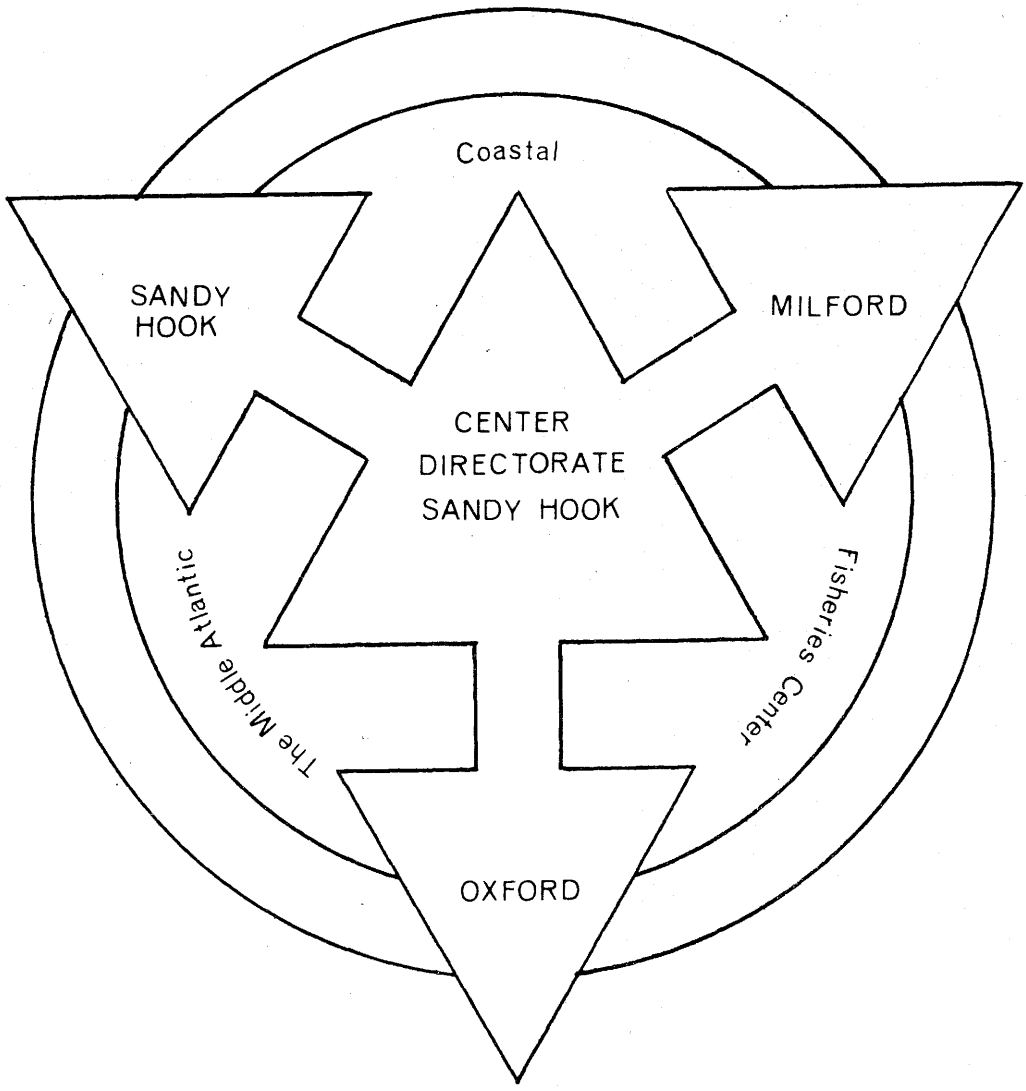
RESEARCH PROSPECTUS: BIOLOGICAL BASELINES FOR POLYCHLORINATED BIPHENYLS AND THEIR SIGNIFICANCE IN THE MIDDLE ATLANTIC ECOSYSTEM

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region

MIDDLE ATLANTIC COASTAL FISHERIES CENTER



INFORMAL REPORT NO. 95

March, 1976

Research Prospectus: Biological baselines for polychlorinated biphenyls and their significance in the Middle Atlantic Ecosystem

Introduction:

