The Consequences of Contaminants To Living Marine Resources and Human Health

FY 1986 Program Description

Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service

March 1986

National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Rockville, MD

The Consequences of Contaminants Program

Introduction

Contamination of marine waters is a primary concern when it presents risks to human health or when ecological changes are induced that could result in decreased abundance of valued living marine resources. The Consequences of Contaminants Program of the Coastal and Estuarine Assessment Branch (CEAB), Ocean Assessments Division, addresses these concerns by focusing upon two marine environmental quality management questions: 1) What is the significance of existing or potential levels of contamination as risks to human health or populations of valued living resources; and 2) can consequences of contaminants be predicted and quantified with a level of confidence useful in ocean-use management decisions? In addition to addressing these questions, the program is designed to explore new measurement techniques for application in monitoring marine environmental quality under NOAA's National Status and Trends Program. A description of this program is available from the Ocean Assesssments Division. This second annual document briefly describes progress made over the last year and future directions.

The major objective of the Consequences of Contaminants program is to develop techniques for determining whether populations of fish and shellfish are threatened by contaminants that are already in estuarine and coastal waters. Through these techniques the National Status and Trends Program will be able to expand beyond monitoring contaminant concentrations and histopathological conditions.

Two kinds of techniques are being developed. The first will enable the examination of adult fish to know whether their ability to produce healthy larvae is diminished by contamination. The second will define whether water quality in a given area is inimical to normal development of larvae. Finding either that reproduction or larval development is compromised does not necessarily mean that a population will decrease, but it would be a finding of considerable consequence.

There are many reasons that we cannot relate directly reproductive losses to population declines. Essentially they reduce to our inability to predict the influence of natural fluctuations in climate, circulation, and food availabilty (factors often termed "environmental variabilty") and density-dependent survival (the tendency for survival to increase when the population is diminshed). Sorting out and quantifying the reasons for variations in sizes of fish populations is a major task of the National Marine Fisheries Service. The Consequences of Contaminant Program is not involved in that effort. It does, however, deal at the population level in two ways.

First is the examination of historical data to find whether past trends in population sizes of important species can be correlated with contaminant inputs to estuaries or coastal waters. Finding such correlations, after having already accounted for variations attributable to fishing pressure and environment, would at least demonstrate the plausibility of contaminant inputs having such a consequence. Not finding correlations would contradict the often expressed claim that a stock reduction must be due to contamination.

The second endeavor at the population level is simply to collect all existing data on age-specific survival probabilities and fecundities for resource species. With such data, it is a very straight-forward step to simulate population changes that would occur after so many years of a given amount of reproductive loss or larval mortality or increased fishing. The calculated decreases in population are not realistic because no account is made of density-dependent survival or environmental variation. However, the calculation serves to put in perspective the relative effects of contamination and fishing which are the two influences on populations that can be managed.

Hazards to human health from coastal contamination is the other major threat addressed by the Consequences of Contaminants Program. The objectives here are, for example, to develop methods for quantifying the risk of gastroenteritis through consumption of raw shellfish and to demonstrate a methodolgy for quantifying the consumption of chemical contaminants by urban-area fishermen. Progess along those lines will be described after discussion of results from work on fish reproduction and populations.

Contaminant effects on fish populations

NOAA is supporting two efforts with the goal of finding correlations between historical records of fishery stock sizes and contaminant inputs to coastal and estuarine waters. One study is complete and will soon be published. It is very briefly summarized in Table 1 where it can be seen that for some stocks in some estuaries there is good reason to suspect that human activities other than fishing have affected stock sizes of fish and shellfish. Of 72 species-estuary pairs, 35 showed correlations with human activity. Six of those 35 quantified influences were positive-only in the sense that increased stock sizes followed increased dredging. Among the remaining 28 cases, the important factor was usually either dissolved oxygen (DO), inputs of oxygen consuming substances (BOD), or some measure of monotonically increasing human activity, trend (Tr).

