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J.O. Stromberg et al.:

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PREFACE

The better understanding of the changing problems facing the marine environment is a continuing goal of UNEP's ocean programme, as it provides the necessary scientific background for shaping UNEP's policy towards the protection of the oceans.

The main sources of factual information used in the assessment of the state of the marine environment are data published in open scientific literature, data available in various reports published as "grey literature" and data generated through numerous research and monitoring programmes sponsored by UNEP and other organizations.

Several procedures are used to evaluate critically the large amount of available data and to prepare consolidated site-specific or contaminant-specific reviews.

GESAMP, the IMO/FAO/Unesco/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution, is charged by its sponsoring bodies with the preparation of global reviews. Reviews dealing with several contaminants have been already published by GESAMP and others are being prepared for publication. The first global review on the state of the marine environment was also published by GESAMP in 1982, and the second global review was published in 1990[1/].

In parallel with the preparation of global assessments, the preparation of a series of regional assessments, following the general format of the second global review by GESAMP, was initiated by UNEP in 1986, with co-operation of the Food and Agriculture Organization of the United Nations (FAO) and the Intergovernmental Oceanographic Commission of Unesco (IOC). Fifteen task teams of scientists were set up, involving primarily experts from the relevant regions, to prepare the regional reports under the joint overall co-ordination of UNEP, FAO and IOC, and with the collaboration of a number of other organizations.

The present document is the product of the Task Team for Antarctica. The final text of the report was prepared by J.O. Strömberg as Rapporteur of the Task Team for Antarctica, with collaboration of L.G. Anderson, G. Björk, W.N. Bonner, A.C. Clark, A.L. Dick, W. Ernst, D.W.S. Limbert, D.A. Peel, J. Priddle, R.I.L. Smith and D.W.H. Walton whose contributions are gratefully acknowledged.

The report was edited and prepared for publication by Philip Tortell of Environmental Management Limited, New Zealand.

1/ Publications of GESAMP are available from the organizations sponsoring GESAMP.

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1. INTRODUCTION

Although the Antarctic Circumpolar Ocean has wide connections with the three major oceans, there is a marked physical delineation between them, with cold northward flowing Antarctic surface water that meets southward flowing warmer waters from lower latitudes at the so-called Antarctic Convergence. At deeper levels there are northward flowing, intermediate and deep water currents and a warm deep current going south between them.

This means a relatively marked isolation of the Antarctic Ocean at the surface and bottom levels, which is also marked by a strong endemic component in the marine biota (e.g. Laws, 1985). Another example of the isolation is that only two species of vascular plants have been able to establish themselves firmly on the Antarctic Peninsula, although the climatic conditions on land are contributing factors to this (Smith, 1984).

Thus the spreading of pollutants via surface water from lower latitudes to the Antarctic Ocean is limited by hydrographic factors.

The most obvious human influence on the Antarctic environment is through direct activities in the area itself, e.g. fishing, hunting, pollution and debris from research stations and ships. In contrast to the Arctic there is virtually no river runoff that could transport material into the surrounding ocean in the Antarctic. The only transport is by ice flow and the melting of glaciers and shelf ice. Sea ice, that covers extensive areas (4 to 20 x 10^6 km^2, Zwally et al, 1983) does not contribute to this transport.

The history of whale and seal hunting and the subsequent decline in stocks of these animals are well documented as is the recovery of some species, particularly the Antarctic fur seal, after hunting was banned (Laws, 1984; Brown & Lockyer, 1984). The decline in whales meant less predatory pressure on the main food source, the Antarctic krill (Euphausia superba), which allowed other species to expand and use this source, e.g. Crabeater seals and a number of penguins (Laws, 1984; Croxall, 1984; Everson, 1984).

Human activities have thus already had a major effect on the balance of the Antarctic marine ecosystem. The commercial exploitation of mineral resources might have a more profound impact on the ecosystem and lead to irreversible damage. The achievements within the Antarctic Treaty System and the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) are of great importance for the future of the Antarctic marine environment (e.g. Laws, 1985).

While local input of pollutants might be of limited importance and have only local effects, and while commercial exploitation of non-living resources might be postponed and hopefully will only be carried out in the future under effective international control, there is still the risk of damage to one or more links in the food chain, that could have major impact on the total ecosystem.

