Box - Pollution, BF 55.02

DRAFT COPY
Do not cite or quote
For Agency use only!

EFFECTS OF CHEMICALS USED IN OIL AND GAS WELL-DRILLING OPERATIONS IN AQUATIC ENVIRONMENTS

Norman L. Richards

U.S. Environmental Protection Agency
Environmental Research Laboratory
Gulf Breeze, Florida 32561

Paper presented at:

The Fourth National Conference
Interagency Energy/Environment R&D Program
June 7 and 8, 1979
Washington, D.C.
Sponsored by E.P.A.'s Office of Energy, Minerals, and Industry

ERL-Gulf Breeze Contribution Number 392

ABSTRACT

Increased exploratory and developmental oil and gas drilling offshore and in the Great Lakes has heightened concern over potential adverse environmental effects of such activities. The U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration, Bureau of Land Management, U.S. Geological Survey, and various state agencies have legislative mandates related to various phases of oil and gas exploration and development. E.P.A. drilling-related research and monitoring programs parallel the Agency's missions under the Federal Water Pollution Control Act to regulate discharges into open waters. E.P.A. Regional Offices have authority to issue waste discharge permits and to specify conditions for permits. Environmental concerns include effects of chemicals discharged during oil and gas drilling activities that originate from: (a) "drilling fluids" or "drilling muds" -- chemicals added to the well-bore; later discharged; (b) "cuttings" -- formation solids that become suspended in the drilling fluid; and (c) formation water and its dissolved, emulsified and suspended solids. These effluents are discharged into the aquatic environment during exploratory and developmental drilling.

This paper summarizes objectives of research designed to assess the potential hazard to the aquatic environment and man from drilling practices, and to evaluate mitigating options. Oil and gas drilling hazard assessment is based on a blending of results from research on (a) exposure assessment and (b) effects assessment. Exposure assessment is determined by the chemical analysis of drilling fluids and components, chemical fate studies, field studies of

drilling rigs and platforms, and discharge plume modeling. Effects assessment is accomplished through a stepped sequence of toxicity tests that includes both laboratory and field toxicity testing of drilling fluids and their components. Hazard assessment is region-specific and includes considerations of environmental concentrations of drilling fluids likely to have commercial, recreational, aesthetic, or ecological significance. Hazard assessment must be developed region by region because of community and habitat uniqueness. For example, the New England coast has commercially important cold water fisheries in a high-energy hydrographic regime, "Georges Bank"; the northeastern Gulf of Mexico has subtropical commercial fisheries; the northwestern Gulf of Mexico has petroleum hydrocarbon reserves and coral reefs, the "Texas Flower Garden Bank"; Lake Erie is undergoing restoration and may have gas reserves. Hazard assessment in diverse geographical areas is essential to sound evaluations of candidate alternative chemicals for use in well-drilling operations. Furthermore, the impact of alternate operational procedures can be evaluated on the basis of hazard assessment tradeoffs.

Hard data on environmental concentrations and toxicolgoical effects of drilling fluids may help eliminate unjustified concern about certain chemicals used in drilling fluids which may be safely used in well-drilling operations. It may also prevent over- and under-regulation of offshore oil and gas resource development and production.

INTRODUCTION

Intensified oil and gas exploration and development in the United States has resulted in more and deeper offshore wells. Additional lease tract sales are proposed by the Bureau of Land Management (Figure 1). This activity has heightened concern over the potential for environmental effects of drilling. The purpose of this paper is to: (a) review the "state-of-the-art" in drilling fluids effects research; (b) summarize the interagency regulatory authorities that provide the present basis for offshore oil and gas decision making; (c) state some examples of the limits of technical understanding of processes that could be impacted by offshore development; (d) propose a technical approach to the potential problem that could result in an improved basis for decision making; and (e) review some recent achievements in drilling fluids-related research.

STATUS OF UNDERSTANDING

Drilling Fluids

Recent environmental impact statements on oil and gas lease sales have devoted disproportionately little discussion to the environmental aspects of chemical use in well-drilling operations. This may reflect the fact that few studies have been done, and most are acute static toxicity tests that have little relevance to natural conditions where drilling mud discharges occur (1). Of those acute toxicity tests in the literature, few report adverse effects of drilling fluids or their components. Field observations have revealed a variety of marine life in the vicinity of drilling rigs (2). It is generally assumed that fluids either would have a limited local effect near the plume discharge point or would be dispersed rapidly and diluted in the field (1). Also, it has been assumed that many constituents of drilling fluids are sparingly soluble in seawater and, therefore, might be less biologically available to marine organisms. However, the assumptions have not been substantiated by peer-reviewed research publications.

Research on the environmental effects of drilling fluids and cuttings is further impeded by the chemical complexity of the mixtures of crude chemicals used to formulate mud; drilling fluid is a mixture of clay, water, and numerous chemical additives that is pumped downhole through the drillpipe and drillbit; mud cools the rapidly rotating bit, lubricates the drilling string as it turns in the wellbore, carries rock cuttings to the surface, and serves as a plaster to prevent the formation from crumbling or collapsing into the wellbore. Drilling mud also provides the weight or hydrostatic head to prevent extraneous fluids from entering the wellbore and to control downhole pressures. Chemical ingredients used to formulate mud can include everything from pH-control products, bactericides, calcium-removers, corrosion inhibitors, defoamers, emulsifiers, filtrate reducers, flocculants, foaming agents, lost circulation materials, lubricants, shale-control inhibitors, surface-active agents, thinners, dispersants, viscosifiers, to weighting agents (3). Analyses of potential effects of chemicals used in well-drilling operations must also take into account variations in mud and cutting composition related to type of substrate drilled, well depth, availability of mud components, temperatures generated, relative cost of components, operator experience, etc. (2).