These results indicate that there is good reason to suspect that human influences, other than fishing, can affect sizes of fish stocks. However, they do not indicate whether contaminants are ever at fault. The correlation between decreases in dissolved oxygen and decreased stock size obviously emphasizes the value managing the discharge of oxygen-consuming substances and nutrients. Such materials are not considered contaminants, in the context of this Program. Our objective is to determine the necessary extent of control on chemical inputs to prevent their affecting fish populations.

The fact that some stock sizes varied inversely with Tr[end] implies that some factors other than DO and BOD can have caused a response. However, because of the way this analysis had to be done, any influence whose intensity increased monotonically over the period 1928-1978 would have yielded the same result. If the historical record were well enough documented and we were able to construct a 50-year input record for any particular contaminant, and if that record did not show a monotonically increasing input, we could test whether inputs of that contaminant correlated with stock sizes.

No such tests are possible with fish stocks in Northeast estuaries. Attempts to reconstruct inputs of particular chemicals depend on large extrapolations from very sketchy data and yield only monotonically increasing trends. Moreover, the stock size trends themselves involve extrapolations from records of catch, fishing effort, and fishing technique. The records and the methods of extrapolation become increasingly more imprecise as one goes back in time.

The Northeast estuary study has gone as far as such studies can go. However, it leaves unanswered the question of whether chemical contaminants are involved. We have initiated one other study along these historical lines. It is being done in California where there are two distinct advantages over the Northeast. First is the existence of a long-term record of fish

Table 1. Species and estuaries for which correlations were sought between historical trends in stock size and in human activities other than fishing[a,b,c].

	Estuary				
Species	Potomac River	Delaware Bay	Hudson-Raritan	Narragansett Bay	Connecticut River
Alewife	BOD,Tr	none	Dr*	none	-----
Blue crab	Tr	DO,Tr	none	-----	-----
Bluefish	-----	none	DO,Dr,Tr	none	-----
Butterfish	none	DO,Tr	none	none	-----
Croaker	DO,Tr	none	-----	-----	-----
Eel	BOD,Tr	DO,Dr*	DO,Dr*,Tr	Tr*	-----
Hard clam	-----	none	none	none	-----
Lobster	-----	none	none	Tr	-----
Menhaden	none	none	none	none	-----
Oyster	BOD,DO,Tr	DO,Dr	none	none	-----
Scup	-----	DO,Tr	DO,Dr*,Tr	none	-----
Shad	DO,Tr	DO,Tr	DO,Dr*	-----	Dr*
Smelt	-----	-----	-----	none	-----
Soft clam	Dr*	-----	none	Tr	-----
Spot	none	none	Dr*	-----	-----
Striped bass	none	DO	none	Tr	-----
Sturgeon	-----	none	none	-----	-----
Summer fl.	DO,BOD,Dr*,Tr	none	none	Dr*,Tr	-----
Tautog	-----	-----	Dr*	Tr	-----
Tomcod	-----	-----	Dr*	-----	-----
Weakfish	DO,BOD,Tr	none	none	Tr*	-----
White perch	none	none	DO	Tr	-----
Windowp.fl.	-----	-----	-----	none	-----
Winter fl.	-----	-----	DO	Tr	-----

[a] Historical period is 1928 to 1978. Correlations are listed if they accounted for at least 10% of the variation in stock over and above that accounted for by the stock size itself and by climate (e.g., temperature, river flow, and precipitation).

[b] Historical trends could be constructed for some measures of human activity in some estuaries. Those measures were DO (dissolved oxygen), BOD (inputs of biological oxygen demand), Dr (dredging volumes), and Tr (any parameter such as human population or industrial activity with a monotonically increasing trend over the 50-year period).

[c] An asterick indicates a positive correlation between stock size and the human activity (e.g., Dr* indictates that by correlation stocks increased after dredging). The designation "none" indicates that no trends in any measure of human activity were able to explain 10% or more of the stock variation. When more than one activity is shown it means that each activity considered by itself accounted for 10% or more of the stock variation. No correlations were made that incorporated more than one human activity. When it was not possible to reconstruct a 50-year record of stock size, no correlations could be attempted and that is shown as "-----" in the table.

population dynamics collected in the context of the California Cooperative Oceanic Fisheries Investigation (CalCOFI). Second is the better record of contaminant inputs from coastal outfalls and other human activities. Extrapolations will still be made but the historical trends within which to seek an influence of contaminant inputs will be more precise than in the northeast estuary study. The California study is in its second year. The historical trends in fish stocks and climate have already been constructed. During 1986 the major effort will be to construct the corresponding record for contaminant inputs.

