5-1-1974

The Energy Future: An Unanswered Question

Jeffrey A. Carver
University of Rhode Island

THE ENERGY FUTURE:

AN UNANSWERED QUESTION

MASTER OF MARINE AFFAIRS
UNIV. OF RHODE ISLAND

Jeffrey A. Carver

Marine Affairs Seminar

Dr. Cameron

May 1, 1974

CONTENTS

INTRODUCTION

"The Energy Crisis"

The winter of 1973-74 will be remembered, for a little while, as the time when the "energy crisis" first struck home in the United States and abroad. It was the winter in which post-world-war America was first inconvenienced in a major way by both threatened and real shortages of petroleum products, and in which enough Americans were frightened into adopting conservation measures for a significant reduction to be made in energy demand. It was a time of rising - sharply rising - fuel costs, and of public outrage against the rabbit-like multiplication of "fuel charge adjustments" levied against users of electricity. It was the year of the Arab Oil Embargo. All in all, from an energy standpoint, the winter of 1973-74 was not a pleasant one to remember.

The spring of 1974 has been the season in which the energy crisis has been all but forgotten. Big-car sales are up, and the recently lowered highway speed limits are widely ignored. Prices have not returned to their former levels, but gas seems plentiful, and one can become accustomed to higher prices.

How quickly we learn.

The energy crisis did not begin in 1973, nor will it end in 1974. Its beginning, for practical purposes, can be traced back into the

last two decades of rapid economic growth in America, in which populations increased, while the industrial products used by the populations seemed always to grow bigger and better - and, if possible, discardable. Its end lies at some indeterminate distance in the future, at which point we will have either mastered such virtually inexhaustible energy sources as fusion, or we will have returned in either an orderly or a chaotic way to a less energy-intensive lifestyle. Either way, the energy problem is here to stay for the foreseeable future.

The purpose of the following paper is to examine broadly some of the implications of the energy shortage in terms of the following: the new kinds of technology being developed to tap alternative energy sources; the relationship between the energy shortage and the soon-to-be-felt shortages of other resources; possible effects of the energy shortage upon efforts to protect the environment; and social implications of the inevitable limitation to economic and population growth, at least on this planet. The paper is presented in two parts. The first will be a brief discussion of the major elements of the problem and a look at the probable course of our national effort to cope with it. Secondly, I will address the problem of public awareness of the significant issues; in this part will be presented a short story, portraying a slice of the world as it might exist in twenty or thirty years.

PART I

A. National Energy Policy

The future direction of the energy policy to be pursued by the United States is presently under consideration by a number of agencies and study groups, the most influential of which are probably the Atomic Energy Commission and the Federal Energy Office. Despite this consideration, and despite the serious nature of the long-term energy problem, there is a little indication at present that either the public or industry are taking meaningful steps to forestall future energy shortages. Projections for future demand are being revised downward somewhat, but the only forces acting to limit energy consumption are economic - the availability of fuel, and the price. (Price, however, has been a relatively ineffective inhibiting factor; according to FEO officials, a $.10 increase in the price of gasoline produced a decrease of about 3% in demand.[1]) Whether or not effective government and public measures will be instituted to cope with the long-term problem remains to be seen.

The following brief outline of the national energy picture is drawn primarily from the The Nation's Energy Future, a report to the president prepared by the Atomic Energy Commission on 1 December 1973. The recommendations are based upon the familiar exponential growth curves for projected energy demand, with some allowances made for conservation. (Estimates of the total U.S. energy demand in the year 2000 vary, depending on one's sources, from triple the 1970 level to much higher figures - the point being that no leveling-off of demand is expected, and even the most optimistic estimates indicate only that

the rate of increase of demand might stop increasing.) The report discusses, at the President's request, the steps that must be taken if the U.S. is to achieve energy self-sufficiency. It is these recommendations which are of particular interest, since they describe the positive actions which might well be taken at the national level to determine our future energy policy .

The following five major tasks are proposed for immediate and urgent research and development, in order to further the national goal of energy self-sufficiency "at minimum dollar, environmental, and social costs":

- Conserve energy and energy resources.
- Increase domestic production of oil and gas.
- Substitute coal for oil and gas on a massive scale.
- Validate the nuclear option.
- Exploit renewable energy sources to the maximum extent feasible.[2]

The five tasks are all familiar and underway, in various stages of research and development. The AEC report suggests levels of funding which ought - in the Chairman's opinion - to be provided to individual projects within the five categories; the emphasis is placed upon short-range conversion to domestic supplies (pursuant to President Nixon's stated goal of self-sufficiency by 1980), and lower levels of spending are indicated for long-range solutions. Consistent with the Nixon Administration's official rose-colored-glasses view of America's future, limited credence is given to the possibility that the goal of self-sufficiency in the face of continually increasing demand might be unrealistic without serious environmental harm, possible public hazard

from a large-scale move toward nuclear power, and extremely high economic costs. Potential problems are outlined and evaluated, to be sure, but there was no consideration given - nor was any asked for by the President - of the basic wisdom of allowing the nation's economic and energy growth to continue indefinitely into the future.

Most of the technology referred to in the report should be familiar to the reader; for details of the program, refer to the report itself. What follows here is my own evaluation of problems which are left unresolved by the proposals - primarily, questions of the most basic sort, which have yet to be considered on a policy-determining level.

1) Conservation

The thrust of the proposed conservation program is technological, primarily development of more efficient processes of energy conversion (e.g., MHD and combined-cycle generators, more efficient automobile engines), more efficient distribution and transmission of energy, less waste in industrial processes and building space heating, and improved systems of mass transit. The suggestions are all commendable in themselves, but the issue which is avoided is that of changing the essentially wasteful American lifestyle. No mention is made of the fact that planned obsolescence in manufactured goods, commercial advertising which encourages and literally conditions the public to buy wasteful and unnecessary products, and public policies which reinforce public dependence on the automobile are all factors helping to make the U.S. the greatest energy-consuming nation in the world. No campaign to improve the technological efficiency of our present lifestyle will produce the kind of conservation needed for the coming decades; and most technological improvements, in any case, require such long lead times that they will

provide little immediate relief.

2) Domestic oil and gas

There is no doubt that stepped-up production from U.S. oil reserves will be a necessary part of achieving energy independence. With increasing market prices, many domestic sources once considered unproductive will now be expoited. It would be a mistake, however, to increase production with a goal of supporting consumption equal to the present per-capita rate. The result of doing so would be a faster depletion of our nonrenewable resources and an encouragement to the public to continue its high rate of consumption, with little regard for inevitable future shortages. An urgent public goal should be an orderly and early changeover to less wasteful modes of consumption, particularly in the area of transportation; yet an increased short-term availability of petroleum will only serve to delay such a change by decreasing in the public mind the urgency of the problem.

Environmental costs of expanded petroleum usage include the direct hazards connected with production, transportation, and refining of oil. More important, however, will be the exacerbation of air pollution - and thereby marine hydrocarbon pollution - particularly in view of public reluctance to sacrifice fuel economy for the sake of pollution abatement.

3) Substitution of coal for oil and gas

The abundance of America's coal reserves makes almost inevitable a large-scale utilization. However, the technological problems of coal gasification and liquification are formidible, and any massive conversion to coal by these means may take well over a decade, and

is likely to be expensive. The major drawback to massive coal utilization will probably be environmental - the present technology for pollution control in the direct combustion of coal for heat is both costly and relatively unsophisticated. Furthermore, the environmental risks of large-scale strip mining are poorly understood; it has not yet been demonstrated that high quality land reclamation following strip mining is economically feasible, or even in all cases possible.[3] (Similar environmental problems present themselves in the case of oil production from shale reserves.) A real possibility exists that large areas of land in the western states will be seriously damaged, if strict controls are not observed, in order to satisfy the insatiable energy hunger of urban and industrial America.