<u>Fate and Effects Research</u>

Consider the chemical complexity of drilling fluids, the diverse geographical conditions of areas being drilled, varying oceanographic conditions, the broad spectrum of aquatic organisms that could be exposed to drilling fluids during different seasons in different geographical locations, that very little is known about the basic biology of marine systems (4), and the resource - intensive nature of offshore research. It is not surprising that there is a dearth of peer-reviewed papers published in scientific journals on the effects of drilling fluids on marine organisms. Except for the present research that was sponsored through the Interagency Energy/Environment R&D Program and a few studies funded by Bureau of Land Management (B.L.M.) (5,6,7,8), most other studies in the United States were funded by oil companies and performed by contractors, often in response to federal government regulations (9). These studies were either: (a) attached by the B.L.M. to particular tracts offered for lease; (b) required as a drilling permit condition of approval by the U.S. Geological Survey (U.S.G.S.) or were associated with Environmental Protection Agency National Pollutant Discharge Elimination System (N.P.D.E.S.) permits. Only a few copies of reports that result from these studies are printed; the scientific community does not have an opportunity to critique the conclusions before or after publication.

REGULATORY FRAMEWORK

Legislative Mandates of Federal Agencies

The sequence of federal agency involvement in offshore oil and gas drilling operations has been described by Richards (10) and is illustrated in Figure 2. The process that allows private firms to purchase offshore leases involves a sequence of activities. The National Oceanic and Atmospheric Administration has authority to designate ocean areas with distinctive value as marine sanctuaries if presidential approval is received (11). Following a preliminary environmental impact assessment, tracts are offered for sale by the Bureau of Land Management. A solicitation of nominations is accepted whereby industries can express interest in a tract; and environmental groups, states, etc., can register objections (negative nominations). A draft environmental impact statement is then offered to federal agencies for comment. For example, the National Marine Fisheries Center of the U.S. Department of Commerce may comment on marine resources. The Geological Survey may comment on seismic activity; the Fish and Wildlife Service, on rare and endangered seabirds; state governments, on potential effects of development on resources or potential onshore impacts, and so on.

Following public hearings, the decision to lease for exploration and for ultimate development is rendered. Tracts that are leased for exploration may ultimately be developed for production. If this occurs, oil companies are required to comply with specific operating orders that are monitored and enforced by the U.S. Geological Survey.

E.P.A. Legislative Authority

An offshore operator must possess a valid and final N.P.D.E.S. permit from the E.P.A. N.P.D.E.S. permits are issued by the E.P.A. regional office that has jurisdiction over the drilling activity. The permit can stipulate a wide range of discharge requirements that depend on the Regional Administrator's assessment of the environmental damage likely to arise from the discharge. It is obvious that a high level of technical understanding of potential impacts is necessary to avoid over- or under-regulation. Table 1 illustrates the region-by-region diversity of areas, resources and additional concerns that are part of N.P.D.E.S. permit issuance.

ONGOING AND FUTURE E.P.A. RESEARCH

Hazard Assessment

Ongoing and future research is designed to assess the potential hazard to the aquatic environment and man from drilling practices, and to evaluate mitigating options. Oil and gas drilling hazard assessment is based on (a) exposure assessment and (b) effects assessment. Figure 3 illustrates that potential damage to marine organisms may be predicted through knowledge of: (a) environmental concentrations of xenobiotics that result from discharges; and (b) the duration of exposure likely to be encountered by feral organisms under "worst case exposure" conditions. A hazard assessment based on knowledge of effects and environmental concentrations produces a better foundation to predict the environmental consequences of drilling. Mitigating options can be more easily selected from the spectrum of alternatives available to the region through permit issuance.

Exposure Assessment. Figure 4 illustrates the stepped sequence of tasks performed in the effects assessment component of hazard assessment. It includes an iterative loop between field and laboratory research. The pyramid is based on a knowledge of chemicals used, but information is inadequate because: (a) over a thousand trade-name products are used in drilling fluid formulation (12); (b) many components are known only by generic name, not by chemical composition; (c) most operators are unwilling to release drilling mud composition information; and (d) no drilling fluid plume and cutting studies have been published in scientific journals.

Effects Assessment. E.P.A. exposure and effects assessment research needs to be closely coordinated in order to arrive at a hazard assessment with "environmentally realistic" concentrations. Figure 5 illustrates the conceptual basis for a stepped sequence of laboratory and field toxicity tests designed to assess drilling fluid effects on marine organisms and communities.

Preliminary screening of selected compounds is accomplished by acute static toxicity tests. Conducted with drilling fluids or their components, these range-finding tests aid in selecting toxicant concentrations for subsequent flowing sea water bioassays of each compound, component, or mixture of interest.

Flow-through toxicity test methods were selected for a higher tier of testing because they more nearly approximate in situ conditions. In contrast to static tests, metabolic products and excreta are removed, while oxygenated sea water and toxicant are continuously supplied. Data obtained from flow-through toxicity tests are generally preferable over static tests as the more precise measure of toxicity and bioaccumulation. A few compounds are selected from flow-through experiments for the next tier of testing: effect on composition and functions of estuarine communities.

The effect of selected xenobiotics on colonization of planktonic larvae and microorganisms is analyzed by means of the apparatus and methods developed at the Gulf Breeze Laboratory (13). Sea water, with its natural components of plankton and microorganisms, is pumped to the laboratory and into the primary constant head box. Xenobiotics are continuously metered into the water after they are siphoned from a constant head box; the control apparatus receives the same flow of water. Water then flows from the secondary constant head box to each of ten adjacent aquaria, i.e., ten replicates for each treatment, including controls. At the end of an exposure period, microflora, macrofauna, and meiofauna are sampled. To determine the effect of the xenobiotic after each treatment, numbers and species of microflora, meiofauna, and macrofauna in control and exposed aquaria, are compared, and concentrations of xenobiotics in test water and sediment are determined. Samples of water from the constant head boxes are taken for xenobiotic analysis, and sediment cores from aquaria are taken from each apparatus at the end of the exposure. The tiered toxicity tests used in effects assessment have the following features:

- there is a continuing iteration between field observations and laboratory research;

- relatively inexpensive and rapid rangefinding tests are used to minimize more resource-intensive tests;
- community structure tests (14,15,16,17,18) can be used to detect both sensitive and resistant species for subsequent detailed testing;
- effect and no-effect concentrations can be found expeditiously;
- the data can be used to estimate bioaccumulation rate, application factors and maximum allowable toxicant concentration.