In terms of fish population models, we have centered upon simple Leslie matrices. With data on survival probabilities (e.g., a 0.33 chance that a 4-year old will reach age 5) and fecundities (e.g., an average 5-year old produces 500,000 eggs) that have been and are being collected during the stock assessment work of NMFS and others, it is a simple matter to project the consequences of increased larval mortality (due to contamination, for example) or decreased fecundity (again possibly due to contamination) or increased adult mortality (due to fishing). The projections are, of course, unrealistic because no account is taken of density-dependent survival or the vagaries of environmental factors. However, the simple models serve three valuable purposes.

First, when data are available on reproductive losses to contamination, the corresponding simple extrapolation to population decreases can be made. The same simple calculation can be made to determine the corresponding amount of increased fishing that would yield the same population effect. This puts contamination in perspective with fishing as a pressure on fish populations. Second, the population calculations emphasize the need to know the physical scale of contaminant effects. This is needed to know what fraction of the total stock is exposed to sufficient contamination to diminish reproduction. The importance of scale is often overlooked when contamination is considered, but with emphasis on populations it cannot be ignored. Third, the sensitivities among stocks to a given contaminant effect are a function of the stocks' age-specific survival and fecundity values, so the relative sensitivities can be assessed with simple models.

This year, collection of age-specific survival and fecundity data will continue. For those stocks for which there is a long-term record of stock size, estimates will be made of how large a decrease would have to occur over a given number of years in order for the decrease to be detected above natural variation. With these estimates it will be possible to estimate subsequently how much of a stock loss would have to be imposed (via contamination or fishing or any mechanism) in order for it to be evident at the population level.

Examinations of historical data and theoretical modeling are important, even if they only serve to put the issue of contamination into perspective. They are not, however, the main thrust of NOAA's effort in the area of resource populations. That lies in developing monitoring methods that allow us to know when adult fish are unable to reproduce successfully or when water quality has degraded to the point where fish larvae are unable to survive. An important corollary of this effort is that in the process of developing methods we will determine the concentrations of contamination that are necessary to diminish reproductive success. The work with adult fish and that with larval fish are distinct and will be discussed separately.

1. Reproductive success of adult fish

Possible effects of contaminants on the reproductive capacity of fish are being examined in San Francisco Bay, in Puget Sound, in Southern California coastal waters, and in New Bedford harbor.

In San Francisco Bay a relationship has been found between the activity of a liver enzyme system in female starry flounder and the ability of eggs to become fertilized. Since that enzyme system, the mixed-function oxidase (MFO) system, is known to be stimulated by an animal's metabolizing of synthetic and natural polyaromatic organic compounds, it follows that ingestion of these compounds is affecting reproductive success. The problem apparently lies in the fact that normally, during the spawning period, a fish will suppress its MFO activity in order to not metabolize hormones required for production of normal eggs. A normal function of the MFO system is to aid in adjusting hormone levels. That function may become unbalanced by the need to metabolize chemical contaminants. Furthermore, among those eggs that are fertilized successfully, it has been found that the higher the concentration of PCB's in those eggs the less likely they are to develop into healthy larval fish. These observations were made possible by the fact that flounder from the central portion of SF Bay are more contaminated than those taken from the less developed San Pablo section of the bay. Two products with very important management applications can result from this continuing study. First it may be that the differences in tissue contamination and sediment contamination between the central and San Pablo sections of the Bay represent the difference between areas that are contaminated to the point where reproduction is diminished and those where contamination is not severe enough to have that effect. Secondly, the most tedious measurements being made are those that require actually spawning the fish. If the simpler measurements of enzymatic activity, tissue contamination, or sediment contamination prove to be valid correlates of reproductive success it will be possible to use those measurements over a national scale to identify areas where reproduction of resource species is diminished.