One way in which damage or at least major perturbations can be caused is through changes in the atmosphere. Studies of Antarctic ice cores have revealed an increased CO_2 level in the atmosphere over the last century from a level of about 260 parts per million by volume before major anthropogenic influences ("pre-industrial", before 1850) to the present 345 p.p.m.v. This change may not only be related to the burning of fossil fuels. One calculation indicates a "pre-industrial" level of 295 p.p.m.v. which could be the result of natural, but so far poorly understood, changes. The ice core analyses indicate that the CO_2 level was not stable during the centuries preceding 1850 (Raynaud & Barnola, 1985; Neftel et al, 1985). Evidence also seems to indicate that ice ages have an effect on the atmospheric CO_2 level with a decrease during such periods (Schackleton et al, 1983). Thus the ocean plays an important role in the CO_2 flux (Golitsyn, 1985). It is generally accepted that an increase in CO_2 level in the atmosphere will create a green-house effect with increased melting of the polar ice-caps (Bolin, 1986). If this does occur, we can expect changes also in the Antarctic Ocean circulation and in its marine ecosystems.

Another effect of human activities is the reduction of the stratospheric ozone layer above the poles. Much effort is directed towards research in this field. Farman et al, (1985) have proposed that the Antarctic stratosphere is particularly sensitive to increase of inorganic chlorine, primarily by the effect of this increase on the NO_2/NO ratio, during the cold winter and early spring. In combination with the height distribution of UV irradiation peculiar to the polar stratosphere this would account for the observed losses in O_3.

An increase in the ozone hole above the Antarctic could adversely affect phytoplankton reproduction and growth if ocean areas are exposed to an elevation of UV radiation. Wood (1987) has shown that the UV component of solar radiation inhibits growth and causes ultrastructural damage in large algae, such as kelp. There are good reasons to believe that pelagic, unicellular algae that dominate the Antarctic marine flora e.g. 100 species of diatoms and 60 species of dinoflagellates (Heywood & Whitaker, 1984) would suffer in the same way in the upper 5 m of the water column.

A reduction in algal production that would result from increased UV radiation would most likely also reduce the algal production of dimethylsulphide. This is oxidized in the atmosphere to form a sulphate aerosol, which seems to be a major source of cloud condensation nuclei over the oceans (Charlson et al, 1987). If this occurs there might be a reduction in cloud formation and an enhanced radiation which would then further increase the effect. More research is needed to verify this feedback system.

2. GENERAL WATER CIRCULATION

The Antarctic Circumpolar Ocean can be defined as the water between the Subantarctic Convergence, situated between 45°S and 50°S and the Antarctic continent. The following discussion is based to a large extent on Deacon (1984).

The circulation in the Antarctic Circumpolar Ocean (Fig. 1) is dominated by the deep-reaching Antarctic Circumpolar Current. The transport in this current system which is driven by predominantly westerly winds is about 130 Sv. The velocities are usually between 1-2 knots. Close to the continent easterly winds often generate westward currents.

The meridional circulation pattern shows much smaller velocities but the mass transport may be comparable to that of the circumpolar current. At the surface it is a northward flow up to the Antarctic Convergence (at 50-60°S), where this cold, relatively low salinity water sinks below the warmer and more saline water north of the convergence. This northward flow is compensated by a warmer and slightly more saline southward flow at deeper levels. It enters the circumpolar ocean at 500-1000 metre depth and forms there a relatively warm layer with maximum temperature about 2oC. This southward transport has been estimated to be about 80 Sv. Around the Antarctic continent high salinity, low temperature bottom water is formed. This water originates at the shallow shelf areas or below the ice shelves. Most of the bottom water is believed to form in the Weddell Sea. This water then flows along the bottom into the surrounding oceans. A schematic picture of the meridional circulation is shown in Fig. 2.