Polychlorinated biphenyls (PCB's), like DDT and its derivatives, appear to be both persistent and ubiquitous in terrestrial and marine ecosystems. Their persistence reflects the stability and resistance to oxidation characteristic of the biphenyl structure; the ubiquity of PCB's reflects their long- and widespread usage as heat-transfer agents (electrical capacitors, transformers, etc.). PCB's consist of a mixture of compounds only slightly soluble in water; they are highly soluble in fats, oils and non-polar liquids. Exposure to PCB's is known to cause lesions of the skin and to increase liver enzyme activity. PCB's have been detected in sludges from sewage treatment plants and in the riverine effluents therefrom. Their major sources, however, appear to be releases or leakages from closed systems. PCB's are contaminants known to have adverse effects upon the health of fish and shellfish and, in seafoods, to pose potential health hazards when ingested by humans. Action levels to prohibit the sale of finfish containing 5.0 ppm of PCB or more have been established by the U. S. Food and Drug Administration. The PCB content of many of the fishes from the Hudson and Delaware Rivers exceeded the FDA action levels. In apex-predator fishes, PCB levels have been estimated, as a consequence of postulated biological accumulation throughout the various and complex levels of the food chain, to be concentrated by a factor of 75,000. Official national and international actions taken to curtail or to end certain usages of PCB's, and thereby to reduce its potential for entry into food and water supplies, have been reasonably successful. Nevertheless, the levels of PCB's in the tissues of fish and wildlife appear to have increased over the years, as would be expected of a highly persistent, selectively accumulated contaminant. Some five million cubic yards of sewage sludge and 7 to 11 million cubic yards of contaminated dredge-spoils and 2.5 million cubic yards of industrial wastes are dumped annually in the New York Bight. In addition, approximately 300-400 billion gallons per year of highly contaminated Hudson River waters flow under the Verrazano Bridge on its way to the New York Bight. The possible accumulation as a result of these activities of PCB's in the sediments and the water columns of the Bight as well as in the indigenous living marine organisms, merits investigation. In the Middle Atlantic Bight, owing to the very large numbers of fishes harvested and consumed, by sport and commercial fishermen, the public health hazard, implicit in PCB contamination, takes on a very special, as yet totally unquantified, dimension. Special short-term and local pilot studies conducted by this Center on the statistics of the mid-Atlantic sportfish

catch indicate that, for many species, the sportfish catch equals or exceeds the commercial catch. Thus, from a resource-conservation viewpoint as well as from a justifiable concern for the public health, it is proposed that the Middle Atlantic Coastal Fisheries Center (MACFC) undertake an assessment of the impact of PCB's upon the mid-Atlantic marine ecosystem and as to the implications thereof for the health of users of the ecosystem.

Facilities:

The Middle Atlantic Coastal Fisheries Center, at one or more of its three major installations, is uniquely competent, in terms of staff expertise and specialized equipment, to measure and assess the biological significance of many pollutants (at the ppb level) for the well-being of the living marine resources. The experimental exposure systems (for long-term, flow-through, subacute exposures) are almost unique on the Atlantic coast, as is the complementary battery of three Brett cruising speed respirometers. Special ancillary facilities for hatching, rearing and maintaining test animals and automatic systems for supply of large quantities of specialized foods, as well as for purification of incoming seawater and for treatment of effluents, are available. The Center's large staff of trained physiologists, chemists, immunologists, pathologists, enzymologists, etc., ensures that a broad spectrum of detailed studies are performed on all test-exposed animals. In addition, the Center regularly surveys, by means of several seagoing vessels, the distribution and abundances of finfish and shellfish in the Middle Atlantic Bight. Such surveys can also be utilized to collect samples of finfish from all oceanic areas in the Bight for subsequent PCB and histopathological analyses.

Objectives:

1. Determine the concentrations of PCB which cause 0% and 50% mortalities in eggs and larvae of the American oyster and of the hard-shell clam.

2. Determine the mutagenic effects on eggs and larvae of striped bass (*M. saxatilis*) and of winter flounder (*P. americanus*) of long-term exposure to sublethal levels of PCB's.

3. Determine the physiological damage induced in young-of-the-year striped bass (*M. saxatilis*) and in winter flounder (*P. americanus*) by long-term exposure to sublethal levels of PCB's.

