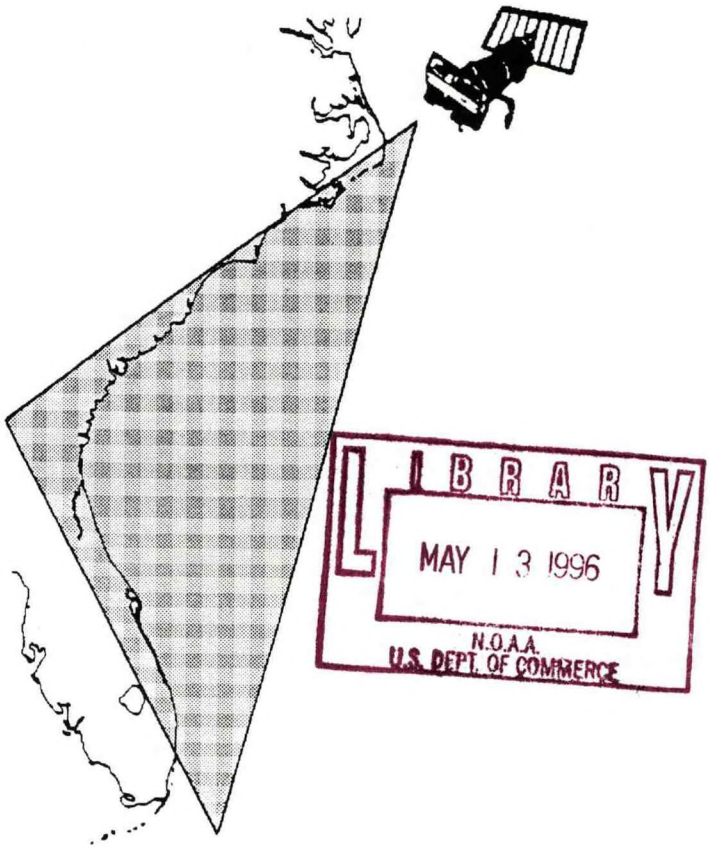
NOAA CoastWatch Developmental Plan

COAST WATCH

Developmental Plan



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service
National Marine Fisheries Service

Version 2.1
March 17, 1989

Background

NOAA CoastWatch is a program designed to rapidly provide environmental data and information to scientists and decisionmakers. Focussed on specific regional and national requirements NOAA CoastWatch takes advantage of observing capabilities in the National Marine Fisheries Service, National Environmental Satellite, Data and Information Service, the National Weather Service and the National Ocean Service.

NOAA CoastWatch has recently begun producing prototype regional near real-time data products using its environmental satellites along with oceanographic and meteorological data for the southeast coast. Weekly summaries of sea surface temperature, wind drift, Ekman transport, and other information are integrated and distributed to a network of federal scientists and state and local agencies in the southeastern US concerned about outbreaks of noxious algal blooms. Figure 1 illustrates conceptually the flow of data within this portion of NOAA CoastWatch.

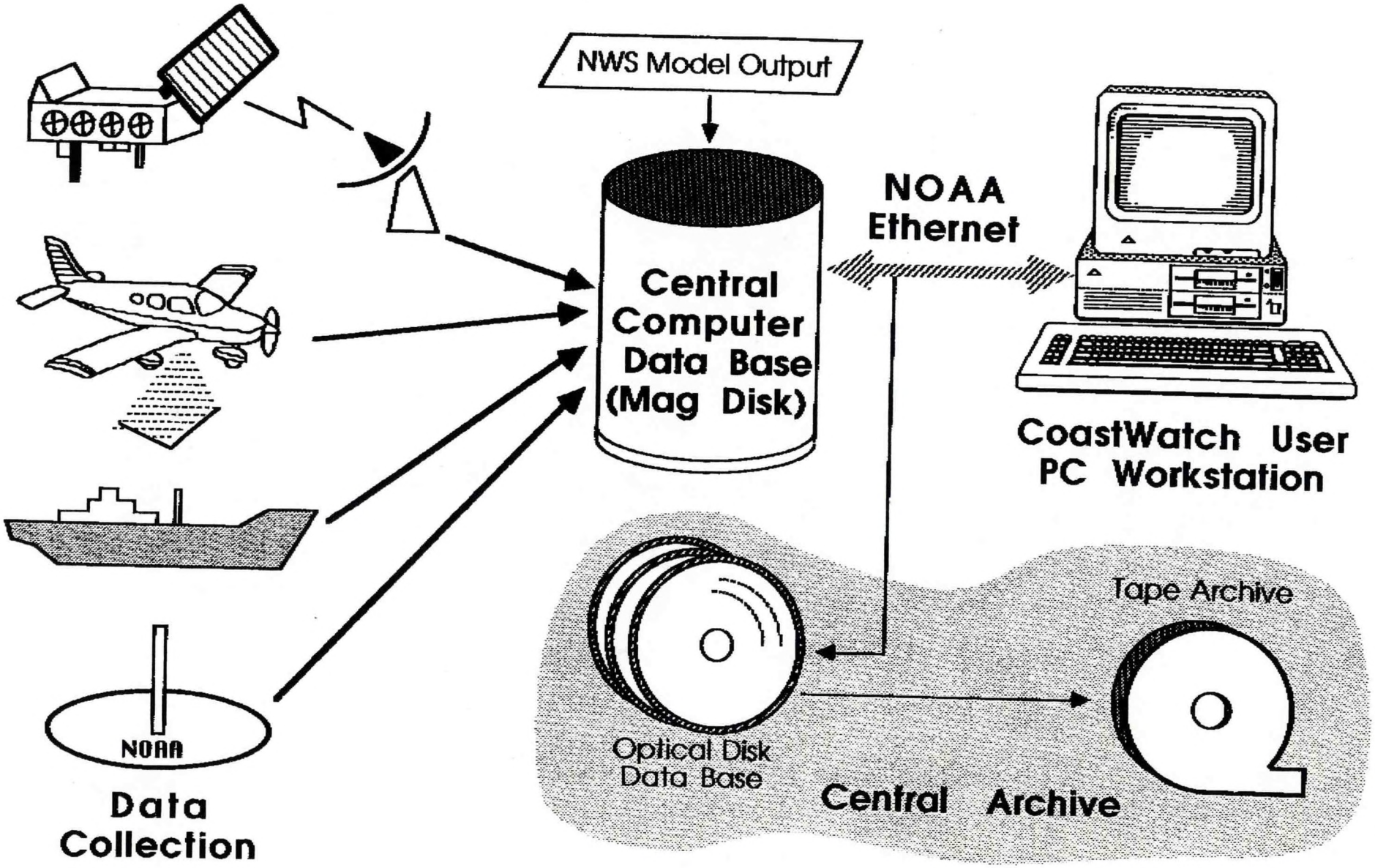
A pilot Chesapeake Bay CoastWatch will be conducted between March and May 1989 in conjunction with the multi-state/Federal agency Chesapeake Bay Program, to improve spatial and temporal resolution of algal blooms during the spring season. It is anticipated that Chesapeake Bay CoastWatch will continue to provide improved estimates of total spring algal biomass, thought to be closely linked to the Bay's oxygen depletion problems.