4) Nuclear energy

Though nuclear energy presently accounts for approximately 5% of the nation's total production of electrical power, the figure is expected by the AEC to increase to about 60% by the year 2000.[4] Electricity, in turn, will account for an increasingly large share of total energy production, since many of the new technologies will be applied to the production of electricity. If projected energy demands are to be met through the rest of this century, nuclear energy will have to absorb an increasing share of the load. This means a proliferation of nuclear power plants, and the development of breeder reactor technology to supersede the light water reactors.

Many serious problems (not all technological) will accompany such a course, and there is no certainty that satisfactory answers to all the problems can be found. Among the most significant:

a) Power plant siting, already difficult, can be expected to

become more so, as suitable and available sites disappear. Siting delays are costly, and they contribute to already-lengthy planning and construction times for new plants. Overall, it is doubtful that a sufficient number of coastal sites is available which would not involve environmental harm from either the power plants themselves or the usual accompanying land development. Offshore plants appear attractive for this reason, but pose serious questions of safety - the next problem to be discussed.

b) Reactor safety questions remain unanswered at this time, though rather extensive tests of safety systems, including the Emergency Core Cooling System, are scheduled for the coming year. The possibility of a reactor core melt-down in the event of a loss-of-coolant accident, and questions of normal radioactive releases, are serious public issues. Though the probability of a melt-down is considered by the AEC to be extremely small, the possible consequences could include a large release of radioactive material, rendering significant areas of land uninhabitable; such an accident on a floating power plant could be even worse than one on land, since the released material would immediately enter the marine environment. At least some scientists at the Environmental Protection Agency are seriously concerned by this possibility, and feel that safety systems should be far more rigorously tested through operating experience before floating reactors become widespread practice.[4½]

c) The dilemma of radioactive wastes - their handling and storage - is still unsolved. Present AEC plans are for high-level wastes to be stored above ground until more suitable means are devised for long-term storage. To vastly multiply the number of operating power plants

before such problems are solved would seem unwise, in view of the long half-lives of many of the wastes and the hazards of potentially faulty storage systems. The handling of radioactive materials would become even more serious a question in an economy dependent upon breeder reactors, which produce plutonium fuel as a byproduct of their fission reactions. Plutonium has a half-life in the neighborhood of 24,000 years; it is a deadly toxin; it can be converted with relative ease into a nuclear bomb.[5] Careful thought should be given to the potential for terrorist activities and international blackmail if plutonium shipments should, for example, be hijacked by criminal organizations. Assurances that elaborate security measures can prevent such occurrences are unconvincing - security systems are subject to human failure, and nothing short of a traveling army could prevent a sufficiently determined terrorist group from eventually stealing the valuable material.

5) Renewable energy sources

This refers to the potential utilization of virtually inexhaustible energy sources - most significantly thermonuclear fusion, solar energy, and geothermal heat. Development of these sources, still in its infancy, is long overdue and even now underemphasized. Fusion will likely be the closest thing to an ultimate source of energy which we will see for a long time to come, but it is not expected to be commercially feasible before the year 2000. A recent move by the Office of Management and Budget to cut appropriated funds for fusion research has pushed the final development schedule back by several years.[6]

Solar energy could theoretically be used for space heating in new buildings in the very near future, but high initial contruction

costs will probably delay the widespread application of solar heat. Large-scale use of sunlight for the generation of electricity is much farther from reality. At least one authority, Howard T. Odum, believes that solar energy will not produce a significant contribution to electrical power production, due to the energy-costly technology required for its collection.[7] However, many other authorities disagree.

The relatively low priority afforded long-range solutions such as fusion is typical of the present administration, and is unfortunate for the country. Fusion and solar energy - when and if they become technologically and economically feasible, will almost certainly be environmentally superior to both fossil fuel and nuclear fission power. It would seem worthwhile in the long run to expend greater effort toward realizing the potential of renewable sources - with the emphasis in the meantime on conservation - rather than to invest massively in environmentally risky technologies. If fusion and solar energy should prove unrealistic in the end - an unhappy thought, but one that ought to be considered - the sooner we know it, the sooner we can accustom ourselves to the necessity of rationing our limited remaining energy resources.

In summary, the future energy policy for the U.S. as proposed by the AEC is based upon an apparently thorough inventory of existing and pending technology, and an assignment of priorities for research and development of new technologies, based upon the probable lead-times and ultimate payoffs of the various new systems. But although the tactics for energy R&D seem reasonable in themselves (with the noted exceptions), the underlying strategy suffers from a lack of perspective of the U.S. as an integral part of a finite world system,

with limited resources and already-burdened ecosystems. Continued economic growth remains the goal, and national self-sufficiency within that growth. This is the stated objective of the Nixon Administration - an objective consistent, I suspect, with the present feelings of the majority of Americans - and it is this objective of sustained growth which is most in need of careful and critical re-examination.

B. Energy and Society

The pessimism of the preceding section has been purposeful. Politically-motivated optimism in government tends to disguise basic thorny issues by its offering of relatively painless short-term solutions, and it is my conviction that voices need to be raised to strip the masquerade of well-being from our nation's economic policies. For all the scientific study and journalistic attention given to the world's dwindling resources, the most influential U.S. policymakers - in which category I include corporate heads - have declined to acknowledge the existence or the extent of the problem. The electoral process, as it has functioned in the U.S., practically ensures that actions of public officials will be keyed usually to the goal of short-term visible results - and re-election - even if such results are contrary to the long-term public good. The unfortunate fact is that affirmative, responsible action which might anticipate and circumvent future world resource shortages would necessarily result in immediate public sacrifices in supplies and costs, and a readjustment to a significantly less wasteful lifestyle. It seems improbable that such basic changes will be initiated through government action.

Nevertheless, changes will come sooner or later - and the later

they come, the more drastic and traumatic they will be. In The Limits to Growth,[8] Meadows, et al., have described computer-model projections of current world trends, considering such variables as population, mineral resource consumption, food production, and pollution on a global scale. Various projections were made, allowing for widely disparate estimates of world resources, including "unlimited resources" and "pollution control"; and the final results - assuming continued economic and population growth - was in every case an eventual peaking of world population followed by a sharp and calamitous drop, caused by various combinations of food, resource, and pollution crises. The precise quantities of resources available to the world do not affect the final results, other than pushing the probable date of the collapse forward or backward by one or two decades. What does matter, according to Meadows and associates, is that if population and/or industrial growth is permitted to continue at an exponential rate - and no reversal of this trend is presently in sight - the projected post-growth collapse will occur, will occur suddenly, and there will be no way by that time of preventing it.

In the meantime, the pinch on energy supplies is directly related to shortages, both present and threatening, of other resources, including that most critical one - food. "Ecology," in the true sense of the word, means that everything on Earth is related to everything else, and nowhere is that concept better demonstrated than in the role of energy in all activities. Howard T. Odum, in Environment, Power, and Society,[9] discusses the energy-flow patterns of various living communities, from low-energy systems such as estuaries, to high-energy technological society. A primary distinguishing feature of technological society

is that it utilizes highly concentrated energy sources to accomplish work and sustain productivity. For example, fossil fuels supply the largest energy input for heat, industrial production, and transportation; this is energy which has been concentrated in the earth for millions of years, and it is being used up at a prodigious rate. As the most easily accessible supplies of energy (and other) resources are exhausted, an increasingly large financial (read: energy) cost is incurred in developing, building, and operating the technology required to free new sources. As we drill deeper and deeper in the ocean for oil, as an example, we pay a higher and higher price for a lower and lower return in net available energy.