ADVANCES IN UNDERSTANDING

Fate and Transport

Research tools for predicting the potential environmental fate and effects of drilling fluids are now becoming available. Figure 6 was composed from the plume data of Continental Shelf Associates (20) and community profile studies by Bright (21). Under the conditions studied, a near-surface discharge of drilling fluid did not disperse uniformly but concentrated above the thermocline (20). Adequate research has not been accomplished to determine the probability that a similar transport mechanism could ultimately cause exposure of coral reef communities in the Texas Flower Garden Banks. However, Figure 6 does illustrate that the potential for direct and/or indirect drilling fluid exposure *via* thermocline transport should be investigated under different hydrographic regimes. "Shunting" (discharging the drilling fluid to the "nepheloid layer") has been proposed as an alternative to surface discharge (See broken line Figure 6). However, information on the transport and fate of shunted drilling fluids is inadequate for making an informed decision on the relative merit and hazard associated with shunting.

Effects on Coral

The E.P.A. Environmental Research Laboratory at Gulf Breeze and Texas A&M University have a combined research program designed to determine the direct and indirect effects of drilling fluids on corals, coral communities, and coral reef processes. Current E.P.A. experiments are run at a research laboratory located twelve miles offshore at Panama City, Florida. The purpose of this program is to determine concentrations of drilling fluids that affect the survival of corals. This research will be validated in offshore experiments.

Effects on Benthic Communities

Laboratory experiments on the effects of drilling fluid on benthic communities are part of the tiered toxicity tests diagrammed in Figure 7. Similar results of experiments with drilling fluids and their components on benthic estuarine organisms have been published (14,15,16,17,18,19). Figure 7 illustrates the effects on aquaria containing sand initially covered with a 2 mm layer of drilling fluid on the composition of communities that developed from settled planktonic larvae in flowing seawater not containing sand. The average numbers of annelids, arthropods and porifera were significantly less in treated aquaria than in untreated aquaria.

Permitting Options

E.P.A. Regional offices face a spectrum of regulatory options concerned with the discharge of drilling fluids into aquatic environments: Table 2 summarizes some of the options. Although completely adequate and timely data are not likely to be available now for N.P.D.E.S. permit issuance, Regional offices must make the best possible decision from the limited data available. Ideally, both over- and under-regulation should be minimized through timely and scientifically defensible research. In this way, scientifically gained data on environmental concentrations and toxicological effects of drilling fluids may help eliminate unjustified concern about certain chemicals being used in drilling fluids. Similarly, modified operating procedures or drilling fluid ingredient substitution may help mitigate environmental effects that are observed in region-specific field and laboratory based research programs.

REFERENCES

1. Sheen Technical Subcommittee. Environmental Aspects of Drilling Muds and Cuttings from Oil and Gas Extraction Operations in Offshore and Coastal Waters. 1: 1976. pp. 1-50.

2. Fisher, F. Conf. Proc. of the Office of Toxic Substances, EPA Environmental Aspects of Chemical Use in Well-Drilling Operations. Houston, Texas, EPA 560/1-75-004. 1: May, 1975. pp. 1-604.

3. Wright, T. R., Jr. "World Oil's 1975-1976 Drilling Fluids File," World Oil. 1: 1975. pp. 38-71.

4. Parker, P. "Effects of Pollutants on Marine Organisms;" Deliberations and Recommendations of the National Science Foundation. August 11-14, 1974.

5. Alexander, J. E., T. T. White, K. E. Turgeon, and A. W. Blizzard. Rig Monitoring. (Assessment of the Environmental Impact of Exploratory Oil Drilling). Volume VI. Baseline Monitoring Studies, MAFLA, OCS, 1975-6. Final report to the U.S. Dept. of Interior, Bureau of Land Management Outer Continental Shelf Office, Washington, D.C. 1977.

6. Bright, T. B. and R. Rezak. Northwestern Gulf of Mexico Topographic Features Study. Final report to the U.S. Dept. of Interior, Bureau of Land Management Outer Continental Shelf Office, New Orleans, Louisiana. 1978a.

7. Bright, T. B. and R. Rezak. South Texas Topographic Features Study. Final report to the U.S. Dept. of Interior, Bureau of Land Management Outer Continental Shelf Office, New Orleans, Louisiana. 1978b.

8. Groover, R. D. (ed). Environmental Studies, South Texas Outer Continental Shelf, Rig Monitoring Program. Final report to the U.S. Dept. of Interior, Bureau of Land Management Outer Continental Shelf Office, Washington, D.C. 1977.

9. Gettleson, D. Effects of Oil and Gas Drilling Operations on the Marine Environment. In press.

10. Richards, N. L. "Responsibilities for Marine Pollution Research Within Federal Agencies of the United States." In Meyer, S. P. Proceedings of the International Symposium on Marine Pollution Research. 1976. pp. 5-11.

11. U.S. Dept. of Commerce. Draft Environmental Impact Statement Prepared on the Proposed East and West Flower Gardens Marine Sanctuary. 1979.

12. World Oil. World Oil's 1977-78 Guide to Drilling, Workover, and Completion Fluids. Gulf Publishing Co. 1977.

13. Hansen, D. J. "Aroclor 1254: Effect on Composition of Developing Estuarine Animal Communities in the Laboratory," Contributions in Marine Science. 8: 1974. pp. 19-33.

14. Cantelmo, F. R. and K. R. Rao. "Effect of Pentachlorophenol (PCP) on Meiobenthic Communities Established in an Experimental System." Marine Biology. 46: 1978. pp. 17-22.

15. Cantelmo, F. R. and K. R. Rao. "Effects of Pentachlorophenol on the Meiobenthic Nematodes in an Experimental System." In Pentachlorophenol. Plenum Publishing Corp., N.Y. 1978. pp. 165-174.

16. Tagatz, M. E., J. M. Ivey, H. L. Lehman, and J. L. Oglesby. "Effects of Dowicide[R] G-ST on Development of Experimental Estuarine Macrobenthic Communities." In Pentachlorophenol. Plenum Publishing Corp., N.Y. 1978. pp. 157-163.

17. Tagatz, M. E., J. M. Ivey, H. L. Lehman, and J. L. Oglesby. "Effects of a Lignosulfonate-Type Drilling Mud on Development of Experimental Estuarine Macrobenthic Communities." Northeast Gulf Science, Vol. 2 No. 1. June 1978. Pp. 35-42.