Still another NOAA CoastWatch component will monitor the gains and losses of coastal wetlands repetitively every 3 to five years. National habitat mapping is designed to use remote sensing imagery coupled with ecological data and information to quantify and assess the impact of habitat loss. It is anticipated that this portion of the project will begin with the Chesapeake Bay in FY 90 and extend to other coasts of the US over the following three years. Figure 2 outlines the major elements for the National Landuse, Habitat, and Fisheries element of NOAA CoastWatch.

Broadly speaking, NOAA CoastWatch provides new and improved opportunities to understand the marine environment and unusual environmental events through increasing timely availability of environmental data and information. CoastWatch programs for the Gulf of Mexico, the West Coast and the Northeast are envisioned for the future.

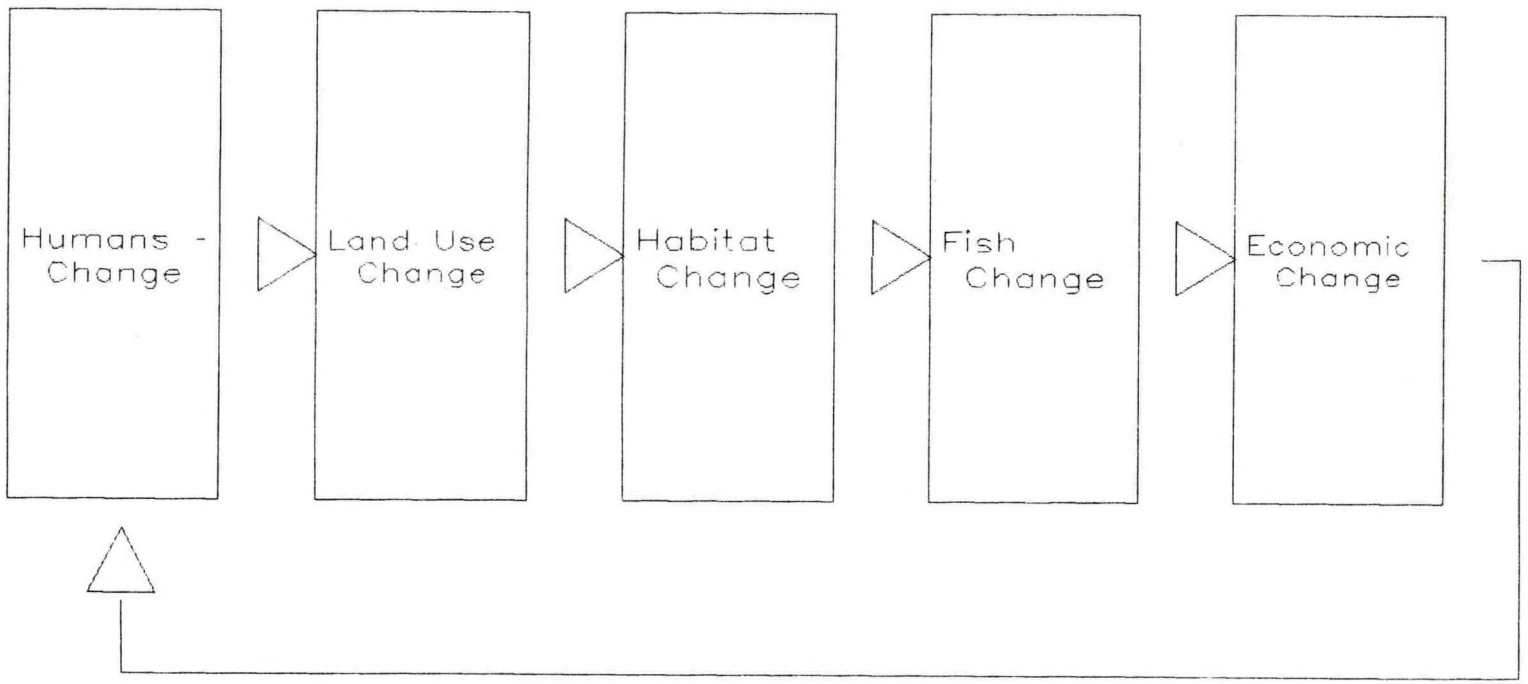
CoastWatch Data Flow

Regional "Near-real time" Services



Land Use, Habitat Change, and Fish

Monitoring and Research for Understanding and Prediction



Approach

NOAA CoastWatch has two major applications: water and land. Water applications generally utilize near real-time observing and dissemination methodologies for responding to specific environmental concerns. Land applications are on longer time scales and are focussed exclusively on national landuse habitat mapping.

Typical water applications of NOAA CoastWatch involve observations of unusual environmental events such as red tides, and anoxia/hypoxia. Involved will be the acquisition and rapid dissemination of satellite data from NOAA (and eventually color sensing) satellites, as well as associated meteorological, oceanographic, chemical and biological data. Users are NOAA and/or other federal state and local agencies with scientific and/or management responsibilities in coastal areas.