For 1986 the work in San Francisco Bay is directed at expanding the range of observations to lower and higher levels of hepatic MFO activity and, by hypothesis, to higher and lower levels of fertilization success. This endeavor will require collecting gravid females from exceptionally clean and contaminated areas within the Bay.

No matter how definitive are the final results are on effects of contaminants on starry flounder in San Francisco Bay, the information cannot move into the realm of management until observations are made on other species in other areas. Work begun in1985 in Puget Sound has not found differences in reproductive success of English sole that correlate with enzymatic activity or tissue contamination or sediment contamination or the location within Puget Sound where the fish are captured. These results are not neccessarily in conflict with those from San Francisco Bay. The livers from fish that were apparently normally reproducing in Puget Sound did not display high levels of MFO activity. When such fish were, however, injected with extracts of sediment collected in a very contaminated part of Puget Sound they did respond with increased enzymatic activity and with decreased reproductive success. It may be that fish found in the more contaminated parts of the Sound are incapable of reproduction. It is known that the females that reproduced normally also had a very low incidence of liver tumors. In the coming year fish will be collected in areas where the incidence of tumors is known to be high and will be injected with hormones that are known to stimulate reproduction. If these fish fail to reproduce, it may turn out that assaying the incidence of liver tumors (which is relatively easy to do) will serve to measure the reproductive potential of adult fish.

A third set of data on contaminant levels and reproductive success of fish is being obtained with coastal species collected off Southern California. Prior work in that area has failed to indentify a correlation between tissue contamination and gonadal histology (microscopically examined gonadal tissue). However, until it is demonstrated that histological measurements are valid substitutes for actual measurements of reproductive success, the reproductive potential of fish in this area remains unquantified. At present bottomfish are being sampled monthly at stations that span a contamination gradient. The annual cycles in gonadal histology and contaminant levels are being documented. During spawning season, fish are being induced to spawn in the laboratory and eggs cultured to hatching in order to measure spawning success. If histological measurements are found to be valid indicators of reproductive success, such measurements can obviously be exploited in a national monitoring program.

In New Bedford harbor, work has been done with shellfish rather than fish and with caged rather than feral organisms. After two years of deployment in harbor waters, female mussels were unable to produce eggs. They were unable to do so because of incomplete follicle development. This very severe type of damage to reproductive organs can be determined histologically. There was no such effect after only one year and in both years the male mussels were unaffected. Since New Bedford harbor is a case of extreme PCB contamination, one can hypothesize that PCB's are causing reproductive damage. This is being tested experimentally.

Possible effects on the reproductive process of soft-shelled clams in New Bedford Harbor will be examined this year. Within the harbor region, recruitment patterns are distinctly different from those in nearby regions. Within the harbor juvenile recruitment is higher than elsewhere but overall mortality is six-times greater. Also, while a condition of hematopoietic neoplasia in this species is currently endemic in the northeastern U.S., its incidence is twice as high in the harbor than in nearby regions. It is possible that the high levels of PCB's in the harbor are causing adults to produce genetically unsuitable progeny, or that PCB's are not allowing successful development of otherwise normal juveniles. It is also possible that recruitment is being affected directly by the disease but that the incidence of disease is increased in the presence of PCB's. These alternative hypotheses will be tested through a combination of field and laboratory investigations.

<u>2. Egg and larval survival</u>

Even if adult fish are able to reproduce normally in the face of contamination, that will be of no value if contamination in the environment prevents the normal development of eggs and larvae. In this area, like that of reproduction, the objectives are to identify some areas where contamination is affecting early life stages and to develop monitoring methods for identifying routinely such areas on a national scale. These objectives are being addressed through a review of toxicity data, assays of egg and larval development in various water bodies, and testing the utility of using surrogate organisms to reflect validly conditions that are not suitable for eggs and larvae of resource species.