Simultaneously, society has tended toward the use of more and more energy-intensive technology - in fact, this has been considered almost the essence of "progress." One must be very careful in discussing the energy cost of a particular activity or piece of hardware to consider the total energy cost - which, in the case of hardware, includes not only fuel consumption but also development, production, miscellaneous operating, and maintenance costs. Computers and nuclear reactors are costly technologies, both financially and energetically; in addition to the primary construction and operating costs (which in the case of nuclear reactors includes prodigious amounts of electricity in the gaseous-diffusion manufacturing of fuel), one must tally the extensive human training, with its own considerable energy costs, required to design and operate the sophisticated systems. In fact, nearly all monetary costs can ultimately be traced back to associated energy costs, whether the system of expenditure is fuel and machinery for transportation, or systems of information storage and education.

In conventional analysis, many energy costs tend to be hidden and, as a result, not considered as such. A man who purchases a new car because it is smaller and less wasteful than his old behemoth may, in fact, not be doing his country a service conservation-wise; to determine that, one would have to sum the energy costs (many of which, again, will not be labeled as such) associated with building and selling a new car, and compare the costs to those which would be incurred in continuing to drive his gas-guzzling, but already-manufactured, old car. Generally speaking, as energy prices rise, this increased cost will be passed on through all activities - of which just one example is the mining of hard minerals, which are themselves becoming less accessible and therefore more demanding of energy for extraction and refining. In this way, rising energy prices contribute both directly and indirectly to overall inflation; and, as long as both energy and non-energy resources continue to become less easily accessible, there will be no end to inflation.

The economic future of the both the U.S. and the rest of the world appears uncertain, as even Secretary of State Kissinger warned in a recent address to the United Nations.[10] A world food crisis is seen on the horizon by many writers, mostly as a consequence of rising populations and shortages of chemical fertilizers. Quite likely, temporary or permanent shortages of nearly everything will become commonplace, particularly if the many nations of the world remain reluctant to seriously seek cooperative solutions. It is, of course, easy for the developed nations, which use far more than their per-capita share of the world's resources, to issue statements decrying the absence of international cooperation; in fact, it is highly improbable that these nations will seek truly equitable solutions to the resource shortages.

To environmentalists (villains, all!) the energy crisis is a two-spiked bludgeon. The fuel shortage of 1973-74 wreaked havoc with many environmental efforts, including air emission standards (primarily through relaxed sulfur-content restrictions for fuel oil) and the blockage of the Alaskan Pipeline. The Federal Energy Office has been rather unhelpful on the environmental side, particularly in their request - fortunately unheeded - that energy-related facilities be exempted from environmental impact statement requirements. Auto-emission controls suddenly became a far more controversial issue, since control devices presently used on late-model cars substantially reduce gasoline efficiency. Partly as a consequence of this fact, and partly because of R&D difficulties, the EPA deadlines for minimum auto emissions have been pushed back several years from the original 1975 date. The oil companies, though under fire in the excess-profits controversy, took full advantage of the fuel shortage to strike hard against environmental restrictions, via a saturation advertising campaign - sometimes subtle, sometimes not. (Sometimes they had help from those who should know better: e.g., the publisher of Skin Diver Magazine producing a television commercial for Exxon, lauding their non-polluting offshore oil wells, yet ignoring the direct relationship between a hydrocarbon-powered society and air pollution - the number one source of hydrocarbon pollution in the ocean.)

All is not bleak for the environment, however - even in the face of to-be-continued-next-year fuel shortages. Though emission standards were in many cases relaxed, and probably will be again in the future, the reduced rate of energy consumption had a significant compensating effect. Looking to the future, a continuing energy problem will hope-

fully, sooner or later, necessitate the construction of improved mass transit systems, and an accompanying reduction of automobile usage - at least on a per-capita basis. Though the intervening years will be difficult, economic factors will inevitably force the public to adopt conservation measures. The greatest environmental threats, meantime, will likely be corporate, government, and public demand for ever-increasing hydrocarbon supplies, and pressure for a vast commitment - of questionable long-term wisdom - to nuclear fission technologies.

The ultimate course of our energy policy will be decided, I believe, by predominantly economic factors - far more than by the efforts of planning, environmental, or legal interests. Environmental law is an instrument of public interest; and, while it might be relatively immune to brief fluctuations in the public perception of issues, it will not stand forever against adverse public opinion. However effective it might be as a buffer to public fickleness, the law will remain effective only if the public continues to value a clean environment as greatly as it does a high-energy lifestyle.

The near future seems to promise a continued energy binge on the part of America, but in time the forces of inflation and repeated shortages must act to slow economic growth - or possibly to set it back with a recession or depression. The next decades will be difficult, optimistically speaking; but actions which could be taken now to ease the transition to a slower pace of consumption do not seem forthcoming, since such action would cause immediate social discomfort, and that is not society's way. Eventually, though, we may hope to witness society's adjustment to a less extravagant lifestyle, and finally the introduction of an environmentally safe fusion power base.

REFERENCES

[1]From a personal interview at the Boston division of the Federal Energy Office, March 25, 1974.

[2]The Nation's Energy Future, United States Atomic Energy Commission, (Washington, D.C.: Government Printing Office, 1973), p. 47.

[3]Harry M. Caudill, "Farming and Mining," The Atlantic (September 1973), pp. 85-90.

[4]The Nation's Energy Future, p. 107.

[4½]From a personal interview with Dr. Paul Bedrosian, Boston office of Environmental Protection Agency, March 25, 1974.

[5]Allen L. Hammond and William D. Metz and Thomas H. Maugh II, Energy and the Future (Washington, D.C.: American Association for the Advancement of Science, 1973), p. 37.

[6]The Congressional Record (March 13, 1974), p. S 3628.

[7]From a lecture by Dr. Howard T. Odum at the University of Rhode Island, February 1974.

[8]Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, and William W. Behrens III, The Limits to Growth (New York: New American Library, 1972).

[9]Howard T. Odum, Environment, Power, and Society (New York: John Wiley & Sons, Inc., 1971).

[10]David Nyhan, "US as a 'have-not' a jarring prospect," Boston Sunday Globe, April 21, 1974, p. A-1.

PART II

Public Awareness

Though the ultimate impetus to conservation is likely to be climbing prices and disappearing supplies of energy and other resources, this bleak prospect offers little hope to those who would seek to work now toward moderation. Most of the significant decisions, such as the extent to which we will place our collective bets on offshore oil and nuclear power, seem to be made by a relatively small number of persons - who thus far have shown little inclination to seriously consider the long-term implications of their decisions. Public input, except in the form of marketplace demand, seems largely stymied; and, even if perfect channels were available for citizen input, present public behavior indicates that the implications of the problem are not widely understood, anyway.

There seems little likelihood of ensuring through the legal process that proper consideration in choosing our national policy will be given to weighing long-term risks against short-term gains. Though Congress has acted - if belatedly - to fund a long-range energy R&D program, it has still given most of its attention to the short-term "crisis." In so doing, both Congress and the Administration have unwittingly postponed real solutions; the more successful their efforts to meet present demands, the longer the delay before necessary and basic changes are undertaken.

The public <u>can</u> carry political weight when sufficiently aroused. Proposed power plants can be halted, for example, if the local citizenry is determined to prevent certain local environmental hazards. Such actions, apart from the local issues, do serve a valuable function in

making life difficult for power utility planners; the harder it is for them to effectively meet projected future demands, the less likely that those demands will fully materialize. Conversely, the more convinced the public is that electricity will continue to be available in plenty, the more certain one may be that their lifestyle will grow to demand that energy. The disadvantage of waging such local battles is that the larger national issues are rarely brought fully into the open.