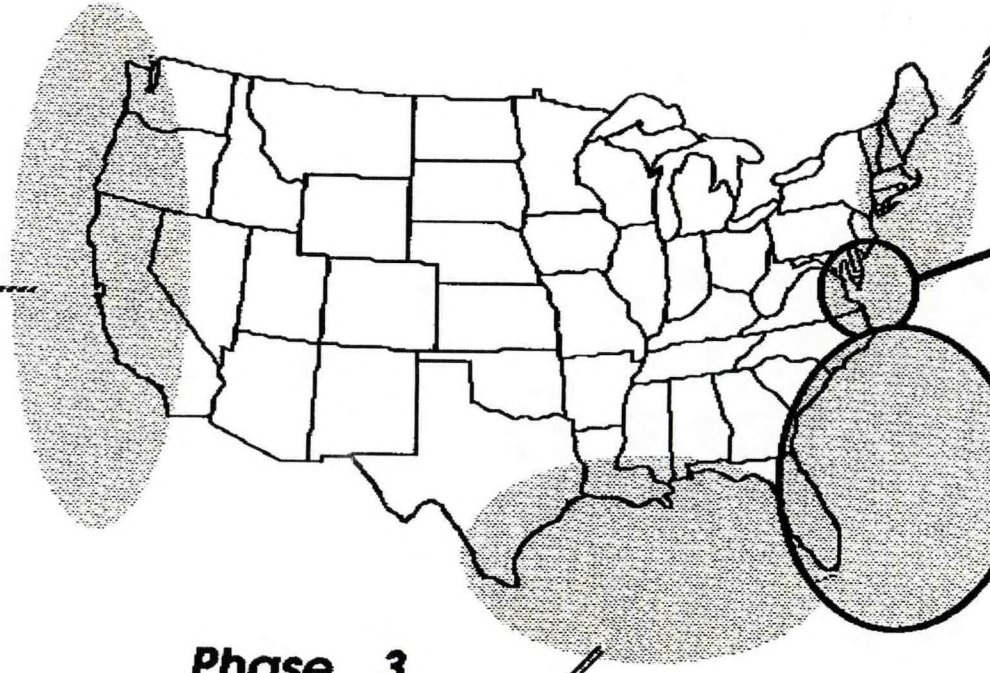
Land applications of NOAA CoastWatch, i.e., habitat mapping, will be repeated nominally each three to five years. With respect to present coastal mapping efforts utilizing aerial and surface mapping techniques this effort will be considerably more timely and because of its repitition more useful. Applications involve sensing and analysis of land use habitat patterns in coastal areas supporting regional and national NOAA Fisheries habitat management responsibilities.

Water Applications of NOAA CoastWatch

NOAA-wide capabilities are utilized for water applications of NOAA CoastWatch. Two prototype CoastWatch areas are currently being developed, one covering the central North Carolina coast, and another covering the Chesapeake Bay. Requirements analysis, research, product development, sample product production, personal computer (PC) image display software development, and prototype demonstrations will be conducted for these areas during FY89. During FY90, products for these regions will be operationally implemented, including automated products, archive creation, and high-speed communication of products and data. In subsequent years, similar activities will be developed for other NOAA CoastWatch regions. Figure 3 illustrates prototype CoastWatch regional boundaries for the southeast, the Chesapeake Bay, the Gulf of Mexico and the West Coast.