Over the past decade or so numerous laboratory bioassays have been performed on the response of aquatic organisms to chemical contaminants. If the data collected have been sufficiently thorough, then in principle one could judge the suitability of water for egg and larval survival on the basis of chemical measurements alone. During the past year NOAA has supported an exhaustive search of the toxicity data to identify what is already known about responses of early life stages of marine fish to some chemicals. The search has also included analysis of data on crustacea because some valued species are crustacea and because it may develop that, in general, crustacea are more sensitive to contamination than are fish. This latter possibility would be of great benefit in selecting a surrogate species for use in a national monitoring program. The results of this data search are now available and confirm the expectation that one can use crustaceans to test water toxicity with little likelihood of underestimating toxicity toward fish.

The concept of "surrogate" species is being exploited to a large extent with the copepod Acartia tonsa. It has been found that the fecundity (egg production) and nauplii (larval) survival of this crustacean are both diminished when the adults and their progeny are exposed to estuarine water taken from the Elizabeth River, VA, Raritan Bay, NJ, and the St. Johns River, FL. On the other hand waters from the Newport River, NC, the Cooper River, SC, and Escambia Bay, FL, do not induce such a negative response. It has been further demonstrated that those waters which are toxic to A. tonsa become non-toxic upon addition of chemicals that form chelates with trace elements. The formation of chelates effectively makes trace elements unavailable to organisms , so it appears that where waters are toxic the responsible agents are trace elements. Limited tests with fish larvae have shown that waters that are toxic to A. tonsa may not affect fish larval survival, but that knowing that waters are not toxic to A. tonsa probably does ensure that they are suitable for development of early life stages of fish. Work done this year will further develop the relationship between responses of A. tonsa and those of resource species. The copepod assay will be exploited as a monitoring tool to assess the toxicity of estuarine waters over a larger scale than has been done to date.

It should be noted that comparisons of toxicity among different water bodies can only be made when a single strain of A. tonsa is used for testing. All the tests summarized above were done with a strain isolated from the Newport River and cultured in the NMFS Beaufort Laboratory. Other strains of that species do live and reproduce in the waters that were judged toxic by the test. Thus, as has been demonstrated earlier with phytoplankton, organisms do develop a resistance to contamination. Since resistance develops over many generations through selection of hardy individuals, and since most valued species reproduce only annually, it may not be assumed that development of resistance is of any practical significance in preserving valued species.

Acartia tonsa in New Bedford harbor have been observed to have lower reproductive success than the same species in nearby Buzzards Bay. Again, because this observation is in New Bedford harbor one suspects PCB's as the causative agent. Here as with observations on A. tonsa elsewhere the effect could be due to trace elements. The New Bedford harbor observations were different, however, because it was not egg production or larval survival that were compromised. Rather there was a decreased success of eggs developing into larvae. What is observed, therefore, is likely to be a deficieny in the reproductive process of adults rather than a manifestation of water being toxic to eggs or larvae.

It has been known for some time that concentrations of chemicals in natural waters can be many times (10 to 1000) more concentrated in a very thin microlayer at the water surface than they are in the water column below.It is also known that the majority of marine fish eggs float on the surface. The possibility that microlayers may in fact be toxic to fish eggs was tested this past year in Puget Sound. It was found that eggs of sand sole collected in the Sound could not become healthy larvae when exposed to microlayer samples collected in urban bays. Microlayers collected elsewhere in the Sound were not toxic. At this point it appears that high concentrations of polynuclear aromatic hydrocarbons are the microlayer constituents causing the toxic response. During the coming year this work will be expanded to determine whether in fact toxic microlayers occur only in discrete zones close to points of discharge. There will also be tests of whether other types of fish eggs (which are available year round from cultures) can be used in place of English sole to test microlayer toxicity. The advantage of such a surrogate is that testing would not be limited to the period during which English sole are spawning.

