:

- Excellent angular resolution
- Excellent range resolution
- Excellent doppler resolution
- Excellent chemical specificity
- Very fast information rates
- Broad range of parameters that can be measured

The basic components of this type system include a laser going through some kind of optical system, some kind of receiver consisting of the biggest mirror that is practical, standard photo multiplier shielded by filters, and standard types of processing.

BIOLOGICAL, PHYSICAL, AND OTHER INDICATORS AND SENSOR RESPONSES

Mr. William H. Stevenson, Manager
Fisheries Engineering Laboratory
National Marine Fisheries Service

This topic was introduced by Mr. Stevenson, who reviewed some of the studies and efforts devoted to this area by NMFS personnel. The group at FEL is interested in identifying the kinds of data that can be acquired and measuring these against the kinds of needs for data that are involved.

Surveying living marine resources from aircraft is not new, having been done on a limited and sporadic basis for many years within the National Marine Fisheries Service, by commercial fisheries, and other organizations in many areas. Thermal infrared surveys have been run recently and information from high altitude platforms has been analyzed since it became available. In the last five years these operations have gone out of the limited sporadic basis into a more organized basis. This topic was discussed in four general areas:

- Capabilities of Using Aircraft for Direct Detection of Fish - Mr. Heeny Yuen
- Aerial Night Surveys and Activities - Mr. Charles Roithmayr
- Aerial Photography - Mr. Joseph Benigno
- Results of Fish - Oceanographic Parameter Relationships - Dr. Andrew Kemmerer

CAPABILITIES OF USING AIRCRAFT FOR DIRECT DETECTION OF FISH - Mr. Heeny Yuen

Mr. Yuen made this presentation from a paper prepared by Mr. J. Squire of the Southwest Fisheries Service, NMFS, who was unable to attend the workshop. A series of studies conducted off the West coast of California with the cooperation of commercial fishermen, verified that aerial fish spotting can be used for research and for providing an index of apparent abundance.

Through the development and utilization of the present program of aerial fish spotting, certain needs of future programs of this type have become evident. Currently, it is possible to conduct both day and night airborne observations of pelagic, near-surface schooling fish using the human eye. However, aids to the eye as a remote sensor are needed for rapid and more effective detection, identification of species, and recording of sighted data. The methods to do this appear technically feasible and development of some types of equipment to do the tasks appears to be nearing completion. Those which should be given additional consideration include:

- Study on the identification of species by behavior characteristics, both day and night. Observations and identification during the day could be based on normal behavior, while identification at night could be based on behavior after flaring the fish with a high intensity light.
- Development of optical aids.
- Completion of optical day/night system.
- Computer program for near real-time stock assessment.

When technical development of the remote sensing equipment has reached an operational stage a light aircraft should be modified and equipped to use all the remote sensors necessary for day and night observations. At that time, identification and size/density data can be collected by operating with the commercial fleet, thereby allowing calibration of the airborne equipment.

The primary use of this equipment would be in the conduct of synoptic surveys in selected coastal areas having a high occurrence of pelagic schooling species and in particular over and about the areas where the commercial fishery is operating. Surveys of these areas would provide a measurement of apparent abundance independent of catch.

The apparent abundance data developed from these surveys would be useful in management. Its limitations must be recognized, in that it gathers information only from the upper layers, and generally of near adult or adult fish. It would not replace some of the current techniques, such as larval surveys, however, it would provide information on adult stocks and some of the coastal species that are not sampled effectively by ichthyoplankton surveys, such as yellowtail, barracuda, seabass, and bonito, species that are of importance to southern California commercial and recreational fisheries.

AERIAL NIGHT SURVEYS AND ACTIVITIES - Mr. Charles Roithmayr

In his presentation, Mr. Roithmayr discussed work being done at MTF and Pascagoula with airborne low light sensors to detect luminescent fish schools at night. Bioluminescence of fish, which results from the mechanical stimulation provided by the turbulent wake of fish that causes luminescing organisms to emit flashes of light, has been known and used by fishermen to spot and catch fish for centuries. Low light sensors, by amplifying the light many times that seen with the naked eye, can detect luminescent schools of fish at very low light levels.