A considerable part of the problem, then, is public education regarding the interrelated issues of energy, the environment, and inflation. To many citizens it may not be obvious that the three are at all closely related - when, in fact, they are simply three different faces of the same problem. So many of the details of the issues are confusing, even to specialists, that the most basic overall elements become lost in the murk of political and technical arguments. The experts, more often than not, communicate among themselves without effectively relaying their information to the general public, which may not, in any case, be able or willing to assimilate the information. Most working people are apparently too busy trying to beat inflation to worry much about the underlying problems, or to understand that perhaps America should <u>not</u> try to grow forever; and this is unfortunate, because it is the spending and consuming behavior of these same people which influences the patterns of economic growth.

To a person whose only exposure to the problem is through television, newspapers, and the marketplace, it is probably difficult to identify with statements - however authoritative-sounding - that the energy crisis is not over, and that other sorts of crises are likely

to accompany recurrences of the energy shortage. We are all bombarded daily with advertising encouraging us to consume - in fact, assuring us that in order to lead fulfilled masculine (or feminine) lives we must consume a plethora of manufactured goods of questionable value, not the least of which is the luxury automobile. We all enjoy luxury, but we are subjected to a conditioning which tends to make us continually dissatisfied with whatever standard of luxury we have achieved. Advertising is a powerful behavior-molding force, and one responsible only to the sponsoring industries - which themselves are responsible to the profit motive. The oil companies provided many examples during the energy shortage of advertising devoid of public responsibility; and yet, all advertisers and consumers can be held accountable for America's unconscionable waste of natural resources.

When mention is made of "public education," the first thought that probably comes to mind is public and formal education; but an equally if not more important factor in public awareness is the media, both printed and electronic. How much of our conception of "the American way" of doing things comes to us from the books and magazines that we read and the television programs that we watch? Think for a moment of the consistent success with which sex is used to sell goods. Imagine (try, anyway) what the effect might be if Playboy, by some inversion of its values, assured its readers in its own inimitable style that the man who consumed the least would be the one who was guaranteed success with women. In a lesser stretch of the imagination, suppose that ads for home air conditioners portrayed luckless owners unplugging their units because of repeated "brownouts."

Like advertising, fictional drama depends for its impact on audience identification with its characters. As a reader or viewer, one can empathize far more closely with a character, a fellow person, experiencing the consequences of a given situation than one can with a graph or a scholarly discussion of the same situation and its possible consequences. The meaning of the energy shortage touched the public for a brief time in the past months, but once the immediacy of the shortage - the personal inconvenience and worry - subsided, the personal identification with the shortage disappeared, and no amount of warning from energy authorities about the long-term nature of the crisis can take the place of that personal empathy.

Dramatic fiction - whether written, staged, filmed, or televised - offers the possibility of re-creating that empathy in the same way that literature has always identified and illuminated human behavior, with its foibles and flaws, as well as its delights. Successful fiction can allow - can induce - its audience to see and understand, to <u>feel</u>, the consequences of living in a situation or a world which is different from that encountered in daily life. The difference may be of time or place, and may involve a crossing between worlds; whatever the specific case, the purpose of a story is to let the audience experience on both intellectual and emotional levels some life situation outside his own, and to allow him to draw whatever parallels he might find in his own life.

In the field of literature, science fiction most frequently deals seriously with the impact of technology, both present and future, on human society and individuals. An extrapolative SF story may project trends of the present into a particular future which <u>might</u> arise; it

does not predict, but rather suggests possibilities. Once the future-reality has been established, the important task is to portray the consequences of that reality for the people who must live in it, and to make that life intellectually and emotionally vivid to the reader. Hopefully, a reader who has experienced for a time life in, for instance, a post-environmental-catastrophe world might think more carefully about the sort of world he himself is helping to build.

The following short story is one effort to portray a near-future world which might arise from Earth, 1974. SYSTEM'S TRIAL is the second in a planned series of stories dealing with alternative futures of man-in-the-sea. The objective is to present each particular world situation as a background to the real story of an individual attempting to cope with that world. SYSTEM'S TRIAL is the story of a working saturation-diver at the end of this century, in a world in which an unsolved energy crisis has driven inflation to frightening levels and has set back, rather than advanced, the state of rational ocean exploration. It is not the sort of world most of us would like to see, but it is one of which we should beware. It was a strange world about which to write; perhaps it will be a frightening world about which to read.

Here, then, SYSTEM'S TRIAL...

Jeffrey A. Carver

Beacon Avenue

Jamestown RI 02835

System's Trial

"Number Seven in sight, Danner. Looks cloudy, Edge - we're in for some work." Davis Ferrell winced at a whine of feedback in his helmetphone and leaned sideways to see past his partner in the wet-sub. A yellowish plume drifted through the sub's nosebeam; beyond that light, there was only darkness on the Atlantic continental shelf-bed. Ferrell could not yet actually see the outfall, but it would not be far beyond the edge of its silt plume. Or so he hoped.

"Cheer up, Davis," a voice squawked in his ear. "You'll be finished in no time - say, about six hours. We're losing your signal - don't get lonely, now. Check in after Eleven." The voice was that of Edgar Reddick aboard the habitat/barge Danner, now several kilometers behind them on the seabed. Reddick and Lou Jenning, the fourth of their team, stayed behind on alternate days to rest and tend the habitat.

Ferrell turned down the gain on his sonarphone to silence the feedback in his divesuit helmet. He and Phillip Roesler would be out of communication range of the habitat for several hours or more while

they completed their work - an inspection of effluent outfalls in the New England Offshore Upwelling Range, where they had been stationed now for three days. While Roesler maneuvered the little sub, Ferrell sat quietly in the rear seat, listening to the whining propulsion motors, and tried hard not to think about the job.

Rested all day yesterday - why so tired now? Day's only begun. Do your worrying off the job, or Roes will be down your back. With good reason.

The whine of the motors changed pitch as Roesler applied braking thrust and guided the sub bottomward. Visibility had dropped to zero; the seafloor was hidden from view even with the sideboard lights on. The aging craft trimmed sluggishly and swayed in the turbulence of its own propellers, but Roesler landed it with hardly a bump. A rumble passed through the hull as he valved compressed air through keel clearing channels to minimize bottom adhesion; then Roesler cut power to the four gymbaled motors. The sub sat grounded with a slight negative buoyancy.

"Sonar on, and check your circuits," Roesler said, sliding back the canopy over his head. He was barely visible, floating out of his seat in the dusky murk.

"Jawohl." Ferrell switched on his helmet light and sonar transceiver. The unit started beeping quietly, and a tiny lens-fronted screen flicked on above his left eye, a spidery red grid and three dots: Roesler, the sub, and the outfall structure. Test lights for his mixed-gas circuitry blinked on satisfactorily. He pushed himself lightly out of the cockpit, and the sub was swallowed beneath him by turbid water and darkness. Roesler was wreathed in a yellow silt haze, a shadow

in the backscatter of his own light and the sub's noselight. He appeared a strange figure in helmet and cryoelectric scuba, like a deformed space walker in a weightless, monochrome world.

Maybe you are, Roes.

Roesler turned, his helmet light blinding Ferrell for an instant. "You set, Davis? More or less?" he asked, his voice harsh over the gasflow hiss in Ferrell's ears.

Don't be sarcastic. "I'm ready." Such a perfectionist, Roes - but why not about things other than each single job. I'm leaving, okay...not to be a drone.

"Move back a bit, Dave," Roesler said, nudging him. Ferrell moved, and helped open the tool bay. They each picked out a pry lever; then they moved off into the silty fog. Ferrell followed his partner, walking his fingers lightly on the bottom to keep a sense of dimension in the blinded, directionless world. He finned leisurely, but took care as they approached the structure. A current, apparently caused by an obstruction of the effluent ejector, eddied downward around the base of the outfall and lifted the fine cloud of silt which obscured the area. Ferrell vented some gas from his suit's buoyancy compensator and waited at the bottom while Roesler ventured over the top to diagnose the problem.

