Preliminary results of the South African SIBEX I Cruise to the Prydz Bay region, Antarctica, 15 March – 3 May, 1984: Overall Résumé

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OVERALL RÉSUMÉ

The thermal structure of the upper ocean layers between Cape Town and Prydz Bay and in the SIBEX area was examined by means of expendable bathythermographs (XBT probes) at stations along two cruise-legs and by Crawford bucket at closely spaced surface stations. These measurements delineated clearly the locations of four major ocean fronts. These were the Agulhas Front, Subtropical Front, Subantarctic Front and Antarctic Polar Front. The temperatures at these features were found to be, in general, higher than the average readings reported in the literature and it was concluded that a well-developed summer thermal regime had been observed. In the surface layers of the SIBEX survey area itself a clear front at 64°30'S and the Continental Water Boundary were the setting for the survey.

Examination of the temperature profiles at each station in the South African SIBEX sector indicates the presence or absence of Winter Water beneath the surface mixed layer. The distribution of stations with a stable midwater column as opposed to those exhibiting active mixing reveals the extent of midwater upwardly inclined isopycnals. These features demonstrate a distinct change in physical conditions along a line at roughly 64°S. It is in the light of this basic phenomenon that the other parameters are evaluated. No evidence emerged to support the earlier Russian and Australian hypothesis that a major Prydz Bay gyre exists in which large swarms of krill appear.

Analyses for the micronutrients silicate, phosphate, nitrate, nitrite and ammonia were undertaken. Ammonia analysis was abandoned because of experimental difficulties. Distribution of silicate concentrations in the surface mixed layer, the Winter Water, and the mid-water mixing layer showed a general horizontal increase toward the south but no frontal effects. The vertical distribution of phosphate and nitrate was uniform in the mixed layer, increased to a maximum around 200 m and decreased toward the bottom. Nitrite was uniform in the mixed layer, decreased in the Winter Water and was undetectable in the Deep Water. The analyses were made to provide a background for biological studies.

Silica and dissolved oxygen were suggested as useful indicator properties to augment, or substitute for, conventional temperature and salinity signatures. They were used to show the presence of newly formed Antarctic Bottom Water that was not detected by temperature and salinity data. In the

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Die termiese struktuur van die boonste oseaanlae tussen Kaapstad en Prydzbaai asook in die SIBEX-gebied is met behulp van afskryfbare batitermograwe (XBT-peilers) ondersoek by stasies langs twee vaartroetes, en ook met behulp van die Crawford-emmer by na aan mekaar geleë oppervlakstasies. Dié metings het die posisies aangedui van vier skerp omlynde oseaanfronte, naamlik die Agulhas-, die Subtropiese en die Subantarktiese front asook die Antarktiese poolfront. By dié fronte was die temperatuur oor die algemeen hoër as die gemiddelde lesings wat in die literatuur opgeteken is. Die afleiding hieruit was dat 'n goed ontwikkelde somertermiese regime waargeneem is. In die SIBEX-waarnemingsgebied was 'n duidelike front in die oppervlaklae by 64°30'S en die Kontinentale Watergrens die terrein waar die opname gedoen is.

'n Ondersoek van temperatuurprofiele by elke stasie in die Suid-Afrikaanse SIBEX-sektor het aangetoon dat daar nie Winter-water onder die oppervlakmenglaag aanwesig is nie. Die verspreiding van stasies met 'n stabiele middelwaterkolom, in vergelyking met stasies waar aktiewe menging voorkom, het die omvang aangedui van opwaarts geneigde middelwater-isopiknale. Hierdie verskynsels dui op 'n uitgesproke verandering in die fisiese toestande langs 'n lyn wat by ongeveer 68°S lê. Die ander parameters word in die lig van dié basiese verskynsel geëvalueer. Daar is geen getuienis gevind om die vroeëre Russiese en Australiese hipotese te staaf dat daar 'n omvangryke sirkulasiekolk in Prydzbaai bestaan waarin groot skole kril voorkom nie.

Daar is analises gedoen ten opsigte van die mikrovoedingstowwe silikaat, fosfaat, nitraat, nitriet en ammoniak. Vanweë praktiese probleme is die ammoniakontleding laat vaar. Die verspreiding van silikaatkonsentrasies in die oppervlakmenglaag, die Winterwater en die middelwatermenglaag het aangetoon dat daar 'n algemene horisontale toename na die suide toe is, maar geen fronteffekte nie.