Work at Pascagoula with low light sensors was initiated in 1968 with a Star Light Scope which was borrowed from the U. S. Army's Night Vision Laboratory, Fort Belvoir, Virginia. For the initial experiments off the west coast of Florida, the Star Light Scope was coupled to a TV camera. A video recorder, a seven-inch TV monitor, and a camera control unit completed the system. The first images were obtained with the system mounted on a commercial gill net vessel for observation of a school of Spanish mackerel.

In a subsequent version of the equipment, the Star Light Scope was replaced with a larger unit to which the eye piece of the TV camera was mounted. This equipment, which was also borrowed from the Night Vision Laboratory, was designed for use on a helicopter.

When the program moved to the Mississippi Test Facility, a new instrument was purchased that essentially combined the image intensifier and the TV camera capabilities in one small compact box. A front surface mirror enables the unit to be mounted in a horizontal position. This eliminates the probability of the impurities in the tube falling on the face plate causing image imperfections, which might occur if it is operated in the vertical position.

After successfully participating in an experimental research program with the Seattle Laboratory to detect schools of saury (anchovy and krill were also detected), the system was returned to MTF to observe schools of Gulf menhaden in the Mississippi Sound. It was felt that this area would provide a good locale for adequate imagery since luminescing organisms are present in large concentration in shallow water, and it contains large stocks of menhaden.

During the tests in the Mississippi Sound, it was determined that there are some major operating limits for the airborne low light sensor. These include ambient light in the form of moonlight and shore lights, cloud cover at 1500 feet or less, sea with white caps, and turbid water. The optimum conditions for detecting schools of fish with the low light sensor are dark nights, clear water with luminescing organisms, and a clear sky.

As part of the test and development program, a standard survey area with eight transects making a total of approximately 160 nautical miles was outlined in the eastern part of the Mississippi Sound. The transects were flown at a speed of 100 knots and an altitude of 3000 feet. At the time the tests were being flown, a surface vessel was collecting sea-truth data including bioluminescence, transmissivity, and in some instances samples of the fish were obtained with gill nets. The information acquired in the test mode was relayed to the commercial spotter pilots to determine whether any correlation existed between the low light sensor data and the commercial catch. The results indicated a good correlation between the night sightings of luminescing schools and catches by commercial vessels.

The data collected has been processed manually for enumeration, location in latitude and longitude, and determination of surface area for each school of fish. These data have been recorded and entered into a data bank and at present automatic means of extracting this data are being sought.

Based on data collected over a two year period, the month of October is the best time for menhaden observation in the Mississippi Sound. The reasons for this are:

- Menhaden are abundant
- The water is clearer than at any other time
- There are more cloud-free days in October than any other month.

By using school depth, fish weight, and fish packing density, all based on direct observation from a surface vessel, together with school surface area from videotape; the school volume, number of fish, and total school weight can be determined. This is a crude estimate, but it is believed the data reliability can be improved.

There were only two questions asked following the presentation:

Question - Mr. J. Johnson - What is the next step in the program?

Answer - Mr. Stevenson - Basically the program plan calls for a continuation of field work to: (1) verify school geometry, (2) verify the kinds of relationship between the information we are getting and estimates, and (3) get a better feel for operational characteristics. In parallel with the field work is the image analysis automation program.

Question - Dr. Derr - Is the low light level intensifier unclassified now?

Answer - Mr. Roithmayr - Yes, for sometime now.

AERIAL PHOTOGRAPHY - Mr. Joseph Benigno

An aerial reconnaissance program was initiated by the Fisheries Service in 1963 which constituted visual observation from low flying aircraft. This proved to be an unsatisfactory method for determination of fish schools. From this point, aerial photography was the next step in finding a means of obtaining synoptic data on fish and fish schools at a relatively low cost. At this time, very little information existed on the photographing of fish schools. As a result, tests were run on many types of films and filter combinations, altitudes, and various other things that had not been worked out for ocean photography. Three color and one black and white film were tested with all three of the color films providing much better results than the black and white film, with Ektachrome infrared giving the best results.