18. Tagatz, M. E., J. M. Ivey, J. C. Moore, and M. Tobia. "Effects of Pentachlorophenol on the Development of Estuarine Communities." Journal of Toxicology and Environmental Health, 3. 1977. pp. 501-506.

19. Tagatz, M. E. and M. Tobia. "Effect of Barite ($BaSO_4$) on Development of Estuarine Communities." Estuarine and Coastal Marine Science, 7. 1978. pp. 401-407.

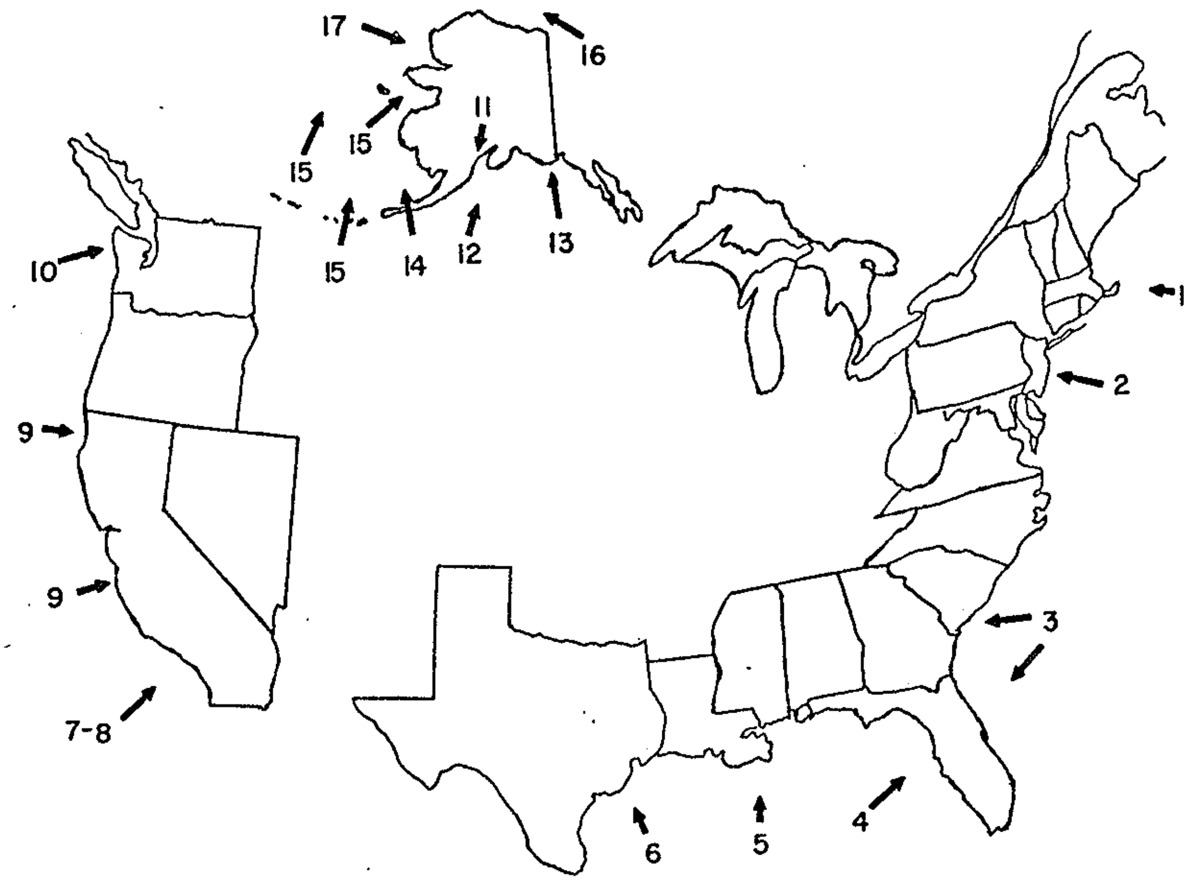
20. Continental Shelf Associates, Inc. Monitoring Program for Well #1, Lease OCS-G 3487, Block A-367, High Island Area, East Addition, South Extension Near East Flower Garden Bank, Vol. I, II. A report for American Natural Gas Product on Company. 1978b.

21. Bright, T. J. "Coral Reefs, Nepheloid Layers, Gas Seeps and Brine Flows on Hard-Banks in the Northwestern Gulf of Mexico." Proceedings: Third International Coral Reef Symposium. May 1974. pp. 40-46.

FIGURE 1 - TRACTS PROPOSED FOR OIL AND GAS EXPLORATION AND DEVELOPMENT

Norman L. Richards

TRACTS PROPOSED FOR OIL AND GAS EXPLORATION AND DEVELOPMENT



KEY

ATLANTIC COAST

1. North Atlantic
2. Mid-Atlantic
3. South Atlantic and Blake Plateau

GULF OF MEXICO

4. East Gulf
5. Central Gulf
6. West Gulf

PACIFIC

7. Southern California Borderland
8. Santa Barbara
9. North and Central California
10. Washington-Oregon

ALASKA

11. Cook Inlet (State-Federal)
12. Southern Aleutian Shelf
13. Gulf of Alaska
14. Bristol Bay
15. Bering Sea Shelf
16. Beaufort Sea
17. Chukchi Sea