Damn city sewage. Pollutants of the millions, cycled or not. Pleasant.

The outfall was a concrete and steel structure, terminating a long pipeline from a coastal sewage center. The effluent, a mixture of secondary sewage and warm coolant from a nuclear power facility, circulated upward from the outfall to the euphotic zone near the surface, where it

nourished phytoplankton and ultimately larger animals. There were nineteen outfalls in the Upwelling Range; it was the first deliberate fertilization of the open sea - spurred by a growing burden of human waste onshore, and public pressure against the destruction of estuaries by excessive nearshore disposal.

The network had been staggeringly expensive, and by many accounts scarcely worth the price. It served marginally to increase some fish stocks but fell far short of meeting urban-coastal disposal needs.

Build the fish people a gadget...not bad in itself, maybe - just a nosethumb at anyone who thinks we're too big and too many and none the better for it. Spend, and call it a solution.

If only it weren't paying your living, Ferrell.

Roesler's light descended through the murk. "Heavy rocks on top," he reported. "There's been some sliding from the slope behind. Let's hitch up and see if we can move them."

Ferrell fingered a chest button to inflate his compensator slightly; and he followed Roesler to the top and attached himself with a nylon tether - a restraint against the buffeting current. The water was clearer near the outflow point, and the fragments of rubble blocking the ejector screen were visible in the lights like oddly shaped blocks, jumbled in the midst of a flying snowstorm. Though not large enough to require use of powered equipment, the rocks were awkward to remove by hand. Even with his buoyancy vented to a minimum, Ferrell had difficulty positioning himself in the current, and he had to maneuver so as to utilize handholds as points from which to exert prying leverage. Working in concert with Roesler proved not much simpler; both men worked hard merely keeping still long enough to move single rocks.

Ferrell was soon panting from the exertion, and he rested, by floating outward to the end of his tether and drifting back to the bottom. The nitrogen/heliox mixture freeflowing in his helmet was dense at the six atmosphere pressure, and breathing resistance accentuated the effort of his work.

Relax now, dizzy...too much CO_2. In, deeply...out...in...out, again - slowly, forget air hunger. Slow and easy.

The air felt like a syrupy liquid in his windpipe. Ferrell flexed his fingers, as strength returned to his limbs. "Why did they build this thing at the base of an incline?" he wondered aloud. And put us to all this work.

Roesler stirred beside him. "Probably someone ran out of money. Or pipe. About set to go, again?"

Or brains. "Let's get it done." Ferrell propelled himself upward and set to finishing the job. The rest of the work was relatively light, and, as they cleared the remaining debris from the ejector screen, the effluent began to move cleanly upward, being considerably warmer than the surrounding water. With the clearing finished, they proceeded with the inspection. While Roesler, who was particularly hampered in his part by the turbidity, probed by hand for gross defects, Ferrell scanned for structural integrity with a close-held ultrasonic test unit. The turbidity had cleared slightly by the time the scan was complete, and the outfall was vaguely discernable in the yellow beam of Ferrell's headlight. "Let's go," he said.

They returned to the sub and prepared to move on. The sub's aluminum skin glinted dully in the lights as they replaced the tools and closed the bay on the craft's flank. "Nine is a kilometer north," Roes-

ler said. "It's rockier there, should be less mucked up."

Ferrell took his place in the cockpit and closed the bubble over his head. Tired, Roes? Can't tell through the phone - but then, you wouldn't show it.

Roesler lifted the sub in a plume of silt and set course for Outfall Nine. Ferrell had the feeling that he was being ferried by some ungainly rocket from the surface of a mist-clouded, alien world. He settled back to enjoy the ride. The cruiselight wandered over the bottom from their altitude of three meters; the terrain blurred and undulated in the beam - mud and silt, broken in places by bumps and ledges of buried rock. Green and red flecks passed beneath them, probably lobsters or crabs or other bottom-feeding animals. The course took them gradually deeper, into a zone of mostly exposed bottom rock, reflecting earthier colors in the floating searchbeam. Ferrell was pleased by the lonely landscape - it brought to mind romantic notions of exploration in a strange universe, notions which occasionally surfaced amidst his cynicism of the actual state of ocean exploration.

He shivered - the ocean chill was penetrating his suit long before it should. Heater going flukey, now? Have to bear it.

Liking it or not, Ferrell and his partners accepted many risks once considered intolerable in saturation diving. Every work contract counted, in the present cutthroat economy, and if sacrifices in equipment quality had to be made, that was the nature of the business. Their firm's maintenance budget went mostly to their cryo/mixed-gas lifesystems, on which they were dependent throughout the mission, including the lengthy, critical decompression preceding their return to surface pressure. Discomforts, of any kind, were secondary to considerations of breathing.

Out of such craziness will the sea be conquered, right? Great hunter, prowling the undersea jungle of sewers.

Ferrell leaned his helmet against the side of the dark canopy, listening to the whir of the electric propulsion units and the whisper of his helmet's gasflow system. Quit carping, now. So you wanted shiny domed cities. The ocean's maybe sick - but it's not dead yet. Might see those cities some day.

He did not believe that, except during rare mellow moments. Worldwide economic instability - and particularly the recurring recessions in America during the eighties and nineties - had kept most ocean development at a standstill, at a time when the world increasingly needed the ocean's resources. Oil exploitation alone had leapfrogged - and with it atmospheric pollution, the major contaminant of the marine environment. In America, inflation had finally leveled energy demand, and the newly austere nation had quickly forgotten frontiers, in its jealous protection of short-lived affluence. Following its costly and futile investment in nuclear fission, only the now-. infantile fusion industry offered hope of lifting the economic yoke stifling creative exploration. In time - perhaps - the ocean would be given a second chance.

If it lasts that long. Maybe the fish will live on auto exhaust - but no, that would put the sewer people out of business.

Cut it out, Ferrell.

Self indulging, again. Maybe they're right. Quitting because you're underpaid and over-risked.

No.

The droning motors slowed, like hidden dynamos winding down in

the night. "Mine looks clear. Should be a simple inspection," Roesler said, trimming the sub's nose slightly downward.

Ferrell peered over Roesler's shoulder. The outfall was spotlighted by the sub's nosebeam, a dusty looking oblong. The feeder pipeline snaked in from darkness on the left - down a tumbled ridge, to meet the terminator on level seafloor. All appeared in order, to his grudging satisfaction. Thank you, whoever.

Roesler grounded the sub and cut power, leaving only the noselight on to illuminate their work. Ferrell mentioned the problem with his suit heater. "Keep it on max, and let me know if it gets any worse," Roesler advised. "You're liable to make mistakes if you're cold and tired."

Crossing the short distance to the outfall, Ferrell swam through the light beam, relaxing in the easy glide of weightlessness, and watched his shadow on the outfall shrink at his approach from a monstrous blur to a life-sized caricature of a diver. The concrete structure stood highlighted in the gloom, its sides and back dark but for the moving beams of the divers' headlamps, which at close range sparked the silt-dusted landscape with its only tinges of warmth. Though the seafloor was littered with rocks, the outfall itself was clear, and only lightly encrusted by fouling organisms. A mottled bottom fish drifted sullenly in the spotlight, the only visible representative of its kind.

Roesler made a short visual inspection and then urged Ferrell to proceed with the sonar scan. "I'll look over the pipe while you're doing that - there may have been some rocks sliding around upslope."

Ferrell waved acknowledgement and watched Roesler move off into the darkness. The scan was uncomplicated, but it required concentra-

tion; he swam back and forth across the outfall surfaces, studying the luminous readout of the test unit for signs of damage. Finding the structure in excellent condition, he then continued with a scan of the pipeline, upward along the ridge.