Altitudes were tried from 1500 feet up to 10,000 feet. A compromise of 3000 feet was selected between optimum visual parameters and optimum photographic parameters. Through this experiment, in which approximately 1000 fish schools were photographed, aerial photography was determined to be a reliable, effective tool for fish detection. In addition to detecting fish, aerial photography also affords a means of providing an estimate of quantity/tonnage of fish. These studies have shown also that identification of species is possible through aerial photography.

The Pascagoula office participated in the ERTS-A experiments with their objectives being to:

- Determine the relationship between the distribution and relative abundance of fish schools and selected environmental parameters.
- Determine the effect of weather on photographic detectability of fish schools.
- Determine and provide abundance estimates for pelagic fish schools.

The type of data taken from the ERTS-A photographs included:

- Basic data consisting of location or position of each photograph, cloud and cloud shadow, sun glow, photo overlap and land mass.
- Fish data consisting of number of fish schools, size of schools, shape and species.
- Other data including number of trawlers, seiners, sports fishing boats, and oil slicks.

Interpretation of the data collected from processed film was done in four stages: (1) flight line was established, (2) basic and other data, (3) counting fish schools and measuring surface area, and (4) keypunching and putting data into data bank.

Overall cost of aerial photography surveys was estimated at approximately $1.20 per square nautical mile. On an extended scale, the projected cost would be reduced considerably.

There was some discussion of the relative merit of aerial photography as compared to visual observation. Two of the primary problems of visual observation; counting fish schools when they are abundant and measurement of surface area; can be accomplished rather easily from photographs.

RESULTS OF FISH-OCEANOGRAPHIC PARAMETER RELATIONSHIPS - Dr. A. Kemmerer

The overall objective of the ERTS-A satellite experiment is to demonstrate the feasibility of utilizing satellite imagery for determining the availability and distribution of living marine resources. The experimental approach employed is to convert satellite and aircraft remotely sensed data into oceanographic parameters, relate these parameters to the fishery resource, and then determine if the relationships have meaning in terms of the commercial fisheries and their management. The task of developing useful oceanographic parameter information from space and aircraft remotely sensed data is being performed by the Earth Resources Laboratory at the Mississippi Test Facility. The National Marine Fisheries Service is attempting to define relationships between these oceanographic parameters and the distribution and relative abundance of fish and the final task, which is to determine if the relationships have meaning in terms of commercial fisheries, is being handled by a private company working in conjunction with the National Fishmeal and Oil Association.

The study area selected for the experiment includes the Mississippi Sound and adjacent offshore waters out to approximately the 10-fathom curve. This area was selected because: 1) it supports an abundant supply of a commercially valuable surface schooling fish, i.e., mehaden; 2) there is an active commercial menhaden fishing industry in the area; 3) the fishing industry was willing to participate in the experiment; 4) there is a great deal of available background information on menhaden; and 5) prior remote sensing experience has been gained in this area.

Data acquisition activities were divided into four categories: main-day missions, secondary day missions, special purpose missions, and commercial fishing. The main-day missions occurred at the time of selected ERTS-1 overpasses (7 August, 25 August, and 28 September 1972). Secondary missions were scheduled to occur on Tuesday of each week from July to October 1972 and special purpose missions were conducted periodically throughout the experimental period. Commercial fishing activities, which included some environmental measurements, occurred throughout most of the experimental period.

The only data acquisition activities included in this review were those which occurred on the main days. During these missions, approximately 144 sea-truth stations were occupied where a variety of water quality and oceanographic measurements were obtained. Distribution and relative abundance fisheries information was gained through aerial photographic sensing and commercial fishing activities. In addition, a variety of remote aerial sensors were employed to measure several oceanographic parameters. These latter measurements, however, are not yet available.

Although the Mississippi Sound appeared to be an ideal area for the experiment initially, there were a number of disadvantages encountered. For example, the Sound was found to be an extremely dynamic environment. Water quality characteristics at a given sampling station often varied as much as 400 percent within a 1- or 2-hour period. Thus, unless simultaneous measurements were acquired, relationships between selected parameters could be obscured by short-term temporal variations.