FIGURE 2 - SEQUENCE OF FEDERAL AGENCY INVOLVEMENT IN OFFSHORE OIL AND GAS DRILLING OPERATIONS

Norman L. Richards

SEQUENCE OF FEDERAL AGENCY INVOLVEMENT IN OFFSHORE OIL AND GAS DRILLING OPERATIONS

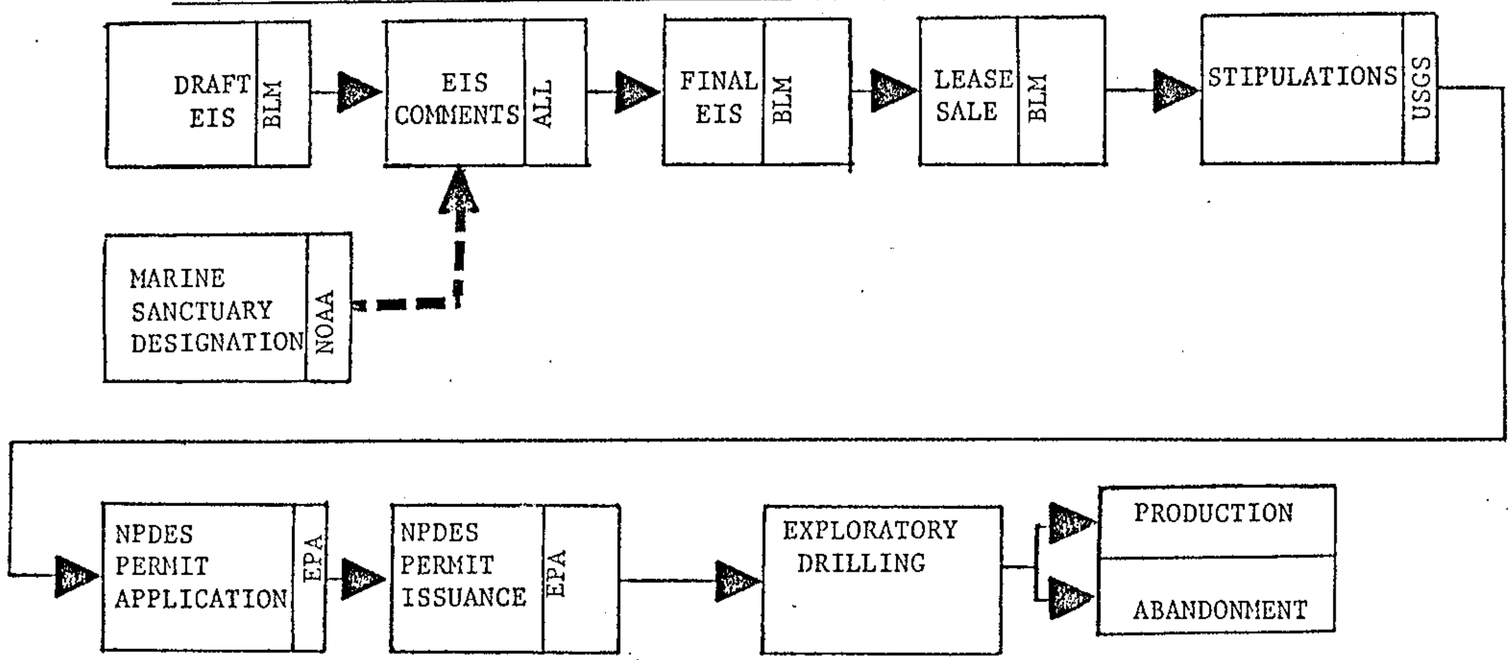
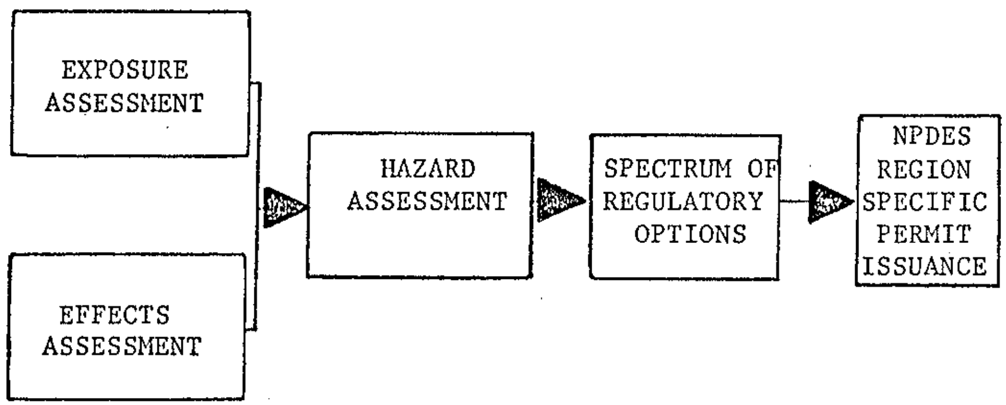