A smudged spot of light moved toward him higher on the slope. "No problems, but the bottom is a little loose," Roesler called, his transmission faint across the distance. "Best not to - "

A rumble drowned Roesler's voice. Ferrell felt a vibration in his helmet, and below him a dusting of silt jumped upward as a tremor passed through the bottom. What the hell? "Roes!" His partner's light vanished, and he saw a wave of silt cascading toward him. In its forefront were tumbling rocks, bouncing and gathering speed.

Godallmighty get up out.

He kicked upward, stabbed at and missed his buoyancy valve. The cloud engulfed him, and stones hailed violently against his body and helmet. He threw his arms protectively in front of his faceplate and kicked desperately. A massive fragment glanced off his forearms and slammed him backwards in a slow tumble. Dizzily, his vertical sense lost, he jarred helmetfirst on the bottom and careened heavily to one side. He huddled and bounced helplessly, his arms paralyzed by crushing pain, as rocks pummeled him and crashed deafeningly against his helmet.

The rockslide ended moments later; the rumble faded as the disturbance reached deeper, leveler bottom. Ferrell, dazed, bumped and drifted along the slope. The water was turbid with silt, and only a yellow blank showed in the light of his headlamp. He groped painfully at his chest to vent unwanted buoyancy, and finally steadied himself in a kneeling position on the rocks.

"Roes." His voice cracked. He cleared his throat and shouted, "Roes! Phil!" No answer. He turned his phone to maximum power. "Roes! Dammit!" The only sound was his own harsh breath and the whisper of the gas circulator. He thought hard, trying to blank out the pain of his battered sides and limbs. No whine. No feedback in the phone. Broken.

He shifted position, trying unsuccessfully to ease his discomfort. His helmet light flickered, but remained on. Visibility was nil, but the light was reassuring. How long? Check yourself, now. Sonar blank, no function. Cryo circuits - gasflow okay, but no test lights. Hang on to that one, or you're dead. Hell of a beating.

He tested both arms gingerly. His right arm hurt more than the other, but he could probably use both. The wrist instruments seemed intact. Roes, where are you? Avalanche, probably just a small one. Did you start it, Roes, or was it going to happen anyway?

"Roes, dammit!" Forget it, no phone.

He turned, slowly. The light flickered and stayed on, but he was enshrouded in an opaque cloud of silt, cold and featureless in the dull beam. If he's hurt, can't afford to lose my position. If not - lose only time searching. How high is this stuff?

He set his wrist compass for a northeasterly direction, which he estimated should bring him back to the pipeline - the only possible orientation for a search, if Roesler were injured somewhere on the bottom. If. Roes - if I have to tow you...must have taken a pounding when that hit.

Neutralizing his buoyancy again, he turned, floating, to a swimming attitude. Though his arms were stiff and sore, he had to extend them

to probe the murk. Reading the compass required a painful bending of his left arm. Even breathing was difficult, his bruised sides pressing in and out against the thick, dense gas.

When he reached the pipeline, he turned thankfully upslope, probing an arms-length swath to one side. He moved at a frustrating crawl, unable to do more than feel his way along. After a time, he crossed over the pipe and worriedly started down the other side. The headlamp flickered a last time and failed - and suffocating darkness collapsed around him. Engulfed by vertigo, he clung to the pipe, his head pounding, sweat cold at his eyes and lips.

Steady...steady, now. You were blind before. Just makes it final. Move...slowly..go.

He moved again, unsteadily. Another slide waiting? Don't think of it. Don't need light, just water and rocks here - and somewhere Roes. God but it's cold. What?

He rolled to stare off to the left, blinked sweat from his eyes, and tasted salt at his mouth. A faint smudge lightened the gloom, a ray of light so vague in the darkness that he wondered if it could be an afterimage in his eye. He hesitated, strained to read his luminous compass, and set off toward what he hoped was a light. Gloved, nervous hands tested each foot of the bottom. He felt wet and cold, and had to struggle to keep from shivering.

The smudge lightened to a brown blur. He stopped. One hand had touched Roesler's chest; the diver was drifting gently on the silt. Ferrell seized him and groped to find his head, then squinted futilely at the faceplate. Roesler's headlamp was blinding at close range, but, using his hand to deflect the light, he was able to see the glass sur-

face and a billow of turbid water - and after much effort the inert shape of a face.

Hurt - but how bad? Are you alive, Roes? Conscious? Can you move dammit, where are you hurt?

Ferrell's lungs burned, demanding relief. He drew back, suddenly lightheaded. Deep and steady...don't force...don't think. In...out... flush slowly.

Air is thick - have to watch the CO_2.

Easy. Now think. Have to tow - check him over first.

Carefully probing his partner's suit-clad body, he could find no sign of the injury, nor was there obvious damage to the scubapack or helmet. Might be okay, if you can get him back. And find your own way.

Ferrell pressed the buoyancy control button on Roesler's chest to inflate the man's compensator slightly, and gripped Roesler's harness tightly. The buoyancy would make towing simpler, with the man drifting above him; but if he lost control Roesler could float out of his grasp and ascend to suffer explosive decompression. Ferrell began finning awkwardly, discovering that he had to stop again and again to recheck his compass.

He found the pipeline by crashing blindly into it, then turned after a moment's confusion and headed downslope, Roesler's bulk bobbing in his grasp, and helmet light flashing about crazily. By the time he reached the outfall, he was panting like a weary runner and had to pause once more to let his breathing catch up with his exertion. Moving again, he guided Roesler around the outfall base, and saw a dull glow from the sub's noselight, seemingly far off in the murk.

No stopping, now. Don't tangle your feet with his...now kick!

The final distance was the worst, and his legs failed him in the last few feet, his lungs torn with air hunger. He sank to the bottom with Roesler, dizzy, his chest heaving to exchange lungfuls of oxygenated gas. Get him up...move. Groggily, he floated Roesler over the sub and lowered him into the rear seat by thumbing the man's buoyancy-release. Over the rumble of escaping gas, he realized that the sub was heeled strangely to one side; still, he managed to seat Roesler securely, if awkwardly.

With slow, consciously deliberate movements, he stopped to recapture his wind, and then groped in the cockpit for a hand lantern. He switched off Roesler's headlamp and shined the handlight directly into the man's faceplate. Roesler's eyes were closed, and what little he could see of the face appeared pale.

Unconscious? What color - blue? No, dammit - pink. No cyanosis.

He backed away, blinked, and peered again. Colors underwater could be deceptive, and the water and his eyesight both seemed blurry.

Still not blue. There - eyelids twitched! Alive, dammit, alive.

Whatever else was wrong, at least Roesler's cryo-scuba had to still be functioning. Next task was to examine the sub; he felt his way along the flank of the craft, able to see only inches, even with the aid of the light. Groping past a mound of debris, he reached the rear motor and stopped, stunned. The motor was half buried and inoperable, its prop-guard badly dented. Checking the front, then, Ferrell realized the full impact of the rockslide. Debris had cascaded into the entire length of the sub's portside, and had snowed the craft under, in a hopeless starboard list.

Stupid...why so near the slope? Bad, bad mistake...Roes, why?

On the far side, he found the starboard motors pinned against the seafloor. The tool bay was rolled under, obstructed from opening. What now - dig? Not a chance. Blow ballast?

Returning to the pilot's seat, canted as it was, he sat and tried the controls. Three motors delivered power, but only one swiveled for down-thrust. He blew both ballast tanks and blasted compressed air through the keel channels; the sub groaned but did not move. Reversing thrust and attempting to rock back and forth gave no better result. He swore violently, hoarsely, and glared at the lantern glowing in the murk. What next?