The first stage of the analysis consisted of attempting to derive relationships between environmental conditions measured at discrete sampling stations and the relative abundance of menhaden schools. Oceanographic parameters considered were chlorophyll-a, water temperature, salinity, secchi disc visibility, color, water depth, sea state, and station distance from shore which were compared to the absolute and normalized number of fish schools. Before reporting the results of these analyses, however, it is worthwhile to point out some of the major sources of experimental error. These sources of error included the fish sensing technique, which was aerial photography, and its detection limitation with respect to fish school size, schooling characteristics, and interpretation error. Significant oceanographic parameter related error sources included temporal and spatial variability, missing data which forced questionable extrapolation and interpolation of data, and influence by the commercial fishing fleet on the fish population and water quality parameters.

Because of the known sources of errors, only trends were expected to be found between the distribution and relative abundance of fish and selected oceanographic parameters. Surprisingly, however, four parameters were determined to be significantly correlated with the distribution of menhaden: salinity, color, secchi disc visibility, and depth. By combining these parameters through a multiple regression analysis, it was possible to develop an empirical model which predicted the distribution and relative abundance of menhaden schools with fairly good precision.

The satellite imagery for each of the three main days was examined to determine if it might contain fisheries significant information. This imagery was produced by a multispectral scanner system which provided images in four discrete spectral bands: 0.5 to 0.6, 0.6 to 0.7, 0.7 to 0.8, and 0.8 to 1.1 microns. Initial analysis of the imagery indicated that the spectral range represented by band 5, 0.6 to 0.7 microns, appeared to contain fisheries significant information. Unfortunately, the only main-day mission for which this imagery was available was 7 August. All of the schools were found to lie within the least dense portions of the imagery as determined by density slicing and color enhancement. It was further noted that in every case the schools tended to fall adjacent to density interfaces.

Because the ERTS-1 imagery appeared to contain fisheries significant information, the next appropriate step in the analysis was to attempt to explain the 7 August imagery density patterns based on the oceanographic parameters which correlated significantly with the distribution of menhaden schools. The statistical tool used to aid in this analysis was multiple regression, where film density patterns were regressed against secchi disc visibility, water depth, and the 2-factor interaction between these two parameters. The relationship developed was highly significant and explained the density patterns of the imagery with a high degree of precision.

Tentative conclusions include: 1) the distribution of photographically detected menhaden in the Mississippi Sound was significantly correlated with secchi disc visibility, surface salinity, color, and water depth; 2) ERTS-1, 7 August 1972, MSS band 5 imagery contained fisheries significant information; all photographically detected menhaden schools were located in areas of lowest image density; and 3) image density patterns could be explained with good precision based on water depth and secchi disc visibility measurements, parameters which correlated significantly with the distribution of menhaden.

Following the formal presentation, a short question/answer/discussion period was held. Some questions dealt with the extrapolation of findings to other areas and whether some of the areas where fish were not located might contain fish that were not seen. The data bank indicates that where fish were not seen, there were no fish.

Mr. Stevenson, after a few concluding remarks, opened the floor for discussion or questions related to the area of Biological, Physical, and other Indicators and Sensor Responses.

Dr. Kemmerer noted that in the model developed for analysis of ERTS-A data tests of correlations of fish and chlorophyll had no significance.

Question - Dr. George Maul - Didn't we have a good correlation before between turbidity and chlorophyll?

Answer - Mr. Sherman - We had a good correlation between first cut spectrometer ratios in each case but not cross correlation.

Some comments relative to prior reference to ERTS-I channel five were made by Dr. Maul, Dr. Davis, Dr. Kemmerer, and Mr. Sherman.

Question - Dr. Ingham - Would you care to speculate why the fish were where they were?

Answer - Dr. Kemmerer - Sir, all I did was establish the correlation.

Comment - Mr. Stevenson - We refer to you the fact that the objective of this particular series of experiments is to demonstrate the feasibility of correlating remotely sensed environmental and fisheries data; with the desire that it will, if successful, tweak imaginations of people to go into the whys of these phenomena.

Question - Dr. Royce - Are you interpreting this as demonstrating the feasibility of locating fish?

Answer - Mr. Stevenson - No - at this stage of the game, I would be very reluctant to say what interpretation we would want to make of this as far as its applicability from an operational standpoint.