FIGURE 3 - ENVIRONMENTAL CONSIDERATIONS IN DRILLING PERMIT ISSUANCE

Norman L. Richards

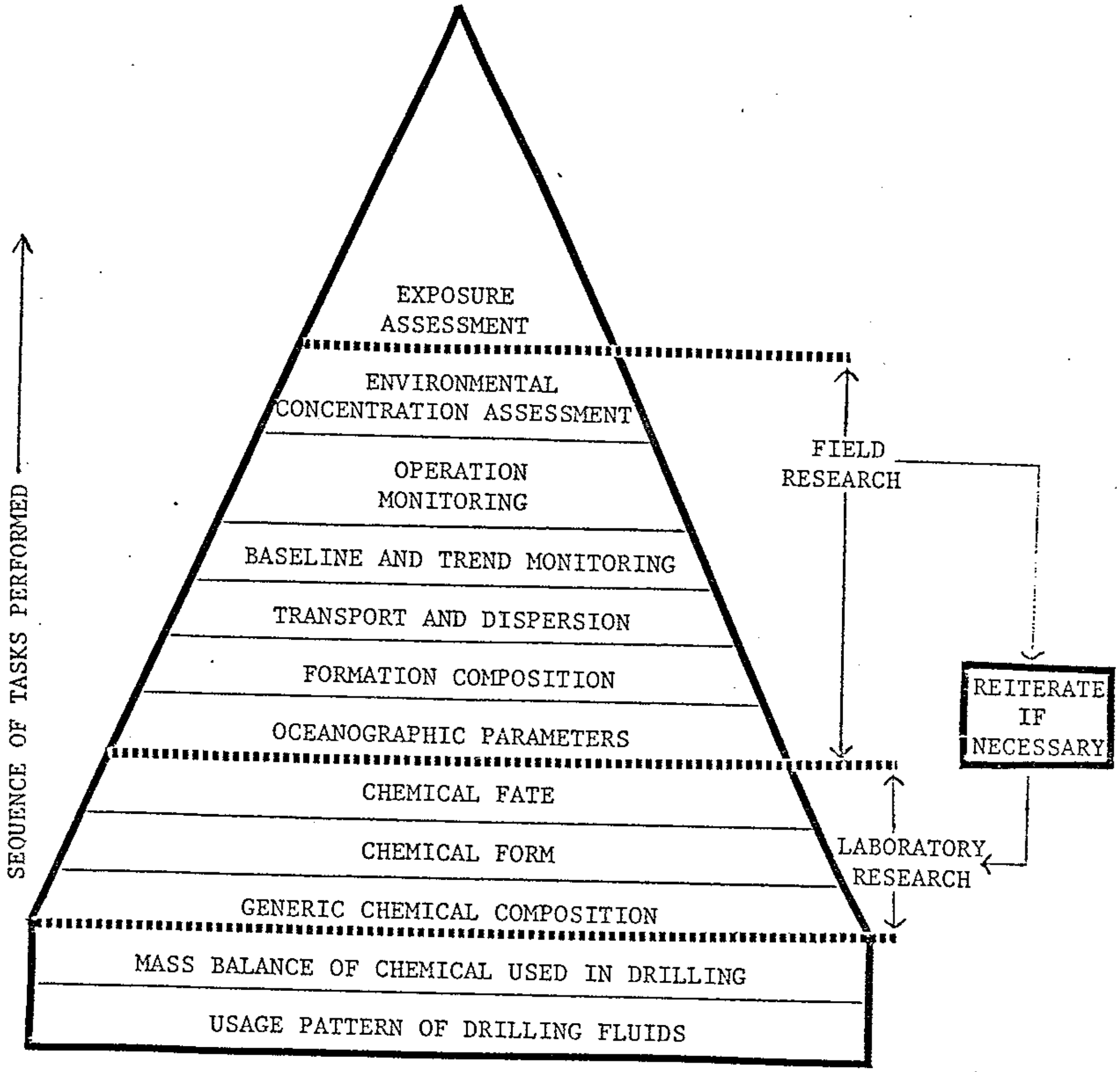


ENVIRONMENTAL CONSIDERATIONS

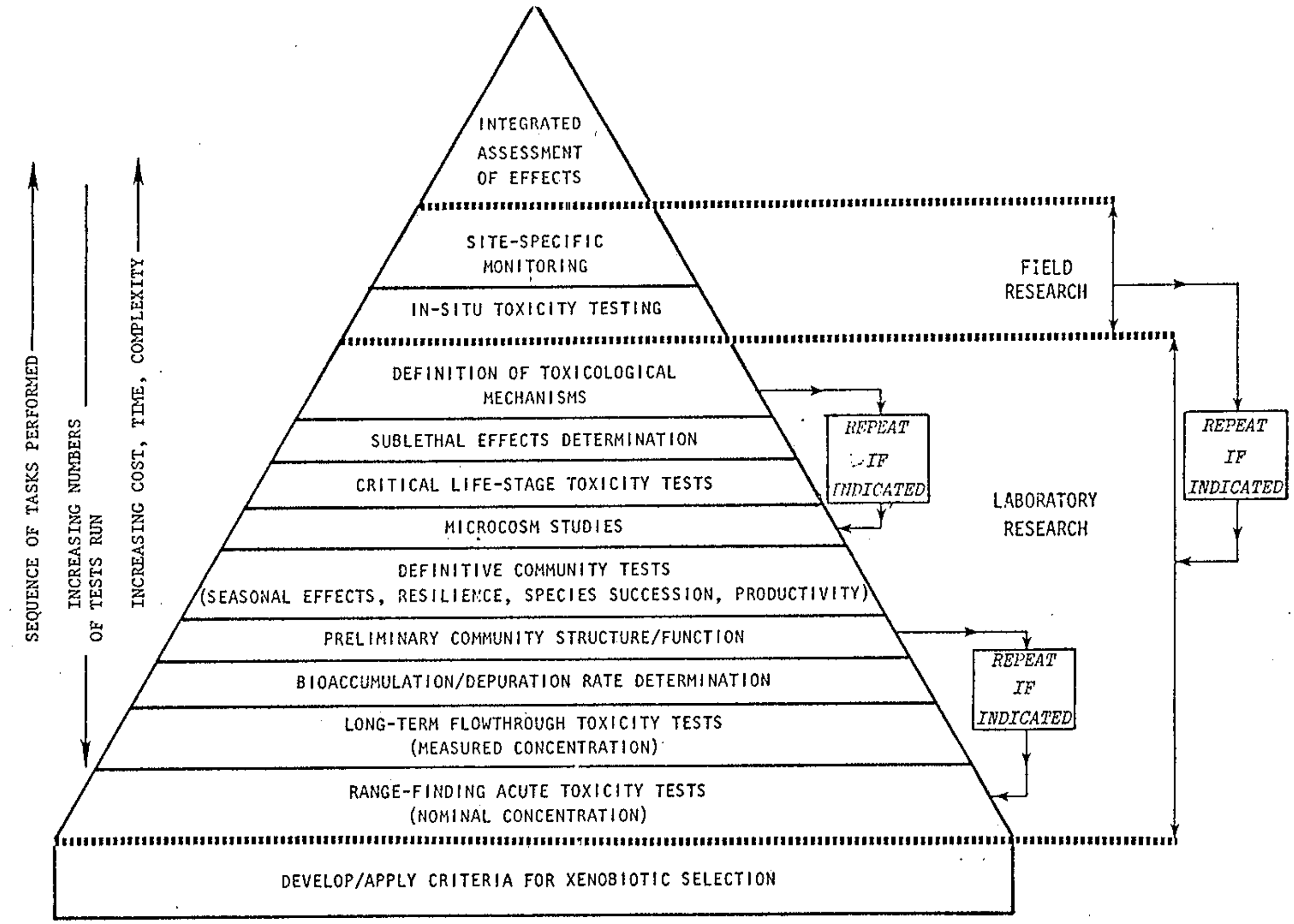
DRILLING PERMIT ISSUANCE

FIGURE 4 - STEPPED SEQUENCE OF TASKS LEADING TO EXPOSURE ASSESSMENT

Norman L. Richards



STEPPED SEQUENCE OF TASKS FOR EXPOSURE ASSESSMENT



STEPPED-SEQUENCE OF TOXICITY TESTS TO ASSESS XENOBIOTIC EFFECTS ON ESTUARINE AND OFFSHORE ORGANISMS IN SELECTED GEOGRAPHICAL LOCATIONS

FIGURE 5 - STEPPED-SEQUENCE OF TOXICITY TESTS TO ASSESS XENOBIOTIC EFFECTS ON ESTUARINE AND OFFSHORE ORGANISMS.