Die vertikale verspreiding van fosfaat en nitraat was konstant in die menglaag, het tot 'n diepte van ongeveer 200 m toegeneem en verder na die bodem toe afgeneem. Nitriet het reëlmatig in die menglaag voorgekom, maar die konsentrasie was laer in Winterwater en nie meetbaar in Diepwater nie. Die voorgaande ontledings is gedoen om agtergrond vir biologiese ondersoeke te bied.

Daar is voorheen voorgestel dat silika en opgeloste suurstof in die water nuttige aanwysers kan wees ter aanvul-

north of the survey area the silicate content is low in the upper mixed layer and delineates its lower limit. It increases with depth below it. In the south there is no marked vertical gradient. The horizontal demarcation is between 64°30'S and 65°S, substantiating the observed changes in physical conditions at this latitude. Changes in dissolved oxygen concentrations also corroborate this pattern.

The light regime was investigated by means of Secchi disc transparency measurements and determination of attenuation ($\bar{k}$ m^{-1}) by means of a selenium barrier cell incorporating a Schott VG14 optical filter. By these means a mean Secchi disc depth (D) of 19,4 ± 2,7 m was obtained and a mean attenuation coefficient $\bar{k}$ = 0,052 ± 0,01 m^{-1} was found equivalent to an euphotic depth 1 % = 99 ± 11 m. The relation between D and $\bar{k}$ m^{-1} at λ max 525 nm is given by $\bar{k}$ m^{-1} = 1,01/D. Thus when $\bar{k}$ m^{-1} cannot be measured a good approximation is given by the reciprocal of D, viz. 0,052. The euphotic depth (1 %) is then found from *ln* 100/0,052. This relation was used in place of the conventional $\bar{k}$ m^{-1} = 1,70/D that would underestimate the euphotic depth. The very high transparency of the study water is attributed to reduced algal growth and loss of cells from the mixed layer at this time of year. On the whole the chlorophyll concentration was rather low, 0,04 – 0,08 mg m^{-3} (n = 86) with the highest concentration (0,255 mg m^3) being manifest near the pack-ice. A chlorophyll maximum was present at about 100 m and this was more obvious at stations south of 63°S. This appeared to be associated more with proximity to the pack-ice than with the break in distribution of physical properties noted above.

Data on specific production (mg C. mg Chl a^{-1}. h^{-1}) are related to light flux and at low light intensity vertical changes in value coincide with chlorophyll maxima at the bottom of the euphotic zone, and a change in community structure. The results of onboard incubation experiments suggested that the algal community was not operating at maximum efficiency and that the chlorophyll peaks were related to a concentration of degradation products at this depth. Field determinations of the photosynthetic pigments and their breakdown products disclosed that a high proportion of chlorophyll *a* at the pycnocline is present in its degraded form – photosynthetically inactive chlorophyllide *a*. This is reflected in the low productivity values recorded.

Studies of the bacterial biomass above the 100 m pycnocline show an increase of metabolically active bacterioplankton at this depth of high chlorophyllide *a* and low productivity values. The high values of degradation products indicate senescence of the phytoplankton population and, in terms of carbon, estimates of bacterioplankton biomass exceed those of cellular phytoplankton. Detritus is the main source of particulate organic carbon. Calculations of regenerated nitrogen from all sources (protozoan bactivory) zooplankton excretion or bacterial remineralisation suggest that it contributes upwards of 50 % of phytoplankton requirements and confirms its significance to primary production.

The levels of naturally-occurring radioactive nuclide ^{210}Po were comparable with those reported from other oceanographic regions. They appear to be somewhat higher in the krill samples than the published data for other euphausiids. Experimental procedure precludes all but a preliminary note at this stage.

The phytoplankton appeared to be a generally cosmopolitan group. No notable exotic forms were encountered but a number of species regarded as temperate were noted. It

ling of vervanging van die gebruiklike kenmerke soos temperatuur en soutgehalte. Die nuwe aanwysers is gebruik om die aanwesigheid van nuutgevormde Antarktiese Bodemwater aan te toon waar dit nie in temperatuur- of soutinhoudgegewens opgespoor kan word nie. Die silika-inhoud is laag in die boonste menglae in die noorde van die waarnemingsgebied en dui die minimumperk aan. Dieper in neem die konsentrasie toe. In die suide is daar nie 'n uitgesproke vertikale gradiënt nie. Die horisontale begrensing is tussen 64°30'S en 65°S, wat weer eens die waargenome veranderings in die fisiese toestand by dié breedtegraad bevestig. Die veranderings in die konsentrasie van opgeloste suurstof is in ooreenstemming met dié patroon.

