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REVIEW OF U.S. MUSSEL WATCH PROGRAM

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Conducted for the U.S. Environmental Protection Agency

by

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## INTRODUCTION

The Environmental Protection Agency invited a group of scientists, nominated by participating scientists or selected by the convenor, to meet with participants in U.S. Mussel Watch and review this research program. The meeting was held June 8 through 10, 1981 at the Biltmore Hotel, Providence, Rhode Island. The agenda consisted of presentations by Mussel Watch participants with opportunity for open discussion among those attending. A number of observers from federal agencies and research institutions attended the meeting and were free to offer questions or comments so long as they did not detract from the review process. A list of those attending the meeting is attached. Prior to the meeting, draft summary reports and journal articles by Mussel Watch investigators were distributed to the reviewers. Following the open meeting, the reviewers met to discuss achievements and shortcomings of the program and to develop recommendations for future research. The convenor was responsible for preparing this report which reflects a consensus of the reviewers' opinions, submitting it to each of the reviewers for comment, and transmitting it to the Agency on behalf of the group. Mr. William Robertson IV acted as rapporteur for the review panel and assisted the convenor in making the report true to the consensus views of the panel.

Mussel Watch was proposed by Edward D. Goldberg in 1975 (Goldberg, 1975) and the U.S. program was funded by the USEPA in 1976. The initial objective was to initiate a coastal monitoring program for

four sets of pollutants (petroleum hydrocarbons, artificial radio-nuclides, heavy metals and halogenated hydrocarbons) to provide government officials responsible for the management of marine resources with an assessment of the changes in composition of coastal waters due to pollution by man. The sentinel organisms (the mussels Mytilus edulis and M. californianus and the oysters Crassostrea virginica and Ostrea equestris) were taken from 100 stations on eastern, western and Gulf coasts of the U.S. and portions of the samples from each station were stored for future use.

The analyses were performed by five participating laboratories and the procedures for the program were formulated by a guidance committee composed of scientists whose laboratories were involved in the analyses. Pollutants in each category were analyzed by two laboratories and inter-calibrations among laboratories were carried out on standard materials or on monthly samples collected at Narragansett Bay, Rhode Island and Bodega Head, California.

In 1978, the participants published an assessment of the first years experience (Goldberg et al, 1978). The report highlighted a number of unresolved problems in the use of bivalves as sentinel organisms that were of concern before the beginning of the program and stressed the need for continuing research toward their resolution. There were also suggestions for modifying the program that included the addition of mercury to the heavy metals analyzed. No overview of the program has been published since, although further considerations were included in the proceedings of an international mussel watch workshop (National Research Council, 1980). The draft papers presented to

the review group deal with various portions of the program and did not include a total synthesis or overview of the program. The reviewers felt that a periodic report covering the entire program should be prepared by the Agency and that the publishing of papers in the refereed literature dealing with various aspects of the program by investigators should be encouraged.

Participating laboratories have changed slightly as has the guidance committee, but the basic structure of the program is the same. The guidance committee (and the participating laboratories) now consist of Edward D. Goldberg, Scripps Institution of Oceanography; Vaughn T. Bowen and John W. Farrington, Woods Hole Oceanographic Institution; John H. Martin, Moss Landing Laboratory; Robert W. Risebrough, Bodega Marine Laboratory and Bodega Institute of Marine Pollution Ecology; and Donald K. Phelps, USEPA Environmental Research Laboratory.

#### EFFECTIVENESS OF MUSSEL WATCH MONITORING

The U.S. Mussel Watch has been successful in meeting its original objectives and has demonstrated the feasibility of monitoring contaminants using bivalves as sentinel organisms at modest cost. The review panel considered alternatives to the current program and was unable to suggest potentially more effective alternatives to the use of bivalves in broadscale pollutant monitoring. But, we do have suggestions for modifying the extant program and its management.

The national program should not be expected to pinpoint locally serious contamination but rather to provide an overview of coastal water quality and an indication of areas where more intensive investigation is merited. The more intensive investigations should remain outside the program, and assigning responsibility for them is an administrative decision

beyond the scope of this review. Such intensive investigations should, of course, be coordinated with the national Mussel Watch and may involve state supported shellfish monitoring efforts.

Although the Mussel Watch approach suffers from limitations, the broad periodic sampling of widely distributed bivalves seems to the reviewers more efficacious and relevant than sampling other organisms or environmental media. The current sampling provides a more common denominator and is more reflective of relevant time scales than alternatives. Additionally, it provides some assessment of bio-availability of contaminants being measured.

The effects of environmental variables such as temperature and salinity and the reproductive condition of the organisms potentially dull the sensitivity of bivalves as sentinels. We think that these variables should be better accounted for in Mussel Watch. Salinity effects are particularly apparent for several heavy metals in oysters and reproductive condition affects contaminant levels in bivalves significantly and in complex ways. Sampling must be timed to reduce the variability due to reproductive stage among samples in any given year and across the years as well. Simple observations of reproductive condition should be made for all samples and should become a regular part of the data files. Timing alone is unlikely to resolve the salinity variability problem associated with oysters and we suggest that the agency convene a small group to suggest ways to make the data more readily comparable.

The reviewers thought that conclusions regarding lack of change in contaminant levels from year to year were inadequately supported through formal statistical analyses. The results do, however, suggest

that annual sampling is not needed and that a reasonable sampling frequency would be about three years.