COASTWATCH DEVELOPMENT

Phased approach to monitoring environmental quality of the Nation's coast



Phase 5

- Northeast

Phase 2

- Chesapeake Bay

Phase 4

- West Coast

Phase 1

- Southeast

Phase 3

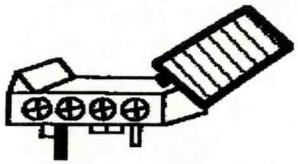
- Gulf of Mexico

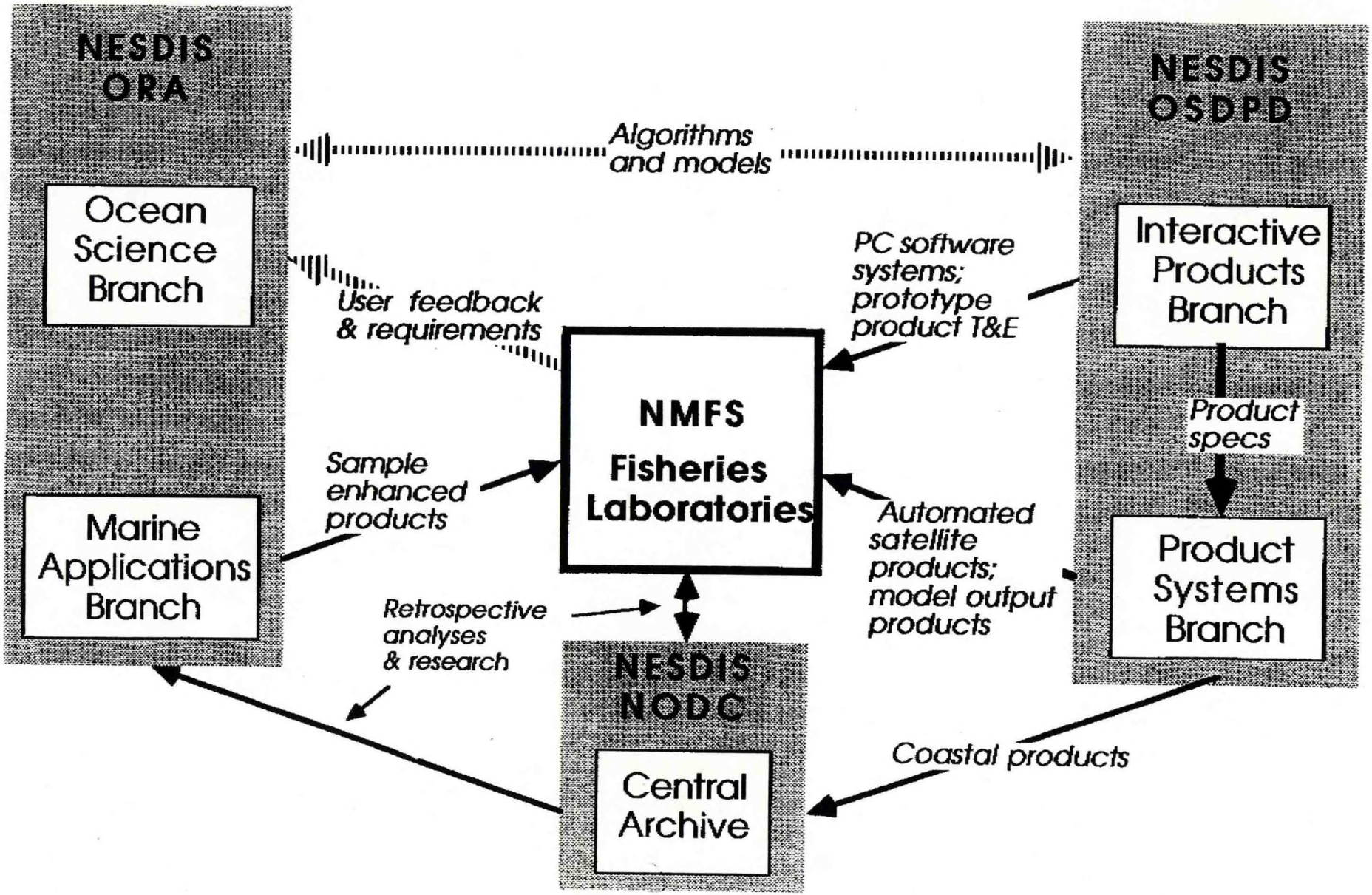
Future Phases

- Alaska
- Hawaii

An "assembly line" will be established to construct and deliver near real-time CoastWatch products and services. Figure 4 illustrates this process. It will be advantageous to learn as much as possible during the construction of one CoastWatch operation before beginning the next. However, practically, research and development for the next regional CoastWatch region will probably begin before the previous one is fully operational. It must be emphasized that feedback from the end-user NMFS offices and the regulatory agencies is a key element in the success of CoastWatch. Time must be allowed for sample product production and prototype demonstrations so that the users can gain enough experience with the data and products to provide accurate requirements. Feedback will be sought at every step of the construction process, and modifications to the product suite and how the data are presented and communicated will be possible at any point in the construction process. An analogy for this "assembly line" is not the robotic assembly of production automobiles but rather the crafting of custom musical instruments, requiring continuous testing and fine tuning (Figure 4). All CoastWatch areas will probably have many products in common; however, each CoastWatch region will no doubt have some unique products. For example, both the Southeast CoastWatch region and the Chesapeake Bay region require sea surface temperature (SST) measurements, but only the Chesapeake Bay region presently requires turbidity measurements.

CoastWatch Product Loop





Land Applications of NOAA CoastWatch - Land use, Habitat Change and Fish

As a first step to linking land-based human activities with the productivity of the coastal ocean, quantification of changes in land use and vegetational cover is needed. Change in the coastal zone due to human population growth and attendant impacts on the physical habitat, water quality and living marine resources is occurring faster and more pervasively than we have been able to monitor. On time scales appropriate for national and regional decisionmaking no appropriate monitoring of land use and vegetational coverage for the coastal zone of the US exists. Therefore, a program is proposed to monitor land use and vegetational coverage in the coastal zone of the US in order to provide information supportive of research needed to determine the impacts of wetland and estuarine degradation on the abundance and distribution of fish. Land use and vegetational coverage in the coastal zone of the continental US, Hawaii, and trust territories will be mapped every five years and monitored annually in regions of significant change.

The activity will emphasize the use of remotely sensed data from the Landsat Multispectral Scanner (MSS) and Thematic Mapper (TM) or the SPOT (HRV) instrument as well as supplemental aerial photography, land based data from wetland and estuarine ecologists, and fishery biologists. This initiative directly supports NOAA legislative responsibilities in estuarine and marine science, monitoring and management contained in the Fish and Wildlife Coordination Act and the Magnuson Fisheries Conservation and Management Act.

Relationship to Other Programs

Although several other land cover mapping programs for the coastal zone are underway in other federal agencies, time scales for their completion and frequency of repeat cycles for change detection make them inappropriate for use by NOAA for effective habitat management on a broad regional, or national scale. For purposes of comparison these programs are briefly described.

The National Wetlands Inventory (NWI) is a major national effort by the U.S. Fish and Wildlife Service (FWS) to map coastal and interior wetlands by type of land cover. Resolution ranges from 0.5 to several acres depending on location. To produce their NWI maps, the FWS makes use of high altitude photography. Interpretation of the photography is subjective and depends on individuals with considerable experience and natural faculties for pattern recognition. Much of the information is not digitized, making analysis of the data difficult. Because the aerial photography is spread out over a number of years, even within a single estuary, trend analysis is awkward due to potential biases caused by gains and losses of adjacent wetland

areas. Under the Emergency Wetlands Resources Act of 1986 (Public Law 99-645) the U.S. Fish and Wildlife Service is to produce by September 30, 1988, NWI maps (not including change analyses) for the entire coastal zone of the Unites States. Additionally, the FWS was to produce by September 30, 1988, and at ten-year intervals thereafter, reports to update and improve the information contained in the 1982 report ("Status and Trends of Wetlands and Deepwater Habitat in the U.S., 1950's to 1970's. This report, however, does not contain change analysis maps showing where and what kind of changes have taken place over time. Such change analysis maps would be valuable to managers and researchers who need specific information on location and kind of change in order to make decisions regarding research and management actions.

The Land Use Data Analysis (LUDA) Program of the U.S. Geological Survey is an effort to map all land use for the entire U.S. The program makes use of aerial photography. The data are mapped only to a 10 acre resolution. Again the data base for the U.S. is not yet complete and subsequent surveys can not be repeated on a frequent basis.

County Soil Survey Reports (maps and text) are produced by the U.S. Soil Conservation Service. The reports generally cover all non-federal lands and report on soil type for the top 5 feet of soil.