4. Determine the histopathological anomalies induced in young-of-the-year striped bass (*M. saxatilis*) and in winter flounder (*P. americanus*) by long-term exposure to sublethal levels of PCB's.

5. Determine PCB uptake rates in selected tissues of all exposed test animals and monitor levels of PCB's in test tanks.

6. Determine the incidence and prevalences of PCB body-burden in representative "wild" fishes taken from all areas of the Middle Atlantic Bight.

7. Evaluate the net effects of PCB's upon the viability of the totality of mid-Atlantic finfish populations as measured by field and laboratory studies and by model systems analysis.

8. Evaluate the degree of hazard to the human (seafood-consumer) population at risk.

Experimental Design:

1. "Controlled Exposure Studies (see also Flow Diagram #1).

   a. Test animals, randomly selected from holding tanks, will be subjected to long-term (90 days) exposure (in subacute, flow-through-system) to five (5) low (ppb) levels of PCB's.

      (1) A subsample of the randomly selected sample of test animals will be analyzed for "normal" body-burden of PCB's and for "normal" physiological and histopathological condition.

   b. Subsamples of the exposed test animals will be removed from the exposure system at regular intervals (every 18 days) for examination:

      (1) Tissue uptake: chemical analysis by gas chromatography.

      (2) Histopathology: tissue studies (utilizing histochemistry, light microscopy, and electron microscopy) to detect gross and subtle evidences of stress- and disease-induced pathology.

      (3) Immunology: tissue studies to detect changes in serology and antibody production capability.

      (4) Respiration: tissue studies to detect changes in respiration and in O_2 consumption rates as well as in serum osmolality and osmotic regulation capacities.

      (5) Mutagenesis: cytogenetic studies to detect abnormalities in chromosomal structures.

2. PCB Incidence and Prevalence Studies in Wild Finfish Populations (see also Flow Diagram #2).

   a. During biannual resource assessment surveys (~170 stations from nearshore to the 100 fathom line and from Block Island to Cape Hatteras) representative samples of commercially or recreational fish species will be taken from the trawl catches for (1) PCB content analyses and (2) histopathological studies. Details of experimental procedures are presented in Flow Diagram #2. Studies, when complete, will afford information on the generel levels and distributions (incidence) of PCB's in finfish over the entire survey area, (2) information as to "hot spots", that is, local prevalences of high PCB levels in finfish, (3) a measure of the "normal" PCB body-burden in sport and commercial finfish, and (4) a measure of the public health hazards for consumers of mid-Atlantic fish products.

3. PCB's in Surficial Sediments, New York Bight.

   From stored Smith-McIntyre grab samples, determine the PCB content of surficial sediments of the New York Bight.

4. PCB-induced Tumor Production Studies.

   Undertake, under controlled conditions, the induction of tumors in susceptible detritus- and filter-feeding test animals by challenge with allegedly carcinogenic PCB's.

Work Products:

1. Seven (7) trimester progress reports.

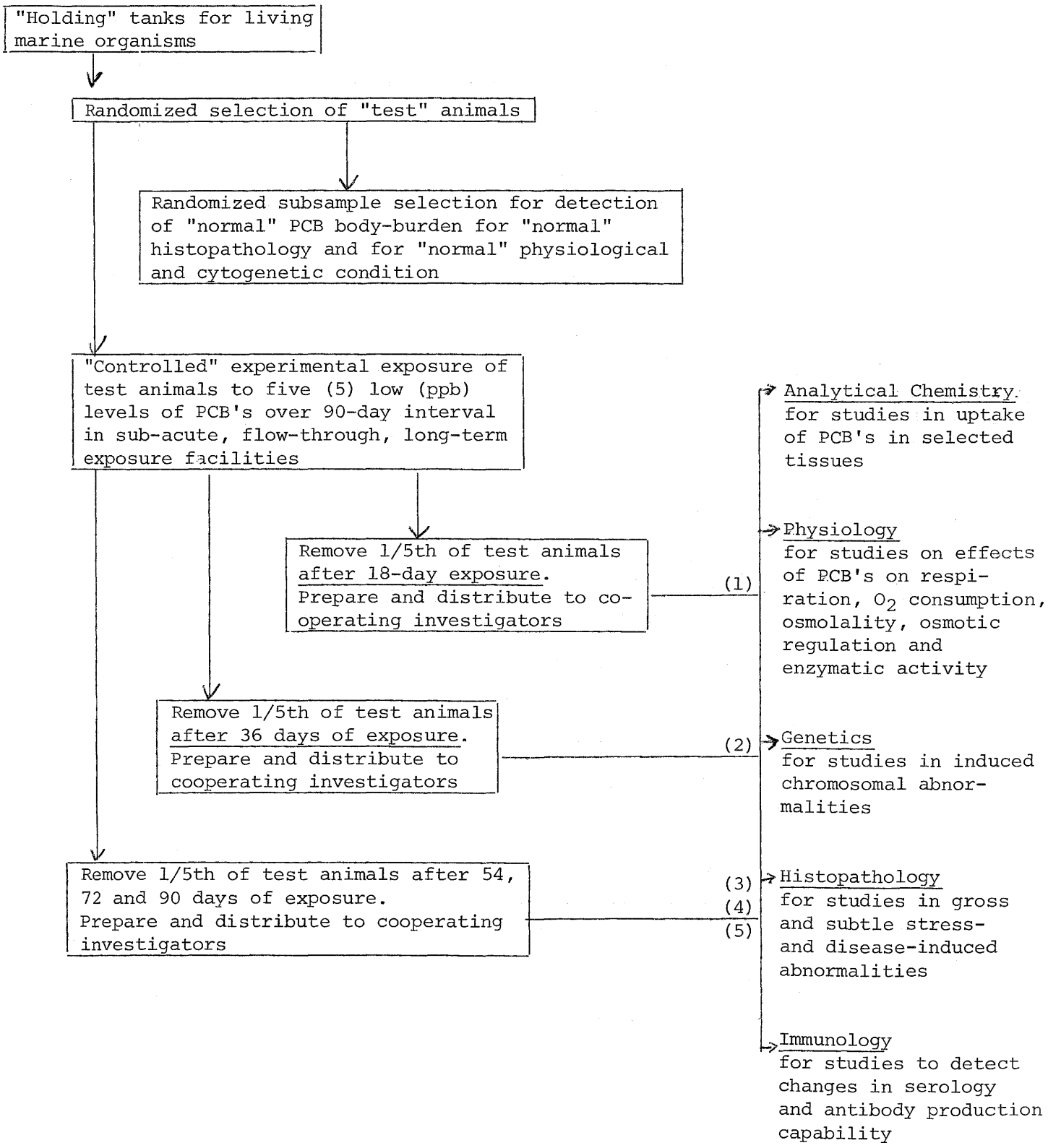
2. Data reports (14) encompassing all aspects of the physiological, histopathological and chemical findings.

3. Technical Report: Biological significance of polychlorinated biphenyls (PCB's) for the living resources in marine ecosystems (incidences and prevalence of PCB's in the ecosystem; physiological, histopathological and mutagenic effects; implications for conservation and management of the resources).