At this point, the floor was opened for discussion of the area on surveillance of fishing activities. Mr. Stevenson noted that there are limitations to the types of data that can be acquired concurrently when a survey is being run. As a result, surveillance of fishing activity; identifying fishing vessels, identifying equipment, and identifying different species of fish, must be approached from the standpoint of a system designed to do just that. With the state-of-the-art, it is probable that effective data can be acquired.

Question - Mr. Wallace - Are you talking about satellites?

Answer - Mr. Stevenson - No, I think that basically we would be using aircraft for quite awhile.

Question - Mr. Wallace - Do you think there is a question that this isn't a useful tool? It seems to me it's about obvious that it can be done.

Answer - Mr. Stevenson - Well, for example, Bob Hutton raised the question that the only way you can get the identity of a vessel is to fly low enough to read the number and get the name off of it. He raised the question of being able to tell the difference between menhaden and river herring. He raised the question of being able to tell the type of gear on the deck of the vessel. He raised the question of day and night observations. I think all these things can be addressed with an adequate system. My point is: You're right, it can be done.

Comment - Dr. Royce - For a price you can probably get the Air Force to do it for you right now.

Comment - Mr. Stevenson - From a technical standpoint, it could be done. I think it's important to recognize this; there is no technical breakthrough required.

Question - Dr. Proni - Bill, if you knew the maneuvers a boat was doing and the speed it was running, would this enable you to deduce the type of fishing it was doing?

Answer	- Mr. Stevenson	- I'd like to take a good crack at that. I think we should do a lot of interpolations and interpretations. There are characteristic performances of those fishing vessels you could use - noise factors - things of that nature, starting and stopping of engines, along with its maneuvering capability, you could tell if it's a seiner or a trawler with this information.
Comment	- Dr. Ingham	- This requires a lot of monitoring.
Comment	- Mr. Stevenson	- You can build a training program to let a machine do that for you.
Comment	- Dr. Ingham	- You must have sensors looking at an area for a long period of time.
Comment	- Mr. Stevenson	- That's true, but if you can train a machine, there are repeatable things that will give you a voltage record so that if that voltage can be a signature, you can train the machine to recognize it.
Question	- Dr. Davis	- Are you suggesting that in time you wish to establish what amounts to an intelligence operation?
Answer	- Dr. Ingham	- I think NESS would like to think it had one right now.

These questions, answers, and comments indicate the direction of the discussion which continued for some time with many aspects of the problem being discussed by a number of participants.

RESOURCE MEASUREMENTS - COST

Mr. E. L. Tilton
Earth Resources Laboratory

This area was to have been presented in the morning session along with the other ERL presentations; however, due to a shortage of time, it was delayed. Mr. Tilton, in his presentation, gave a breakdown of the cost to ERL of some of the programs described previously.

Prior to the discussion of cost information, a summary of remote measurements of oceanographic parameters was presented. In this summary, a number of questions were cleared up relative to prior presentations. A detailed cost chart was presented based on a 200 nautical mile flight line or 600 square nautical miles of scanner data for temperature, salinity, and water color measurements as defined in earlier ERL presentations. Costs were broken down into: labor, A/D conversion, computer, data acquisition, data preparation, and reporting. The total cost for the three parameters shown is approximately $12,800 per 200 nautical mile flight or $22 per square nautical mile. It is estimated that by optimizing equipment and processing, the cost could possibly be cut in half.

OCEANOGRAPHIC REMOTE SENSING

Dr. George Maul
Atlantic Oceanographic & Meteorology Laboratories
National Oceanic & Atmospheric Administration

The final topic for presentation to the workshop was Oceanographic Remote Sensing with Dr. George Maul as chairman. This topic was divided into three areas and presented as follows:

- Coupling of Acoustic Data to Satellite Observation Within the Body of the Ocean - Dr. John Proni
- Products Available Through National Environmental Satellite Service - Dr. Al Strong
- Effect of Sea State on Ocean Measurements - Dr. George Maul

COUPLING OF ACOUSTIC DATA TO SATELLITE OBSERVATIONS WITHIN THE BODY OF THE OCEAN - Dr. John Proni

The Satellite Oceanography Group at AOML, in addition to its satellite work, is also involved in ocean remote sensing and acoustic sounding. Recently this group has begun to investigate the possibility of coupling its acoustic efforts with its satellite efforts. Most of its work has been in the field of ocean dynamics rather than fisheries problems.