The data are collected on foot with a hand auger. Samples are taken approximately every 5 to 10 acres. The scale on the maps produced ranges form 1:15,840 to 1:250,000. Additionally the SCS is conducting a wetlands mapping project on the nation's farmlands for the swampbuster provision (Food and Security Act). An overlay of wetland coverage is being made onto its soil survey base maps. The data are recorded by form number at the field level and fed to state and national computers. With the computerized soils/wetland map, the SCS will work with the landowner to develop a conversaton plan.

Additionally, most coastal states inventory their wetlands. However, wetlands are defined differently from state to state making regional and national analyses impossible. The state surveys, while detailed, generally have been accomplished on foot. Consequently, individual states have taken from 3 to 10 years to complete a survey. In certain states change is taking place faster than they are able to survey it.

In all cases, however, these other programs have the potential to provide valuable information to assist in verification of the digital satellite data. Finally, through the various elements of NOAA, field surveys for verification, and ecological research for establishing linkages between land, habitat and fish can be accomplished.

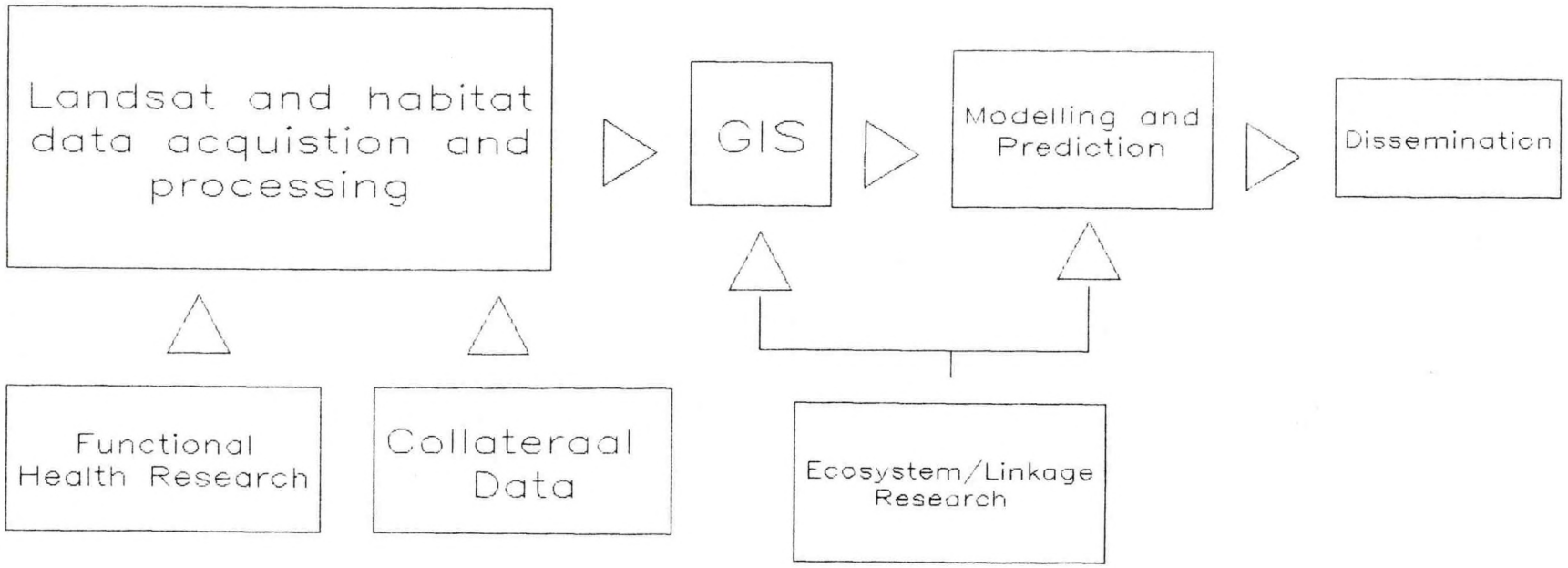
Management

Administrative and technical oversight of Regional Near Real-time CoastWatch activities will be the primary responsibility of the NESDIS CoastWatch Troika consisting of the Directors of NODC,OSDPD, and ORA. New product production must be approved by the Satellite Product Review Board (SPRB). A semi-annual CoastWatch workshop will aid in disseminating status information and obtaining diverse and direct user feedback.

Oversight of National Landuse, Habitat Change and Fish applications will be the responsibility of a joint NMFS NESDIS management team - yet to be defined.

Landuse, Habitat Change and Fish

Functional Relationships



METHODS

Water Applications of NOAA CoastWatch:

General requirements include:

(1) efficient access to in-situ and remotely sensed environmental data, derived products, and model output,

(2) procedures to display these data, products and model output to provide integrated analyses of environmental quality and coastal hazards, and

(3) support to Federal and state regulatory agencies with the information they need to make environmental systems management decisions.

Data from ships, buoys, aircraft, and satellites will be collected, quality controlled, and placed in on-line magnetic disk data bases accessible for at least 4 days (see Figure 3). NOAA satellite Advanced Very High Resolution Radiometer (AVHRR) image data will be stored in a high-resolution (1 to 4 km) mapped format as separate channels (the AVHRR has 5 channels), or as derived products of sea surface temperature (SST), turbidity, and algal blooms, depending on the application needed in a particular CoastWatch region. This on-line magnetic disk data will be written to an optical disk archive medium and retained on-line for a period of 2 or 3 weeks, after which access can only be obtained off-line via tape or optical disk copies. To aid in interpretation, satellite and other environmental data, such as wind data, will be analyzed to fields covering a geographic area equal to or larger than that of the satellite image data. In particular, a 3 1/2 km SST analyzed field will be available for the coastal zone to allow a quick look at the surface thermal structure. The output of models, such as ocean circulation models or weather forecast models, will also be accessible. Data and products on both the on-line magnetic disk data bases and the on-line optical disk system will be accessible on demand by remote image workstations located principally at NMFS offices. These remote workstations will be linked via communication lines operating at 9.6 to 56 Kbps to the on-line data bases, using Ethernet technology with the TCP/IP protocol. In most cases, a Time Sharing Option (TSO) connection will also be necessary using normal telephone lines operating at 1200 bps. This latter connection will be used for catalog queries and for initiating data transfers via the Ethernet.