Norman L. Richards

FIGURE 6 - COMPOSITE DIAGRAM OF DRILLING FLUID FATE (COMPOSITE DRAWN FROM: BRIGHT, T. J.: PROC.: THIRD INT. CORAL REEF SYMP., MAY 1974, PP. 40-40; CONTINENTAL SHELF ASSOCIATES. A REPORT FOR AMERICAN NATURAL GAS PRODUCTION COMPANY 1978; RICHARDS, N. L. PROC. OF: ENV. EFFECTS OF ENERGY RELATED ACTIVITIES ON MARINE/ESTUARINE ECOSYTEMS. 1977 EPA-600/7-77-111).

Norman L. Richards

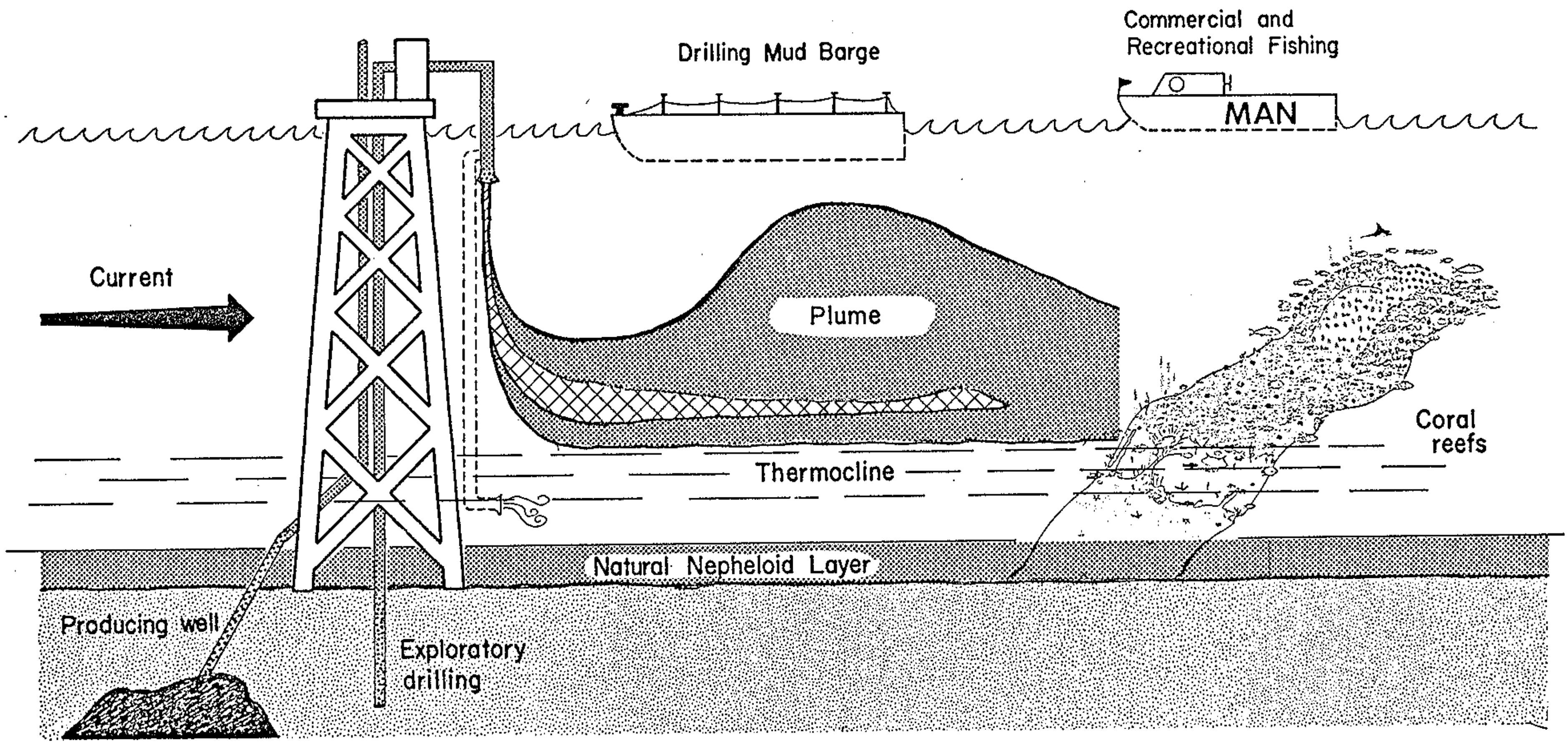

Commercial and
Recreational Fishing
Drilling Mud Barge
MAN
Current
Plume
Coral
reefs
Thermocline
Natural Nepheloid Layer
Producing well
Exploratory
drilling