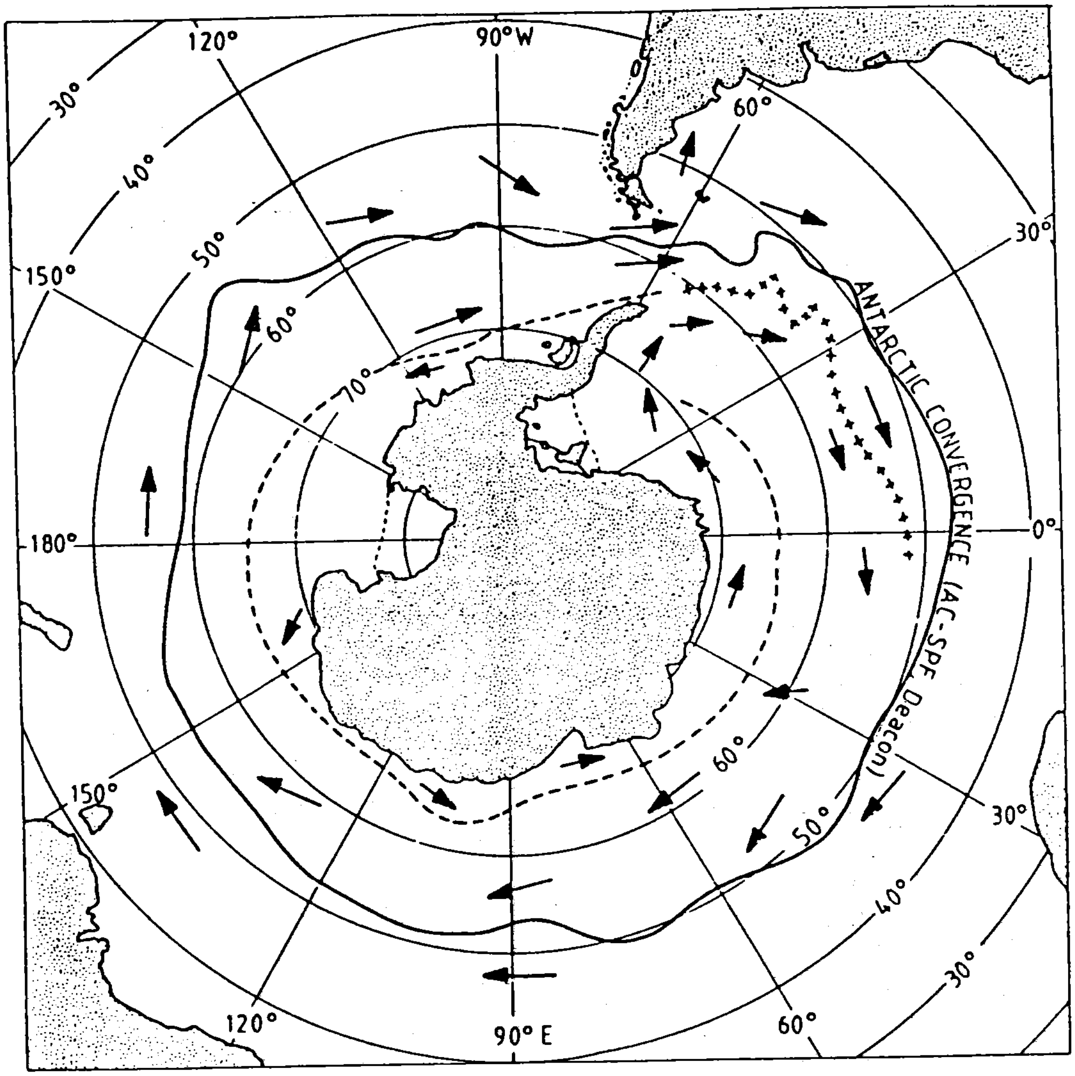

Fig. 1. The surface circulation in the Antarctic Circumpolar Ocean.