Indicators of risk to human health from shellfish consumption

Since before the turn of the century it has been known that people can get sick from eating raw shellfish taken from areas receiving discharges of human waste. Since the 1920's this risk has been minimized in the United States and elsewhere by prohibitions on harvesting shellfish from areas that contain more than a stipulated concentration of coliform bacteria. Methods for measuring coliform bacteria have been cheaper and easier to perform than are the corresponding measurements for other kinds of microorganisms that are indicative of human waste. When control measures were first introduced they were based on simply detecting the presence of coliform bacteria--not on any stipulated concentration. Over the years bacteriological methods have improved and it was decided that when a concentration of 70 fecal coliform per 100 ml is quantified by modern methods the older methods would have detected their presence. That is the basis for the commonly used public health criteria of prohibiting shellfish harvesting when fecal coliform concentration exceed 70 per 100 ml. There is no basis for associating that concentration with any quantified risk to shellfish consumers.

Until recently the situation with regard to health risks from swimming was similarly unquantified. Public health criteria were based on coliform bacteria concentrations with no evidence relating the extent of the risk with concentration. That situation has changed. After an eight-year study at a number of beaches and interviews with thousands of bathers, it was finally possible to demonstrate a relationship between the likelihood of illness and the concentration of bacteria. Rather than coliform bacteria, concentrations of enterococci bacteria showed the best correlation with the frequency of gastroenteritis. It should be noted that neither coliform nor enterococci bacteria are the probable cause of illness, but that, of the two, enterococci concentrations are a better indicator of the likelihood of illness. Criteria now exist with which public health officials can deem recreational waters to present an unacceptable risk. The amount of risk that is deemed acceptable can be defined for a given situation and the corresponding concentration of enterrococci bacteria can be used as the key for opening or closing recreational areas.

NOAA's objective in a study being conducted jointly with EPA is to provide a similar quantifiable relationship between microbial concentrations in shellfishing areas and risks to consumers. During the last year methods have been perfected that allow for easy quantification of several possible microbial indicators. A human-feeding study has been arranged in which the incidence of gastroenteritis will be monitored among volunteer consumers of shellfish harvested from areas that will be monitored for their concentrations of potential indicator microorganisms. The harvesting sites will be in the James and York Rivers , VA. These sites are open to harvesting under present criteria, are near a large human population, and are ones from which shellfish can be taken on a regular basis. This year, shellfish will be harvested, volunteers will consume shellfish, and the rate of incidence of gastroenteritis will be measured against the concentrations of potential microbial indicators.

With one exception, all shellfish-associated illness in the United States has been attributed to pathogenic microorganisms being transfered from human waste, through shellfish, and back to humans. The exception is paralytic shellfish poisoning (PSP), caused by ingestion of a chemical toxin produced by a species of marine phytoplankton. That toxin is accumulated by shellfish during "red tide" outbreaks and can cause severe reactions in human consumers of those shellfish. The symptoms of paralytic shellfish poisoning are so severe and distinct from the gastroenteritis associated with consuming microbially-contaminated shellfish that paralytic shellfish poisoning is never attributed to microbial contamination. However, another toxin produced by another species of phytoplankton does cause a disease called diarreheatic shellfish poisoning (DSP) that has symptoms identical to those of gastroenteritis. DSP is known to occur in Japan and has recently been reported in Europe. In those areas shellfishing waters are closed when they contain certain species of the phytoplankton genus Dinophysis. If this disease is occuring in the United States, two problems arise. First, since it is due to a chemical toxin rather than a bacteria or virus, microbial indicators would not serve to protect public health. Secondly, if DSP is misdiagnosed as gastroenteritis one is lead to the erroneous conclusion that discharges of human waste are at fault.

The single outstanding attribute of DSP is that it occurs within less than 12 hours of consuming the toxin. Gastroenteritis, on the other hand, does not usually become evident until after an incubation time of 24 hours. During the past year, therefore, the records of public health agencies in the northeast United States (the locus of most shellfish-associated illness in the U.S.) have been examined for the presence of disease outbreaks that could have been DSP. No public health agency has a record of an outbreak that could not be attributed to bacterially-contaminated shellfish (usually harvested illegally). So at this time DSP does not appear to be a problem in the United States. It is the case, however, that public health records, which themselves are compiled from reports submitted by physicians, very rarely include data on the time elapsed between shellfish consumption and onset of illness. The findings of this work will be distributed to public health agencies with the suggestion that, in the future, physicians be requested to report that time to onset. If DSP does begin to appear in the U.S., such reports will be the primary way of knowing that it is DSP and not gastroenteritis.