Acoustic waves can be used to show the deep scattering layer in the ocean. This was demonstrated by slides showing the deep scattering layer obtained through the use of a 12 KHz active sonar. The deep scattering layer is known to migrate upward during the night and downward during the day in all of the oceans. It is now believed that internal waves can be detected through the use of acoustic waves because of microstructural turbulence associated with the internal wave. This turbulence is a temperature type turbulence that is detectable by doing a calculation to estimate a cross-section of the internal wave, based on the most reliable information presently available on temperature correlations. This is in contrast to calculations done approximately fifteen years ago which showed it was not possible to detect internal waves in acoustical terms. However, due to improved temperature measuring devices that have become available, this is now possible.

The first twenty fathoms of the ocean, since it is the mixed layer, is normally relatively clear, then structures start to appear. These have been correlated with the appearance of the thermocline. It is hoped that the acoustic program can be merged with the satellite program by coupling these internal waves with certain surface features.

In response to a comment by Dr. Hebard in which he noted the possibility that the alternations of an internal wave might be movement of the thermocline due to the actual movement of the organisms, it was stressed that through more sensitive processing, the wave could be traced through the rise of the biological creatures; thereby, defeating the biological effects.

It is known that internal waves interact with the surface of the ocean to produce slicks. One experiment which is planned for the Satellite Oceanography Group is an attempt at tracking internal waves acoustically at the same time satellites pick up slicks. These slicks will be tracked, if possible, toward the continental shelf, where portions of the internal waves are reflected and portions drive onto the shelf. When the wave drives onto the shelf, it sometimes becomes visible, not through the effect of the slicks, but through the reflection of the visible line. When they get up on the shelf, they can act as pumps to drive eddys on coast lines.

In addition to tracking internal waves, the Satellite Oceanography Group would like to plot the velocity fields as a function of depth, acoustically.

A short discussion was initiated by a question by Mr. Hilton concerning the similarity of the scalloped edge of the slide being discussed to what appears to be internal waves. Involved in the discussion were Mr. Hilton, Mr. Sherman, Dr. Proni, Dr. Ingham, Dr. Maul, and Dr. Strong.

PRODUCTS AVAILABLE THROUGH THE NATIONAL ENVIRONMENTAL SATELLITE SERVICE - Dr. Al Strong

A brief summary of the products available to the ocean community through the National Environmental Satellite Service (NESS) was given by Dr. Al Strong. Most of the products of the National Environmental Satellite Service are meteorological in nature at present but ways are being sought to continue to develop products in the ocean area.

A variety of Very High Resolution Radiometer (VHRR) imagery is presently available that provides one kilometer infrared resolution where features in the water can be seen that have contrasts with initial display of approximately 2^{o} Celsius. One kilometer resolution visible data is also available concurrently from VHRR.

The present charge for the above data is $2.00 per photo which is about 20,000 square miles of data for each cent. Due to the fact that the data is collected for an operation currently in only a research mode, it is not available routinely or easily.

A new product which will be available in March is a printout of sea surface temperatures for any area of the world based on satellite infrared observations. This product is based on the 8-KM resolution scanning radiometer (SR) data.

The floor was opened for discussion of this area. Some discussion was directed toward the cataloging and availability of prior data. In relation to this question, it was pointed out that little satellite data is available prior to 1967; however, since that time, data is available from the National Environmental Satellite Service. One particular product discussed was the global cloud cover statistics that was developed by Miller in 1971.

Another aspect that was dealt with was initiated by a question by Dr. Boudreau as to whether atmospheric corrections had been applied to this data. In answer, Dr. Strong stated that the corrections were available but had not been applied to the VHRR data as of this date. All SR data is corrected for a standard atmosphere.

It was pointed out in response to a question by Dr. Ingham that the cost of $2.00 per picture mentioned earlier, applies to universities, but for NOAA only a request is required to secure most data forms.

Mr. Stevenson noted that a cost is incurred in storage and looking at the data, in spite of the fact that the initial data is free. With a request for data also goes a responsibility to use that data since it costs NESS to provide it. On the other hand, Dr. Strong commented that NESS needs an input from the other organizations to determine their needs.