Each CoastWatch region will have its own suite of products; however, there will be many similarities among products for different regions. The exact list of products will be determined as each CoastWatch region is established. Some likely products

are:

(1) Automated analyses of SST in the coastal regions of the U.S. at 3.5 km resolution produced thrice weekly to be used as guidance products.
(2) Full-resolution mapped images of AVHRR data available in near real-time.
(3) Geophysical measurements such as SST, extent of algal blooms, and turbidity, derived from the mapped AVHRR images.

(4) In-situ physical, chemical, and biological data.
(5) Archived satellite image data and derived products.
(6) Ekman transport and surface wind drift charts.
(7) Surface current information.
(8) Meteorological and oceanographic model output.

Products such as these will be produced during FY90 for the Southeast U.S. coast and for Chesapeake Bay. Other CoastWatch regions will be added in FY91, and beyond.

Technical responsibilities of NESDIS organizations supporting Regional Applications of NOAA CoastWatch are as follows:

ORA OCEANIC SCIENCES BRANCH (OSB) and MARINE APPLICATIONS BRANCH (MAB)

The OSB and MAB will serve as the lead NOAA groups responsible for developing new Regional CoastWatch products, validation techniques, and coastal circulation models. The OSB and MAB will work together to provide the following products and services for CoastWatch.

(1) Assessing NMFS and regulatory agency data and product requirements
(2) Algorithm development, testing, and/or validation for full-resolution AVHRR mapping, remote sensing of SST turbidity, and algal blooms, navigation improvement, high-resolution field analysis, cloud and aerosol detection, wind transport, wave height, circulation modeling, Sea-WiFS ocean color, phytoplankton biomass, total suspended matter, and transparency.
(3) Development of techniques for integration of satellite, aircraft, in-situ, climatological, meteorological, and modeling data for environmental decision making.
(4) Development and trial production of sample products to better define user requirements
(5) Validation of Regional CoastWatch products, including the analysis and tracking of time-series records of comparisons of satellite and in-situ measurements and climatological anomalies.
(6) Development of a Marine Optical Buoy System for calibration/validation of ocean color measurements.

(7) Development of cooperative activities with appropriate universities and state and federal agencies to allow electronic sharing of innovations in satellite data navigation, validation, data storage using optical disk technology, electronic data distribution, and product processing.

<<OCEAN COLOR CHAPTER FROM DENNIS CLARK?>>

OSDPD INTERACTIVE PROCESSING BRANCH (IPB)

The IPB will take the lead in developing the PC-based image display and analysis system to be installed at each CoastWatch field site (the NMFS lab at Beaufort, North Carolina is the first site). IPB will:

(1) Develop software to download, display, overlay, manipulate, and analyze the data and products for each CoastWatch area.
(2) Implement the algorithms developed by the OSB and MAB.
(3) Purchase PC hardware and software and integrate systems for installation at the field sites.
(4) Provide training on the PC system to field personnel.
(5) Update PC software at all CoastWatch sites to make the latest techniques available to all.
(6) Conduct prototype operations with field sites to better determine suitability of PC analysis techniques for environmental decision making.

OSDPD PRODUCT SYSTEMS BRANCH (PSB)

The PSB will have the lead in providing automated satellite data and derived product data bases for downloading to the PC image analysis workstations. PSB activities include:

(1) Development, implementation, and maintenance of automated production of 2 km SST observations and 3 1/2 km SST objective analysis fields for the U.S. coasts.
(2) Development and operational production of full-resolution mapping of AVHRR data for the CoastWatch regions.
(3) Operational implementation and maintenance of derived products such as SST, turbidity, algal blooms, etc. using the mapped AVHRR data.
(4) Development of a high-resolution (500 m) land/sea tag data base and a high-resolution (300-600 m) coastpoint file for the U.S. coastal zone for use in high-resolution AVHRR mapping and SST objective analysis production.
(5) Establishment and maintenance of the on-line rotating magnetic disk data bases of data and products for on-line access by Regional CoastWatch workstations.
(6) Implementation and maintenance of surface wind and other meteorlogical data bases.

OSDPD INGEST SYSTEMS BRANCH (ISB)

The ISB is responsible for establishing and maintaining the NESDIS Central Environmental Satellite Computer System (CEMSCS). This large mainframe computer system, with the first phase scheduled for operation in late 1990, is required to accomplish all the full-resolution satellite image mapping envisioned for CoastWatch. The ISB will:

(1) Procure the CEMSCS, the magnetic disk hardware, and the communications interface needed for the satellite data for Regional CoastWatch.
(2) Maintain the computer system on which the CoastWatch satellite products will reside.
(3) Develop improved methods of navigating satellite data with a goal of achieving 1-2 km navigation accuracy.

NATIONAL OCEANOGRAPHIC DATA CENTER (NODC)

The NODC has the primary responsibility for operating the data system and central archive for Regional Near Real-time CoastWatch data and products. The NODC will:

(1) Establish and maintain an optical disk archive system providing on-line access for Regional CoastWatch remote workstations. The archive will hold all CoastWatch data and products on-line for approximately 3 weeks.
(2) Establish and maintain a tape archive of all Coastwatch data and products.
??? (3) Procure, install, test and maintain communications lines for CoastWatch.

LAND USE, HABITAT CHANGE AND FISH

Digital remote sensing from satellites offers the advantages of synoptic, large-area coverage and frequent, repetitive observation. Interpretation and analysis of digital spectral data can be done in an objective, replicable fashion. The major advantage is that digital remote sensing specialists, using commercial software and equipment, can analyze and communicate far more information about much larger areas with finer detail than ever before. If land remote sensing results are combined with earth-based data and processed in comprehensive geographic analysis systems, they can be helpful in policy analysis and resource management. In addition, the spatial resolution of Landsat and SPOT are substantially more precise than that available on most analog maps available for large areas of the US. MSS data provide a spatial resolution of 79 by 56 meters; each single data point represents spectral data collected from an area of this size on the ground. These picture elements are called pixels. TM data are collected for pixels for 30 meters by

30 meters. SPOT data are collected for pixels 20 by 20 meters. TM offers a greater spectral range (seven intermittent bands from .45 to 12.5 micrometers) than MSS (four contiguous bands from .5 to 1.1 micrometers) and SPOT (three intermittent bands from .5 to .89 micrometers).