Doses of chemical contaminants to urban fisherman

Gastroenteritis and DSP are short-term and usually non-debilitating illnesses. Of much higher public concern is the possibilty of getting cancer by consuming carcinogenic chemicals in contaminated seafood. Methods for calculating the risk are no different or any more certain when the chemicals are ingested from seafood than they are for any other food source. Several public and private agencies are addressing the problems inherent in the risk calculations. Our efforts are restricted to the problem of quantifying the dose of chemicals received by seafood consumers. Since the largest dose will be received by people who regularly fish for food in waters surrounding urban areas, we have limited our effort to quantifying the chemical dose from fish to urban fisherman. We further restricted to this work in one area-Puget Sound. This restriction applies because NOAA cannot conduct similar studies in all urban areas. Our objective is to do it once and document the procedures and results. This experience can then be shared with any local or state agency trying to define chemical doses in particular regions.

We have published the procedures and results of the first part of the study that involved quantifying the amount and species of fish eaten by urban fishermen(these are not all species commonly found in the market place), identifying which parts of these fish are consumed (sometimes it is more than muscle tissue), and observing how the fish are prepared for consumption (which may affect the concentration of chemical contaminants in the food). The second part of the study is being completed. It involves measuring the contaminant concentrations in the species that are most frequently consumed by urban fishermen and for which there was little or no previous data on contaminant concentrations.

Summary of FY86 Program

Ten projects are collecting new data FY86:

1. Correlations between historical trends in fishery stocks and contaminant inputs to California coastal waters. Principal investigators, Dr. Alec MacCall and Dr. Michael Prager, NOAA/NMFS, Southwest Fisheries Center, LaJolla, CA

2. Collection of age-specific survival and fecundity data and estimates of the magnitude of stock decreases necessary to be considered abnormal. Principal investigator, Dr. William Schaff, NOAA/NMFS, Southeast Fisheries Center, Beaufort Laboratory, Beaufort, NC

3. Hepatic MFO activity, egg contamination, and reproductive success of starry flounder in San Francisco Bay. Principal Investigator, Dr. Robert Spies, University of California, Lawrence Livermore National Laboratory. Livermore CA

4. Hepatic MFO activity, liver lesions, and reproductive success of English sole in Puget Sound. Principal Investigator, Dr. Donald Malins, NOAA/NMFS, Northwest and Alaska Fisheries Center, Seattle WA

5. Tissue contamination, gonadal histology, and reproductive success of bottom fish in Southern California coastal waters. Principal investigator, Dr. Jeffrey Cross, Southern California Coastal Water Research Project, Long Beach, CA

6. Effects of PCB's on soft-clam reproduction in New Bedford Harbor. Principal investigator, Dr. Judith Capuzzo, Woods Hole Oceanographic Institution, Woods Hole, MA

7. Use of Acartia tonsa to test toxicity of waters at various locations off the U.S. east and Gulf coasts. Principal investigator, Dr. Ford Cross, NOAA/NMFS, Southeast Fisheries Center, Beaufort Laboratory, Beaufort, NC

8. Toxicity of microlayer samples collected in Puget Sound to eggs of English sole and a surrogate species. Principal investigator, Dr. John Hardy, Battelle Northwest Marine Reseach Center, Sequim, WA

9. Determination of indicator microorganisms whose concentrations quantitatively correlate with the risk of gastroenteritis among consumers of raw shellfish. Principal investigator, Dr. Alfred Dufour, EPA Health Effects Research Laboratory, Cincinnati, OH

10. Chemical contaminant concentrations in fish consummed by urban fishermen in Puget Sound, Principal Investigator, Dr. Marsha Landolt, University of Washington, School of Fisheries, Seattle, WA

For further information on the Consequences of Contaminants Program, please contact:

Dr. Thomas P. O'Connor
Consequences of Contaminants Program
Coastal and Esstuarine Assessment Branch (N/OMA3)
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service
National Oceanic and Atmospheric Administration
11400 Rockville Pike
Rockville, MD 20852
(Phone: 301/443-8698)