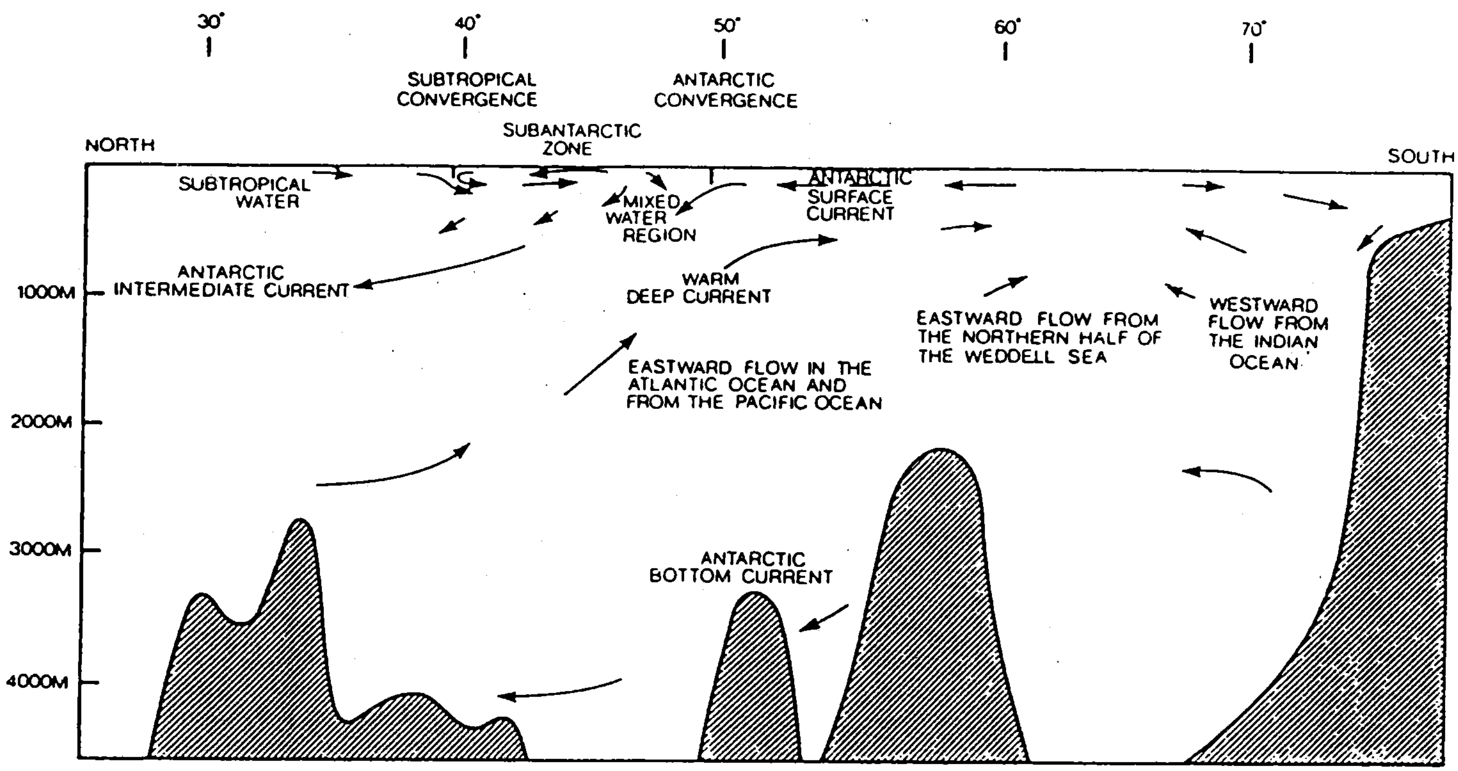

Fig. 2. The meridional circulation in the Antarctic Circumpolar Ocean in a section along 30°W (Deacon, 1984).

It is difficult to find any specific place where marine pollutants could be advected with water into this ocean. One suggested area is the Drake Passage region where eddy formation could help Southeast Pacific water into the Antarctic Circumpolar Current (e.g. Bryden, 1983; Nowlin & Klinck, 1986). The warm, deep current from lower latitudes reaching the surface at about 60°S could be another pathway.

3. HYDROCARBONS IN THE SOUTHERN OCEAN ECOSYSTEM

Monitoring of the Southern Ocean environment and organisms for hydrocarbons has been carried out over the past ten years. This has had two main objectives - the examination of Antarctic systems as possible pristine sites for the establishment of "global" background concentrations of pollutants, and the need to establish baselines for possible future pollution studies of the Southern Ocean.

3.1 Historical background

Studies of hydrocarbons and other contaminants in the Southern Ocean have progressed as methodology has developed. In most cases, detected levels have been low and this requires more refined methods in many cases (G.C. Cripps, pers. comm). Although there have been several sampling campaigns resulting in data on hydrocarbon concentrations and distribution, most have been directed primarily at activities other than pollution monitoring. This has resulted in patchy coverage in space and no useful time series data. In particular, a large proportion of early work was carried out at coastal localities, determined by convenience of access from research stations. It is dubious that these are representative of the majority of the Southern Ocean.

Whilst some compounds are identifiable as pollutants, most are of natural origin (Tables 1,2,3). It is often necessary to carry out extensive analyses of organisms to determine the "natural" biogenic contribution to the hydrocarbon pool.

Table 1. Concentrations of aliphatic hydrocarbons in Southern Ocean seawater, particulates and sediments

	Total n-alkanes	Pristane	Phytane	Reference
<u>Seawater</u>		($\mu g\ dm^{-3}$)		