Mr. Sherman noted that there are many requests for VHRR data to be receified and questions as to why the data is not receified. With the resources available, it is not presently possible to rectify this data; however, NESS is negotiating with the Navy to get at least some of it rectified. Regardless of the need for rectification, there is a grid which fits over the image utilizing one land mark to enable one to use the imagery.

Mr. Stevenson reiterated that the system should not be turned on just for a few pieces of data or just to see what is available, since it is much more difficult to turn off than on and an over abundance of data is likely to result. This data, of course, requires resources to handle, store, and process it. As an example, the receipt of the daily north and south hemisphere cloud cover (bullseye) data requires about two manhours of effort per week just to maintain it.

Further discussion pointed out a need for some means of making product availability known to user groups. Dr. Robert Pyle stated that a listing is not available at this time, although a catalog in printed form of "bullseyes" of cloud cover is expected to be out in the near future on a monthly basis. The consensus of the group seemed to indicate a definite need for a central point of contact for determining what information is available.

EFFECTS OF SEA-STATE - Dr. George Maul

In his presentation, Dr. George Maul presented a brief description of the changes that occur across a deep sea boundary such as the Gulf Stream. Things of interest which occur across the Gulf Stream are: temperature changes, salinity changes, a change in sea state, and color discontinuity. Across a boundary such as the Gulf Stream, there is a temperature change which may occur within 10 or 15 meters, the sea state changes, and a strong color discontinuity is evident. These are the things being tracked at AOML by remote sensing techniques.

When a color boundary is crossed, reflectance varies with the change of chlorophyll and scatterers in the water. As sea state changes, the amount of energy being reflected greatly influences the spectrum of upwelling light. A number of examples were used to show the effect of sea state on reflectance. When taking ocean color measurements by remote sensors, it is necessary to be extremely careful due to the effects of sea state.

Dr. Maul is making monthly surveys (every thirty-six days), or every other ERTS pass, and tracks the location of the flow that comes through the Straits of Yucatan and circles toward Florida. In addition to continuous measurements like fluorescence and surface temperature, a biologist aboard is studying the distribution of plankton as a time history across the boundary.

In closing, Dr. Maul called attention to a contest called Old Salt which is a contest involving a group of fishermen out of St. Petersburg. The fishermen will be given data on the location of the edge of the current. In turn, they are cooperating by providing catch information. This is to be a joint effort between the scientific community of St. Petersburg and the local fishermen.

DEVELOPMENT OF RECOMMENDATIONS

The Friday morning session of the workshop was devoted to developing preliminary recommendations for solutions of Fisheries problems using remote sensing techniques and determining priority assignments for future Fisheries remote sensing research and development programs. After opening statements by the chairman, Dr. Royce, who reiterated the purpose or aims of the workshop, the proceedings were turned over to Mr. Jim Johnson, chairman of the Recommendations Committee.

If any usefulness is to come from a remote sensing program, the primary item of concern to the Fisheries Service is a definition of problems and data requirements. On various programs in the past, the lack of definition of data requirements has been a source of embarrassment for some Fisheries personnel. One reason for this, which was expressed by Dr. Royce, is the fact that most Fisheries programs are still in the research mode and data requirements are intentionally not being defined very far in advance. Large scale, long term programs under which data requirements can be defined well in advance are not presently being worked.

Some of the problems which are considered important in Fisheries work were listed in outline form and discussed as summarized below.

1. Circulation
    a. Vertical (upwelling)
        - Chlorophyll
        - Sea Temperatures
        - Scale
            - Temporal
            - Spatial
        - Color

The discussion which followed the first item of the outline resulted in the further development as shown above. Although there was some speculation as to the advisability of going to this detail, it was decided to continue in this mode.

2. Organic Production

   a. Solar Radiation (cloud cover)

   b. Sea Surface Temperature

3. Census

   a. Living Resources

      - Descriptive

      - Enumerative

   b. Fishing Vessels

4. Hindrances in getting from remote sensing to problem solution

   a. Data reduction

   b. Organizational

At this point the question of Census as listed in Item 3 above, was brought up. It was suggested that tracking is a more practical term. This discussion evolved into a question of whether the approach taken initially was correct. In answer to this question it was suggested that the approach should be: "What is the problem we are trying to solve and what can data contribute?" Extensive discussion followed on this point. There were primarily two points of view expressed:

- Broad basic problems should be dealt with, toward which remote sensing should be addressed, including such areas as Resource Assessment, Resource Management, and Fishing Services, including future applications.