The finer resolution and greater spectral discrimination of TM are valuable characteristics, but they come at a higher cost ($3,600 versus $660 per full scene for MSS and $3,200 per full scene for SPOT) and involve considerably greater data processing and storage. Both the MSS and the TM data are capable of providing classified results with at least 80% or perhaps 85% accuracy. There is little difference between the ability of the TM data and the MSS data in their discrimination of different wetland types. However, the TM and SPOT data are better able to distinguish small land cover features. MSS data, however, are available back to 1972 compared with 1982 for TM and 1986 for SPOT data. Therefore, because the accuracy and discriminatory powers of MSS and TM data seem comparable, and the time series for MSS is longer and costs less, MSS data will be used routinely (initially) for national coverage. In areas of special interest, however, where additional detail may be needed (e.g. seagrass systems) TM or SPOT data or aerial photographs will be utilized.The approach includes five steps:

(a) Establish an operational protocol (methods selection) valid for all regions and able to handle any format of Landsat data. The protocol will establish a uniform basis for classification from scene to scene, and thereby allow intercomparison of two or more different scenes or regions. The protocol will also include ground truth procedures. The establishment of an operational protocol (including software development) will be a one-time cost, involving representatives from each region, and once established the protocol would be shared by all.

(b) Provide methodologically uniform documentation of vegetational coverage, land use or coastal water type. The derived products will consist of tables listing areal coverage (hectares) by state, county and hydrologic unit for each classified type. Color enhanced, geocorrected and registered imagery will be used to produce maps denoting each classified type along with state, county or hydrologic boundaries. These maps will be at a 1:250,000 scale. Data, however, for all areas will be retained at full pixel resolution. Thus, finer scale maps (1:24,000) could be produced for selected areas.

(c) Determine change in areal coverage of each classified type. The derived products will consist of tables listing change (hectares) for each classified (identified) type by state, county and hydrologic unit. Additionally, pixel by

pixel intercomparison of the same path, row scene (geocorrected and registered) from two different times will be accomplished to delineate specific changes. These changes will be presented as geocorrected and registered maps (1:250,000 scale). Data for all areas will be retained at full pixel resolution. Thus, finer scale maps (1:24,000) could be produced for selected areas.

(d) Determine biomass, productivity and health status and change. Step (c) above determines whether a land cover type is present or absent. This step (d) provides the data base that will allow determination of biomass, productivity, and health (i.e. functional status) of wetlands habitat using remote sensing. In this way large areas could be evaluated and assessments made more quickly and easily. The step requires ground based research to relate remotely sensed spectral radiances to biomass, productivity and functional health. This work is particularly related to the Estuarine Habitat Productivity section of the Coastal Ocean Program in which the functional values of critical fisheries habitats are considered. It is anticipated that research will be conducted in each region of the country to establish the relationships.

(e) Determine the impact of wetland and estuarine degradation on the abundance and availability of fish. This is a difficult task requiring the cooperative research andinteraction of personnel engaged in the processing of the remotely sensed imagery as well as wetland and estuarine ecologists and fishery biologists. The results feed directly into predictive models, and for assisting habitat conservation and Federal and state decision making.

Anticipated Products

Anticipated products include the development of a computerized digital data base in a geographical information and analysis system capable of intercomparing various remotely sensed data, land-based data, and biological/ecological data in a number of statistical and graphical ways. Products will consist of tables listing areal coverage (hectares) by state, county and hydrologic unit for each identified land use and vegetational cover type. Additionally, color enhanced, geocorrected and registered images (maps) denoting each identified type by state, county and hydrologic unit will be produced. Finally, pixel by pixel intercomparisons of the same path, row scene (geocorrected and registered maps) from two different times will be generated to delineate specific changes and their location. The digital data base will be flexible and user friendly. It will be able to accept data from various sources, including historical aerial photographs and special surveys for submerged aquatic vegetation.

These products will enable managers to see at a glance where and what kind of changes are occurring so that efforts could be concentrated on areas of greatest change, or decisions could be made concerning human activities where change was most significant. Researchers could use these products to help guide their research into understanding the relationships between land use and productivity of the coastal ocean system, including fisheries.

Coastal Ocean Program -NESDIS
APPROVAL
ACCOMP. Pichel

CoastWatch Implementation

ORIG. APPVL. / /
LAST CHANGE / /
STATUS AS OF 03/06/89

	MILESTONES	89				90				91				92				93				94				95			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
01	Southeast CoastWatch																												
02	Research																												
03	Sample Products																												
04	PC Development																												
05	Prototype Demo																												
06	Operational Implementation																												
07	Chesapeake Bay CoastWatch																												
08	Research																												
09	Sample Products																												
10	PC Development																												
11	Prototype Demo																												
12	Operational Implementation																												
13	CoastWatch Region #3																												
14	Region #4																												
15	Region #5																												
16	Region #6																												
17	Region #7																												
18	Region #8																												
19	Region #9																												
20																													