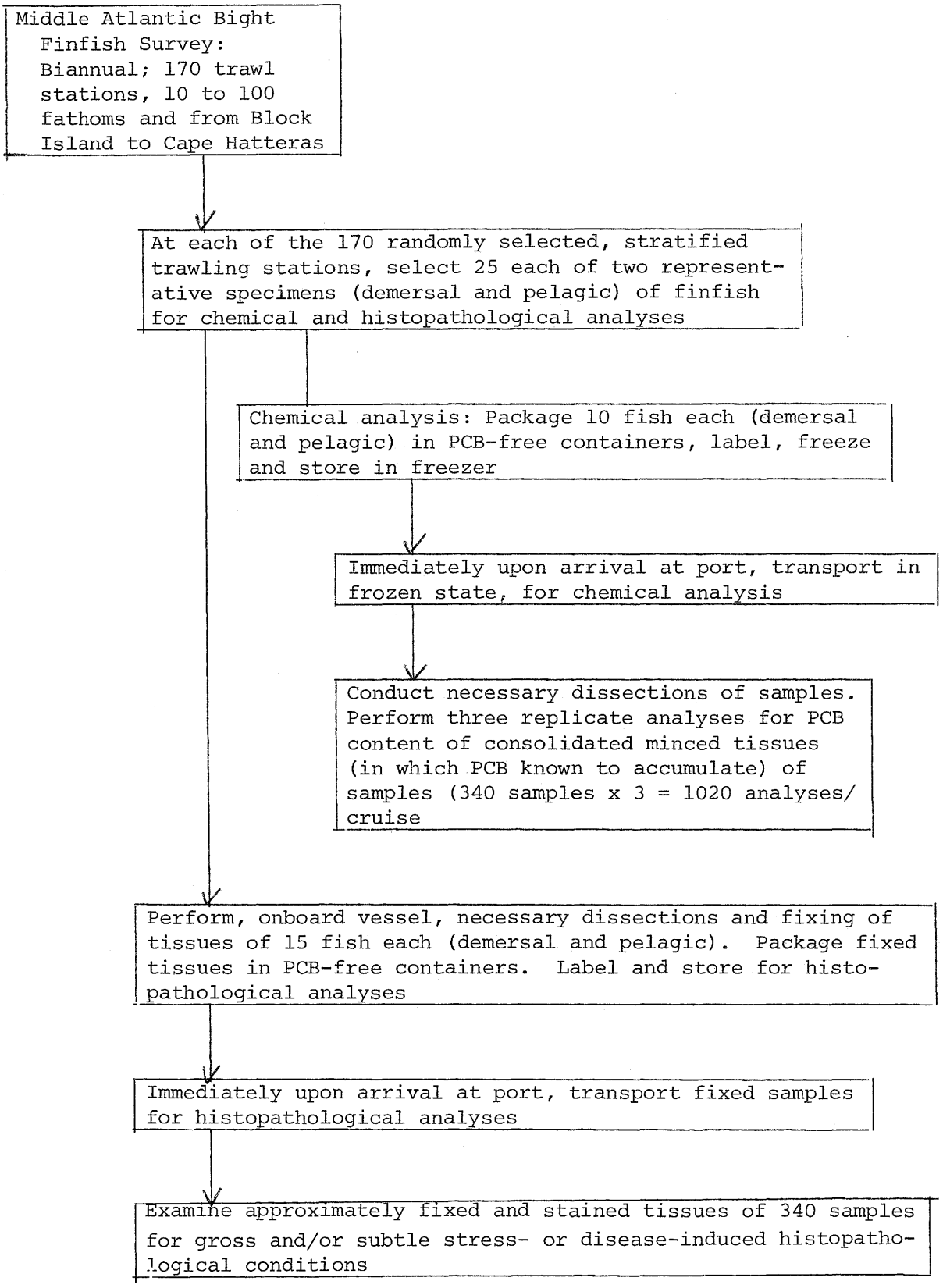
4. Technical Report: Implication of PCB levels in fish tissues for the public health.

5. Technical Report: Systems analysis (inputs, outputs and storages) of the transport and fate of PCB in the marine ecosystem.

Flow Diagram #1: Experimental procedures for exposure studies



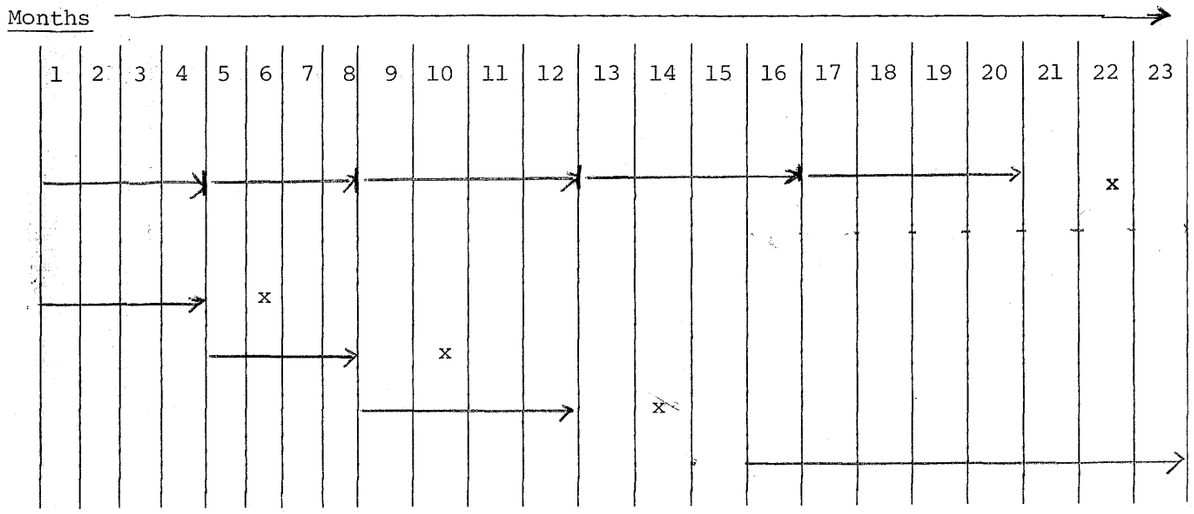
Flow Diagram #2: Incidence and Prevalence Survey Studies