Idiot...use the emergency transmitter.

He opened a lid on top of the instrument panel, lifted out a float package, and tugged a small lanyard. A balloon inflated partially, and expanded as it floated upward, unreeling a thin wire from within the compartment. When the transmitter reached the surface, he could make radio contact with Danner via the habitat's surface buoy.

Work now, if you ever have.

When the reel stopped spinning, he snapped a switch and was relieved to see an orange indicator light up. He plugged a jack into his helmet phone and called, "Danner, Danner. Edge. Lou. Do you read me, does anybody read?" He repeated the call, and then switched to a magnetic key and tapped out a distress code, bypassing his suit phone. When no answer returned, he tested the receiver beeper/light, and then leaned close to the power meter. He cursed. The transmitter output was zero.

Edgar Reddick had repaired the unit twice and had requested, unsuccessfully, its replacement.

Bitch! Ferrell shivered. His suit heater was failing rapidly; it had probably been damaged and flooded.

Decision, now - swim? Leave Roes and come back with the sled? Won't be missed by Edge and Lou for hours...freeze before that.

Four kilometers blind? By dead reckoning?

The longer you wait....

Breathing deeply, he pushed two levers forward. Air thundered from the ballast tanks, and then all was quiet; the sub would now remain bottomed even if another disturbance should somehow free it. He studied his compass for a heading, and had another thought; he found a slate and crayon, and placed it with a scrawled message in front of Roesler. GONE FOR HELP. SIT TIGHT.

In case you wake up, old man. You're not deserted.

He peered into Roesler's faceplate one last time. Roesler's eyes were closed, and skin seemed pale in the lantern light, but there was still no sign of deathly cyanosis.

Turning away, he launched himself into the watery night.

Ferrell floated at rest beside an outfall and flexed his fingers nervously. Six or Eight. Six or Eight...should be Eight, but doesn't look clean the way Edge said. Dammittohell - is this compass working?

He played his light over the outfall again, but the beam was narrow and produced only a cold dash of light on the gloomy, encrusted concrete. Unsure of his course after nearly an hour, Ferrell had traced a pipeline to its terminator in hopes of re-establishing a position relative to the habitat; however, the outfalls nearest his route were those inspected by Reddick and Jenning, and there were no features

recognizable to him. The light revealed a transponder unit on the side of the outfall, causing him to scowl in frustration. If only his sonar were functioning, the transponder would return an identifying beep.

Cold...god. Make up your mind and move.

Fidgeting a last moment, he decided that he had found Six, rather than Eight. With a new compass heading, he set off again into the darkness. Hello, Danner, not a landmark anywhere.

As time passed, the water seemed more and more like a damp, chilly dungeon, and he shivered almost constantly, though still protected from the direct cold by a layer of foam. His legs pushed tirelessly up and down; he had long since stopped heeding the aching fatigue of swimming, but breathing the dense gas remained a continual effort. The lantern shone cheerlessly over the bottom and ahead through a few meters of faintly milky water. Wispy silt lay close about the bottom, like vapor clinging to a moonlit ground.

His left arm twitched - cramped from being held, bent, before him. He flexed it painfully to work out the stiffness, and tried again to concentrate on the wrist-compass dial, wishing futilely that he could be more sure of his heading.

Concentration was difficult, with cold deadening his reflexes, and the shadow realm of the seafloor an almost malicious distraction. Fifty-four meters and still on course. Empty world...Roes, you still there? Men dying in the ocean...why? No need. Economics...system falling down...going to catch itself?

He rubbed his faceplate with one hand, as if trying to wipe condensation from its inner surface. Diving had been a rapidly growing

art, with beaming visions of the future. Though pollution had eliminated some applications before they could be achieved, what had hurt most was the economics. Excesses of the past? Some frontier...desperate man and aging equipment. And how many ready and waiting to take my place?

Wrinkling his nose, Ferrell fought back a sudden desire to rub his damp face and sweat-stung eyes. You leave - and then what? The rolls? Factory - if you can fit in? Been diving nine years...tough to learn something new.

Tougher than a failing dream?

Drifting left...stay on course, man!

Not a friendly night, not at all. Could walk faster here...take off my helmet and run. Keep one eye over my shoulder...must be icebergs in this water. Don't think of that, think of diving...what you must do. Of Roes.

For a moment he kept a thought framed in his mind, a reminder of the harsh limits within which he was trapped. Under no circumstances could he ascend, regardless of cold or exhaustion. To venture above the mooring depth of Danner, the depth to which his body was nitrogen/helium saturated, would be to risk fatal decompression sickness. Forty-nine meters, Ferrell, forty-nine.

He jerked his hand from the bottom, startled at a movement. A flounder had bolted at his touch and vanished into darkness. Sorry, guy.

The slow reflex left him suddenly shaking, and conscious of the toll weariness and cold were exacting from him. The numbing cold, especially, was deadly: loss of concentration and muscle coordination

could finish him in the end as surely as could suffocation. Stopping, he flexed his arms and neck and twisted his trunk painfully. The muscles protested, and chills flushed his spine, but he had to work out cramps before they could worsen. His neck felt as if it had been struck with a lead pipe; the helmet was poorly designed for long periods of swimming, and it was a constant strain just lifting his head to see where he was going.

He moved on. The bottom seemed never to change, but only to crawl beneath him, a dull orange in the feeble lantern glow. The powerpack was nearly exhausted. Ferrell froze - and cursed himself for his thoughtless stupidity.

He switched off the light and plunged ahead again. What will that cost? Can you afford another mistake?

He swam ploddingly, both arms ahead, shivering violently in appalling darkness. Straining his eyes, he could see only the spidery green tracings of his wrist-compass dial. They seemed to float silently in cold ink, like fleeing luminous phantoms. Don't get away.

Danner, where are you. Lose our lives, here - please no. For something better - but not this.

Picture reefs and kelp. Wrass and sparkling sun. Or great luminous cities, deep in a night sea. Lovely emerald portals above submarine docks, where tourists and dark-haired women come to watch the divers harvesting the seafarm.

Steer right...watch the compass. Fool.

His breath rasped, hoarse and labored, and he tasted bile. Call me back to work when you're ready for that, world. May I live so long.

The blackness of the seafloor seemed to have diminished. He might

have been in a cavernous valley, watching the distant aura of a pre-dawn sky. The faintest green light percolated through the water, sunlight from a remote and alien world. Gradually he detected the form of his arms and the sketchiest outline of the sea bottom; his eyes had adjusted to their limit. For a moment, he almost smiled.

Struggling to swim faster against drugging fatigue, he checked his chronometer but could not read or remember the numbers. His breath was a paced grunt, over the steady whisper of the gas circulator and a nagging, rhythmical buzz. Finally he stopped and stared, and realized that he was being signaled. Red digits flashed on and off; he pushed a button on his depth/decom meter, and the numbers remained lighted for a few seconds, then resumed flashing. He tried again.

Forty-six meters. So what?

Forty-six. Danger zone. Blunder.

Stirring suddenly, he understood. He twisted to change course and finned frantically along what he hoped was a downslope. Sides ached and throat cracked, but he swam fearfully, pushing his legs to the limit of their strength. When at last he could go no further, he hugged close to the bottom, puffing, and blinked at his depth readout - still flashing angrily.

Forty-eight six, move dammit move. Cold brings on bends...forget cold...kick.

The readout flashed higher with his dizzy efforts, reached forty-eight nine, and flickered off. He foundered to a rest, his rasping breath steaming his faceplate. For minutes, he heaved fresh gas through his windpipe, clutching his sides until the stabs of pain subsided.

Panicky, Ferrell...should have retreated slowly. Spinning, spinning...stop and think.