FIGURE 7 - EFFECT OF DRILLING FLUID ON DEVELOPMENT OF AQUARIUM COMMUNITY STRUCTURE

Norman L. Richards

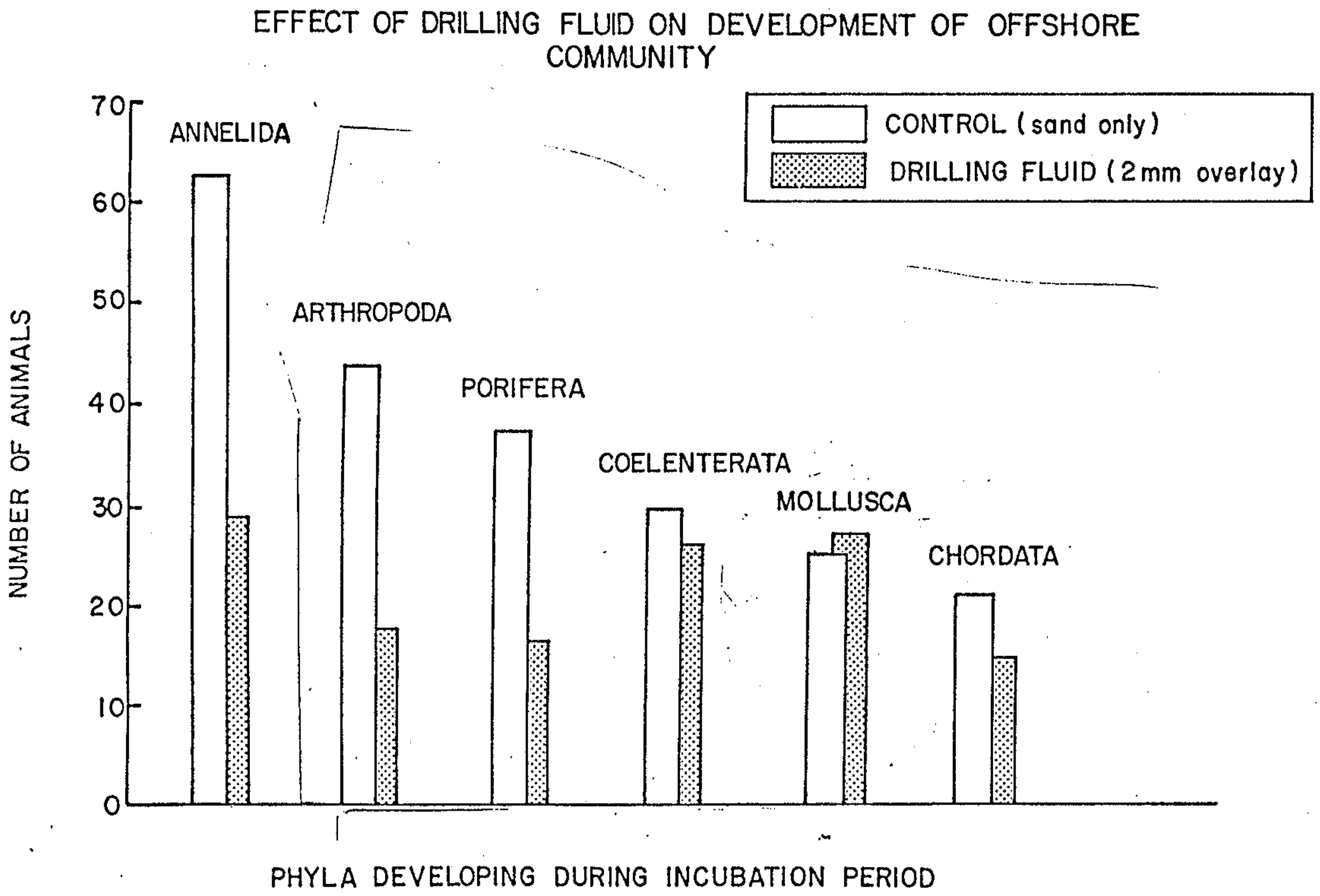

EFFECT OF DRILLING FLUID ON DEVELOPMENT OF OFFSHORE COMMUNITY
CONTROL (sand only)
DRILLING FLUID (2mm overlay)
NUMBER OF ANIMALS
0
10
20
30
40
50
60
70
ANNELIDA
ARTHROPODA
PORIFERA
COELENTERATA
MOLLUSCA
CHORDATA
PHYLA DEVELOPING DURING INCUBATION PERIOD

TABLE 1 - SPECIAL CONCERNS: OIL AND GAS DEVELOPMENT

Norman L. Richards

Table 1

SPECIAL CONCERNS:
OIL AND GAS DEVELOPMENT

EPA REGION/AREA	REPRESENTATIVE AREAS	RESOURCES	OTHER CONCERNS
I N. ATLANTIC	GEORGES BANK	COMMERCIAL FISHERY	
II MID-ATLANTIC	BALTIMORE CANYON	COMMERCIAL FISHERY	SLUMPING
IV S. ATLANTIC, E. GULF OF MEXICO	BLAKE PLATEAU FLORIDA MIDDLEGROUNDS	COMMERCIAL FISHERY, CORAL REEFS	
V GREAT LAKES	LAKE ERIE	DRINKING WATER, COMMERCIAL FISHERY	ICE, SALINITY, EUTROPHICATION
VI GULF OF MEXICO (CENTRAL & WEST)	FLOWER GARDEN BANKS, GULF COAST	CORAL REEFS, COMMERCIAL FISHERY	
IX CALIFORNIA	SANTA BARBARA CHANNEL, TANNER BANK	MARINE MAMMALS, COMMERCIAL FISHERY, CORAL REEFS	SEISMICITY
X PACIFIC N.W. & ALASKA	BEAUFORT SEA	COMMERCIAL FISHERY, MARINE MAMMALS	ICE, WEATHER, ASSIMILITATIVE CAPACITY, SEISMICITY

TABLE 2 - SPECTRUM OF REGULATORY OPTIONS FOR DRILLING FLUID DISCHARGE

Norman L. Richards

SPECTRUM OF REGULATORY OPTIONS

- DRILLING PROHIBITED
- NO-DISCHARGE PERMITS
  - BARGE WASTES TO REMOTE LOCATION
  - OCEAN DISPOSAL AT DESIGNATED DUMPSITES
  - OCEAN DISPOSAL IN ABYSS
  - LAND DISPOSAL
  - REPROCESS/RECYCLE
- LIMITED DISCHARGE PERMIT
  - BARGE PORTIONS OF FLUIDS/CUTTINGS
  - SELECTIVE TREATMENT OF TYPES OF FLUIDS
- BLACK/GRAY/WHITE LIST OF COMPONENTS PRIOR TO DRILLING
- CASE-BY-CASE PERMITS
  - GEOGRAPHICAL RESTRICTIONS
  - SPECIAL RESOURCES
  - RARE/ENDANGERED SPECIES
  - CLIMACTIC RESTRICTIONS
  - SEASON OF YEAR
- DISCHARGE, BUT MONITOR ENVIRONMENTAL EFFECTS/CONCENTRATIONS
- DISCHARGE RATE STIPULATION
  - UP TO PRESELECTED RATE
  - BULK DISCHARGE PROHIBITION
  - SITUATION DISCHARGE (CURRENT, MIX RATE, ETC.)
- SHUNT
  - TO BOTTOM
  - BELOW SURFACE
- RESTRICT/PROHIBIT FISHING
- UNRESTRICTED DISCHARGE