Work Units:

		Months 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
PCB-1	"Controlled" Exposure Studies																							
PCB-1.1	Acute, static tests: LD_o & LD_{50} for shellfish																							
1.1.1	Oysters					x																		
1.1.2	Hard-clams					x																		
PCB-1.2	Subacute, long-term, flow-through studies																							
1.2.1	Initiate long-term (90 days) exposure studies																							
1.2.2	Determine "normal" PCB body-burden, physiology and pathology						x																	
1.2.3	Remove and distribute fish tissues for study																							
1.2.3.1	Complete studies of tissues (1st allocation)1/									x														
1.2.4	Remove and distribute fish tissue for study																							
1.2.4.1	Complete studies of tissues (2nd allocation)1/										x													
1.2.5	Remove and distribute fish tissues for study																							
1.2.5.1	Complete studies of tissues (3rd allocation)1/											x												
1.2.6	Remove and distribute fish tissues for study																							
1.2.6.1	Complete studies of tissues (4th allocation)1/												x											
1.2.7	Remove and distribute fish tissues for study																							
1.2.7.1	Complete studies of tissues (5th allocation)1/													x										
PCB-2	Incidence and Prevalence Studies: "Wild" populations																							
PCB-2.2	Complete 1st of two biannual collections of samples																							
2.1.1	Complete studies of tissues (1st cruise)																x							
2.2	Complete 2nd of two biannual collections of samples																							
2.2.1	Complete studies of tissues (2nd cruise)																							x

Work Units:



PCB-3	Induction of tumors: PCB challenge agents
3.1	Initiate studies - five 4-month challenge intervals
PCB-4	PCB in surficial sediments
4.1	N.Y. Bight apex sediments
4.2	N.J. coastal sediments
4.3	Long Island and offshore sediments
PCB-5	Preparation: Three (3) Final (Technical) Reports

1/ In the event of development of severe, time-consuming abnormalities, time-adjustments, on a case-by-case basis, will be negotiated

* Data reports

BUDGET

Personal Services: 1/

Name	Grade	% Time	Cost	
Dr. A. Calabrese (Physiologist)	GS-13	40	$10.6K	
Dr. A. Longwell (Geneticist)	GS-13	20	5.5	
Mr. R. Greig (Chemist)	GS-12	100	24.4	
Dr. R. Robohm (Immunologist)	GS-12	20	4.7	
Mr. A. Farley (Oncologist)	GS-12	50	11.5	
Dr. F. Thurberg (Physiologist)	GS-12	40	8.7	
Mr. M. Newman (Pathologist)	GS-12	100	20.4	
Biological Lab. Technicians (3)	GS-05	100	28.1	
Biological Aides (6)	GS-03	100	44.7	
Total Direct Labor			$158.6	
Employee Benefits (9.6% of Total Direct Labor)			15.2	
Total Personal Services				$173.8K
Operations:				
Contract (Analytical Services)			40.5	
Computer Services			15.0	
Supplies			25.0	
Travel			10.0	
Total Operations				$ 90.5K
Support: 2/				
MACFC (57.9% Total Direct Labor)			91.8	
NMFS (41.7% Total Direct Labor)			66.1	
DOC (0.5% Total Cost)			2.1	
Total Support				$160.0K
Total Project Cost				$424.3K

1/ All personal service costs are subject to adjustment based on Congressional action.

2/ The support rates used are current and are subject to change due to factors outside the control of this organization.