Fifty meters and lost. He saw nothing in the gloom, except a barely discernable slope. What direction to pick? No doubt he had passed wide of the habitat - but how far past, and wide in which direction?

Think. Slope...follow the depth.

If his knowledge of the bottom geography was correct, he could follow the forty-nine meter depth contour and eventually pass near Danner, or at least within range of its light beacon. But he still had to choose either a northerly or a southerly direction.

Shivering, staring into darkness, he turned to the north and started swimming, determined not to waste time debating a hopeless choice. Time passed numbly in the mute twilight, where the bottom was only vaguely less gloomy than the water. A blurred movement passed like drop of sweat across his eye - perhaps a flounder. Fingers hurt, and he flexed them, druggedly obsessed by the pain. An ache in his forehead distracted him, like a weight drumming on his skull, out of step with his breath and racing pulse.

Bringing his hands to his face, he realized suddenly that his lantern was gone - dropped, apparently, some time earlier. Despite the darkness, which seemed to deepen rather than lighten, he could no longer care. He tried to think of a sky, dazzling and blue, and could not.

Another blur marred his vision, and another. Silvery...fish?

One leg twinged threateningly. Almost without thinking, he stopped to massage his calf to forestall a cramp. He noticed, but did not react

to, other fish flitting nearby; the glimmer of their movements seemed more imagined than real. Moving on, he stared, entranced, and wondered what meaning he should find in the presence of fish.

Not until his hand brushed a rocky surface, and he blundered into a rough, upright object, did the answer occur to him. No fish south of Danner, except strays. Here...fish...reef. Number what...Two.

Reddick had described inspecting an outfall near an old artificial reef of scrap and concrete debris - the only place in the vicinity where bottom fish tended to congregate. Number Two, north of Danner. He was swimming in the wrong direction.

Gasflow hiss filled the awful silence as he blinked weary sweat from his eyelids. Feeling the cold like fire in his fingers, he turned painfully, his breath as labored as his thoughts, and began retracing his route. Each leg movement was heavier than the one before, cold-exhaustion like stale alcohol in his veins. The effort made concentration almost impossible; to center his thoughts on his goal and the need to keep moving, he stared unwaveringly at his depth computer, holding his thumb on the readout button to keep it lighted, regardless of the drain on its powercell. Repeatedly, he lost his sense of vertical direction and lurched into the silt, and each time he shook violently free and swam on.

Dizziness...only the cold. Talk to yourself.

"Ferrell!" Strange sound, like a croak. Try again. "Ferrell! Keep talking!" Yes...keep on.

His teeth chattered uncontrollably, and he had to steel his muscles to begin once more. The cramp gripped his leg, again - a vice clamped around his calf, like teeth biting to his bone.

"God!" The pain was blinding, as he stretched out the muscle. Swear, you fool!

He cursed, and cursed again, repeatedly; he stupidly cursed the night and the cold and his partners and the power industry. He forgot the pain a little and, though winded, could think again of the habitat his goal.

Don't stop - "Roes! Haven't forgotten!"

The job...the company. Words, think of words - thieves, idiots, brigands!

Aren't going to find it...but don't stop screaming. Words!

The tiny red digits of the depth computer were the only lights in his world. World of frigid darkness and vertigo.

No, not the only lights.

Halting clumsily, shuddering, he turned. A green strobe pulsed in the darkness, the flare of a meteor in a starless sky. His legs demanded his last strength, kicking toward the light in ignorance of pain. Slowly, a white haze emerged from the gloom. And then an angular yellow barge - crystallized in a freezing green mist, hard against the powdery glare of the landing-port floodlights.

A cylindrical habitat materialized atop the barge, with three round ports glowing like emeralds in the dark.

So far away...no...don't stop.

Sliding, he propelled himself along the deck and collided with a strut under Danner's rounded bulk. He groped feebly for a support and turned upward. The bright surface of the entry well danced over

his head, and he wondered if he could reach the ladder's faraway summit.

Voices were disturbing his rest, and he said so, as he twisted and groped for comfort, tugging at the silty darkness around him. The sounds annoyed him again, but time seemed to have passed. Shivering in the dark, he wondered where he had dropped his lantern and if he should return in search of it. He pulled his suit snug, a soft, quilty suit, and drifted off once more. Later, cool gas whispered in his ear and chilled his neck. He complained at that; his legs ached and threatened violently to cramp.

The light hurt his eyes. He blinked and frowned at a metal grillwork above him, springs of the upper bunk. Turning his head brought protests from neck muscles; ignoring the sensation, he widened his eyes and then squinted. Curved walls met a flat deck, glaring and distorted, as in a fish-eye lens. Worn and burnished paint, clustered meters and comfortless benches, tiny space altogether, and a fishbowl window.

Edgar Reddick peered at him. Edge, what an ugly, beautiful face.

"Davis, why do you do these things?" Reddick said, tugging at a ragged beard. He seemed to be frowning. "How do you feel?"

"Awful." His voice seemed tiny - not from his own throat. Worse. Let me sleep. Got to get Roes.

Roesler.

He grabbed at Reddick, wildly. "Edge!"

"Easy, Dave. We got Roes - Lou brought him in three hours ago. Do you remember us shaking you, trying to find out where he was?"

Ferrell thought. He remembered fretting voices, somewhere. "Is he - ?"

Reddick's eyes were dark. "He's in rough shape. Concussion and leg fracture. He stayed warm, though - he'll be okay. He's on his way up, now. Navy's topside with a transfer chamber and doctor.

"You're next - rest and recompression. You've got some bubbles, not too bad. You must have strayed upward."

Ferrell did not answer immediately. A thought occurred to him. "How did they get here so fast?"

"They were on standby at a new construction job south of here." Reddick shrugged.

Ferrell rested quietly, then, and awaited the return of the transfer capsule. He would be out of a job while being treated for his bends symptoms, and probably for some time after. The entire affair would cost someone money, hopefully not him. Except for the unemployment problem.

Hell and demoniacry - you're quitting, remember?

Settling elsewhere - anywhere - would be tough, no doubt about it. But those in authority had after all risked his own neck for him, and now they would rush another man in to replace him - at the same poor salary.

Maybe someone else wouldn't have gotten into the trouble you did, huh? Like hell. It's a rotten setup - an affront to civilization.

He cleared his throat. "Edge - " Reddick looked up from the galley stove. "Who's going to help you and Lou finish, here?"

Reddick stirred a saucepan of something and said, expressionlessly, "Oh, the honchoes are sending somebody - I don't know who. With the other sub." Which was even more decrepit than the one they had been using.

"Oh." Well.

"They were a little upset about what happened, I gather. But apparently impressed that you made it back alive. I didn't mention to them that you were planning to resign."

"Mmm." Ferrell closed his eyes. He ached miserably, probably more from the cold and fatigue than from the bubbles in his tissues. Dark, cold ocean...gave you a rough time. Good enough reason in itself to quit...sort of a shame, though, after making it through.

Muttering, he stretched his muscles testily. Though he had not heard previously of the new construction further south, he assumed it was a submerged oil rig or such. Ugly. Destined to feed automobiles and smog. Wonder if they'll ever put labs on the bottom again - maybe when the new power plants come in. Or that little city.

Hell. Is it worth the wait?

Later, he heard a clunk, followed by bumping and scraping noises - the personnel transfer capsule mating at the end of the habitat. Reddick motioned for him to lie still, but he ignored the gesture and sat up. When the portal hatch opened, he rose and walked under his own power to the lock, over the protests of the naval officer who had emerged with a stretcher.

Reddick was watching him silently, when he glanced back. He hesitated. "We're due to start the MassBay job in four weeks. Aren't we, Edge?"

Reddick solemnly tugged his beard, his eyebrows arched.

Ferrell nodded and turned to duck through the lock.