- More definitive, concise problem areas where it is felt remote sensing can provide immediate or near future mechanisms for dealing with them should be the basis for recommendations.

As a result of the discussion mentioned above, it was agreed to divide the recommendations and/or outline into two areas: (1) those which have application in the near or immediate future, and (2) long-range problems or recommendations.

The short range problems/data requirements which were developed as a result of the discussion are shown below:

Identification of Data Requirements

1. Environment
   - Circulation
   - Water Quality
   - Organic Production

   Sea-Stage
   Chlorophyll
   Turbidity
   Color
   Sea Temperature
   Solar Radiation
   Salinity
   Current Velocity
   Sea Ice

2. Tracking
   - Surface
   - Near Surface
   - Fishing Vessels

   Identification
   Location

3. Census
   - Detection and Location
   - Qualification
   - Quantification
   - Vessels

   Surface
   Bioluminescence

4. Fishing Services
   - Forecast of Locations

     Albacore - Sea Surface Temperature

     Shrimp - Turbidity
   - Special Weather Forecast
   - Real Time Fishing Information

Long range data requirements which were developed after some discussion were:

1. Control Pollution
2. Water Chemistry
   - Heavy metals
   - Pigment
3. Identification of Pollutants
4. Signatures
   - Environment
   - Fish
   - Chemical
   - Biological

An additional category which was discussed and developed was Institutional Constraints. Two primary areas were discussed at length: (1) Instrumentation and (2) Data Reduction and Analysis.

- Instrumentation

  In the course of discussion of instrumentation problems, and after some speculation as to whether problems in this area really exist, Mr. Stevenson was asked for an explanation of instrumentation problems. In his explanation, Mr. Stevenson emphasized the existence and operation for some time of a number of instrumentation systems capable of providing required data rather effectively. The means are in place, also, for storage, retrieval, and distribution of this data. The basic problems in the instrumentation field are those related to data analysis; that is, to the instrumentation, including software, required to accept conditioned data, get it into data banks, and utilize it. Mr. Stevenson stressed that the emphasis should be placed on the effective utilization of existing instrumentation systems and improvement of their reliability, rather than in the immediate development of new, more sophisticated systems.

- Data Reduction and Analysis

  In the area of Data Reduction and Analysis, extensive attention and discussions were devoted to the cost effectiveness of systems and programs. It was stressed that although it is extremely difficult to determine the cost effectiveness of a system until after data has been acquired and processed, this area must be carefully considered in any new instrumentation system.

The problem of information flow, or availability of information, among the various organizations, which had been considered previously, again drew considerable attention. In the discussion of the formation of the Fisheries Engineering Laboratory, it was pointed out that the FEL has provided two basic functions: (1) take remote sensing technology, examine it through a series of experimental stages, and transfer it into an operational mode, and (2) provide a window through NASA to the area of technology that had never been made available to the Fisheries Service. One point stressed was that the above service of providing a "window" is a user initiated service and not an information service.

Additional discussion in the area of information dissemination brought out two contributing factors to the problem: (1) many of the new products, with associated technology, are considered experimental by NESS and no particular effort has been made to get them out, and (2) lack of focal point or identified individual in each center has resulted in some information being returned.

In a discussion which revolved around the NOAA budget and policies, it was stressed that the relevant point is in recognizing the opportunity to integrate the work of all laboratories. Some primary, immediate issues are:

- The assignment of an individual representative in each laboratory or center as a focal point.
- Who has the responsibility for calling the next meeting?
- Nimbus G requirements are immediate. Should each laboratory designate an individual to help in determining specific Nimbus G requirements?

After some discussion on these points, during which it was pointed out that the mechanics are in place for determination of Nimbus G requirements, the workshop was closed with the exception of the drafting of recommendations. The Recommendations Committee continued to work through the afternoon, drafting recommendations from the workshop. These recommendations, which comprise a separate document, are based on the formal presentations, the discussions described above, and the resulting outline.