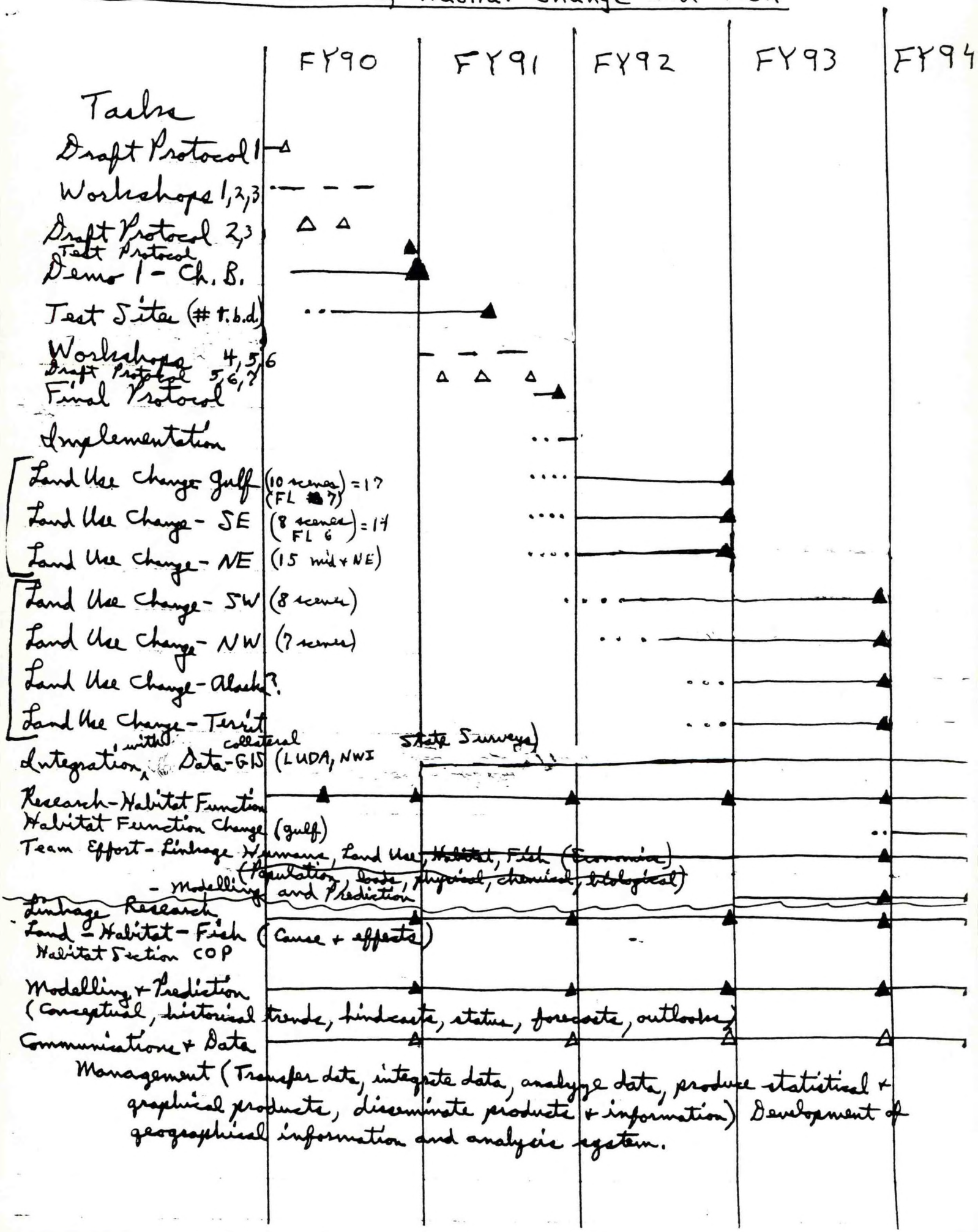
Note: SCHEDULE IMPACTS: CEMSCS AVAILABLE 2/91

National LANDUSE, HABITAT CHANGE, AND FISH:

Time Lines

Milestone:	Begin:	End:
1. Development of a test protocol for classifying and measuring land types and uses in a methodologically uniform manner for the coastal zone (particularly wetlands).	10-89	9-90
2. Demonstration of land cover/habitat change for Chesapeake Bay area using agreed upon test protocol.	11-89	10-90
3. Development of an operational protocol per above.	10-90	9-91
4. Determination of land cover by class for selected test areas in each region.	3-89	3-91
5. Determination of land cover by class for broad coastal regions.	6-91	9-92
6. Determination of change in land cover for U.S. Coastal Zone based on final protocol.	10-91	9-93
7. Determination on biomass, productivity and health of selected coastal habitat and changes in these variables over time.	10-89	9-94
8. Integration of results to determine effects on commercial and recreational fish and shellfish.	10-90	9-95

Landsat – Land Use, Habitat Change and Fish



Proposed NOAA CoastWatch RESOURCE REQUIREMENTS

Water Applications of NOAA CoastWatch

	FY90	FY91	FY92	FY93	FY94
Research					
OCEANIC SCIENCES BRANCH					
Hardware	135	113	68	38	38
Software	90	95	100	105	110
Admin/travel	4	7	7	7	7
MARINE APPLICATIONS BRANCH					
Hardware	70	0	0	0	0
Software	45	95	100	105	110
Admin/travel	5	7	7	7	7
RESEARCH TOTAL:	349	370	335	310	315
Product Development					
INTERACTIVE PROCESSING BRANCH					
Hardware	30	2	42	2	2
Software	90	95	100	105	110
Admin/travel	2	3	4	4	4
INGEST SYSTEMS BRANCH					
Software	190	150	180	180	130
PRODUCT SYSTEMS BRANCH					
Software	203	190	150	140	110
Admin/travel	2	3	4	4	4
DEVELOPMENT TOTAL:	517	443	480	435	360
Operational Products					
INGEST SYSTEMS BRANCH					
Software	30	50	150	255	315
PRODUCT SYSTEMS BRANCH					
Software	40	95	150	175	220
OPERATIONAL PRODUCTS TOTAL:	70	145	300	430	535

Data System Development/Operation

NATL OCEANOGRAPHIC DATA CENTER

Hardware/Software	325	400	200	170	170
Scientific Program	50	100	220	250	250
In situ Data Program	25	50	100	125	125
Communication	75	75	100	125	125
Admin/travel	25	30	35	40	45
Demo. Workstations	64	32	0	0	0
DATA SYSTEM TOTAL:	564	682	650	700	700

OCEAN COLOR

Data acquisition	0	1785	650	650	650
Communications	0	475	255	255	255
Optical buoy	0	1250	1390	280	280
Product development	0	50	150	150	150
TOTAL:	0	3560	2445	1335	1335
FTE's		4	1		

Water Applications of NOAA CoastWatch	**1500**	**5200**	**4210**	**3210**	**3245**
Land Applications of NOAA CoastWatch - Landuse Habitat and Fish	**500**	**1000**	**1250**	**1500**	**1750**
TOTAL NOAA CoastWatch	**2000**	**6200**	**5460**	**4715**	**4995**