#### SIGNIFICANT CONTRIBUTIONS

Although the important analytical advances made by Mussel Watch investigators during the program were largely supported by other programs, the Mussel Watch has contributed significantly to these advances, particularly in analysis of organic compounds. Mussel Watch has also made several significant advances in understanding the fate and persistence of contaminants. Notable examples are the role of upwelling in the distribution of transuranics on the West Coast, the wide dispersal of lead as an environmental contaminant resulting from human activities, the persistence of PCB's in the environment and significant additions to the sparse data on the distribution of silver in the environment. Mussel Watch has demonstrated that there is now no human-caused contamination of U.S. coastal waters by radionuclides beyond that introduced by nuclear testing, and that the levels are far below any national or international health standards. Ancillary research conducted at the Narragansett Environmental Research Laboratory, although resulting from studies not conducted as a formal part of Mussel Watch, has shown the utility of physiological measures, particularly scope for growth (Widdows, Phelps and Galloway, 1981) and has identified problems in using several other sublethal stress indicators for mussels.

#### IMPROVEMENTS

There were several areas in which the group thought that the Mussel Watch should be improved. More emphasis should be given to intercalibration and to improving analytical accuracy, particularly as affected by extraction efficiencies, especially for organics analysis.

The work done to date on exploring sources of variation in the data sets (natural vs. sampling vs. analytical) has not been sufficient and should be expanded. Assessments should be made of the effects of inclusion of materials in gut contents. And, more rigorous statistical analyses of the data should be made and should include intercomparisons among contaminants.

The direction and coordination of the program should be strengthened. Although the rapport among investigators was generally good and several of the investigators had obviously worked closely together, there seemed to be no effective mechanism for ensuring comprehensive synthesis of results. Although more effective program management may be accomplished by the investigators themselves, the ultimate responsibility for management rests with the EPA.

As it has been, the Mussel Watch program involves both monitoring and research. As indicated above, the panel feels that continued monitoring is justified. It was also clear to us that research on new analytical techniques and mechanisms of biological accumulation is also needed. Monitoring and research components of this program in the future should be reinforcing not competitive.

#### RECOMMENDATIONS FOR CONTINUED MONITORING

Another set of samples from all stations should be collected as soon as possible (ca. three years after the last set). This will be important to establishing temporal trends. Additional sampling should be planned for three-year intervals with reassessment of this strategy following the sound statistical analysis of the preceding and earlier data sets. Consideration should be given to staggering sampling on a three-year cycle (East, West and Gulf coasts on successive years). The same

stations should be maintained and the need for additional stations (south-east Florida and major embayments such as the Chesapeake Bay and Puget Sound) should be evaluated.

The panel felt that it was important that locally intense sampling efforts or homing-in on hot-spots not be a part of the Mussel Watch monitoring program. This sort of activity tends to blur the purpose of the program and ought to be handled in such a way as to complement the basic broad monitoring function. It should be done separately by USEPA and other cooperating agencies.

The analyses of the samples should continue as before for the trans-uranics and the trace methals, with the possible addition of mercury. The analyses of organic compounds should be designed to assure the inter-comparability of data among the participating laboratories and over time. We suggest that a meeting of analysts participating in this and other government programs (e.g. NOAA, BLM, DOE) to be convened to decide how best to accomplish this necessary goal. Standardization of capillary columns and retention indices or effective alternative can best be assessed by the practicing investigators. Analysis or preservation of the polar fraction of organic samples should also be considered at the suggested meeting.

Emphasis should continue to be given to a rigorous sampling protocol governed by the analysts. Factors influencing variability (see for example National Academy of Sciences (1980), p. 88-111) must be standardized as much as possible. Some measure of the biological state of the organisms should be included and a better standard of sampling during non-reproductive periods must be attained. In order to accomplish this, consideration should be given to adopting a network of regionally-based collec-



tors with local knowledge.

The initial concept that the data sets and archived samples and extracts would come more valuable as the time series extends is valid and the core of the program. The archives of samples, extracts analytical output and data must be carefully maintained and the intercomparability of data over time must be preserved.

There was considerable discussion by the panel of the possibility of transferring routine analyses to commercial laboratories. The group felt that, while this was technically possible, it would require a relatively long time (three or more years) and a more costly and extensive quality control program. The reviewers saw considerable merit in maintaining close ties between the research and monitoring portions of the program.

#### RECOMMENDATIONS FOR FUTURE RESEARCH

No specific initiative to broadly measure contaminants in the environment nor to investigate relationships of levels in water, sediments, and molluscs is recommended, but a number of specific research projects should be initiated in order to reap the full benefit of Mussel Watch. First, the research program should be more strongly managed, directed and coordinated so that research and sampling are not competing for support and the research should be closely related to the continuing monitoring program.

As noted earlier, homing on hot-spots or locally intense sampling should be viewed as a separate activity and pursued under Mussel Watch only when they relate directly to the refinement of the overall monitoring effort and the interpretation of its results. Such research could include more temporally intense sampling to assess seasonal or

other environmental effects or well-structured biological effects studies including field experiments similar to CEAS that would be vaulable to interpretation of contaminant levels.

Several suggestions for additional work on organic compounds have been noted earlier. Of those, we emphasize the need to establish firmly the intercomparability of data sets, investigation of the polar fractions, and the identification of the compounds in the unresolved mixture. Data management systems to store and analyze complex contaminant data are particularly needed for organics and work on these should begin while the intercomparability questions are being resolved. One of the primary needs of the program as a whole is additional and more vigorous analyses of the data produced to date. This should be done now so that the information gained can be used in designing the research we have suggested.

In summary, we repeat that, in our opinion, Mussel Watch has been successful in meeting its original objectives and the broad periodic sampling of widely distributed bivalves is an effective monitor of general environmental pollution. We have made a number of suggestions for necessary strengthening of the program. It is our conclusion that Mussel Watch is well worth its relatively small coast and should be continued.

#### LITERATURE CITED

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