Die ligrégime is met behulp van deursigtigheidsmetings met Secchi-skywe ondersoek asook aan die hand van die verswakking ($\bar{k}$ m^{-1}) wat met behulp van 'n seleniumsperlaagsel en 'n optiese filter (Schott VG14) gemeet is. So is 'n Secchi-skyfdiepte (D) van 19,4 ± 2,7 m verkry en 'n gemiddelde verswakkingskoëffisiënt van $\bar{k}$ = 0,052 ± 0,01 m^{-1} wat ekwivalent is aan 'n eufotiese diepte van 1 % = 99 ± 11 m. Die verband tussen D en $\bar{k}$ m^{-1} by λ max 525 nm word deur $\bar{k}$ m^{-1} = 1,01/D gegee. As $\bar{k}$ m^{-1} nie gemeet kan word nie, word 'n goeie benadering deur die resiproke van D, naamlik 0,052 gegee. Die eufotiese diepte (1 %) word dan uit *ln* 100/0,052 gekry. Hierdie verband is toegepas in die plek van die gebruiklike $\bar{k}$ m^{-1} = 1,70/D wat te lae waardes vir die eufotiese diepte sou gegee het. Die besonder hoë deursigtigheid van water in die ondersoekgebied word aan verminderde alggroei en die verlies van selle uit die menglaag tydens dié tyd van die jaar toegeskryf. Die chlorofilkonsentrasie was oor die algemeen taamlik laag, naamlik 0,04 – 0,08 mg/m^3 (n = 86), met die hoogste konsentrasie (0,255 mg/m^3) in die buurt van pakys. 'n Maksimum waarde vir chlorofil is op 'n diepte van sowat 100 m gemeet en was opvallender by stasies suid van 63°S. Dit het oënskynlik eerder verband gehou met die nabyheid van pakys as met die breuk in die verspreiding van die fisiese eienskappe wat hierbo genoem is.

Gegewens oor spesifieke produksie (mg C. mg Chl a^{-1}. h^{-1}) hou met die ligvloed verband; by lae ligintensiteit val die vertikale veranderings saam met die chlorofilmaksima onder in die eufotiese sone en met 'n verandering in die gemeenskapstruktuur. Die resultate van broeikastoetse aan boord dui daarop dat die alggemeenskap nie teen maksimale doeltreffendheid gefungeer het nie en dat die chlorofilspitswaardes met die konsentrasie van afbreekprodukte op dié diepte verband gehou het. Die bepaling ter plaatse van fotosintetiese pigmente en hul afbreekprodukte het getoon dat 'n hoë chlorofil *a*-inhoud vanweë 'n afbreekreaksie (wat fotosinteties onaktiewe chlorofillied *a* oplewer) by die piknoklien aanwesig was. Dit word weerspieël in die lae produktiwiteitswaardes wat aangeteken is.

'n Studie van die bakteriebiomassa bokant die piknoklien op 100 m toon op hierdie diepte 'n toename in metabolies aktiewe bakterioplankton met hoë waardes vir chlorofillied *a* en lae waardes vir produktiwiteit. Die hoë voorkomssyfer vir afbreekprodukte dui op veroudering van die fitoplanktonbevolking en, te oordeel volgens koolstofbepalings, is die biomassa van die bakterioplankton hoër as die biomassa van die sellulêre fitoplankton. Die grootste gedeelte van die organiese deeltjieskoolstof is uit detritus afkomstig. Die berekenings vir geregeneerde stikstof uit alle bronne (protosoïese bakterievreter, soöplanktonuitskeidings of bakteriese remineralisering) dui daarop dat hieruit in minstens 50 % van die

seemed probable that they were relics of a summer population occurring in a predominantly fall, early-winter population. There seemed to be no relationship with the 64°S break in physical conditions but there were indications of a W-E change in community structure that could not be ascribed to any physical parameters. The zooplankton distribution too, held no surprises and, on the whole, environmental conditions appeared to be rather stable. The phytoplankton species encountered were listed and relative estimated abundance was given. Counts were made of the zooplankton species of the copepods, chaetognaths, ostracods and gastropod larvae. Systematic comments were made for both phytoplankton and zooplankton species.

No oceanographic effects were found to concentrate the krill, *Euphausia superba,* in the survey region. Abundance was low in both adults and larvae and the hydrological regime apparently favours larval dispersion, resulting in a low recruitment level. It appears, therefore, that the reported Prydz Bay gyre and associated krill concentration is more ephemeral than heretofore suspected. Many valuable data on net efficiency, distribution of adults and larvae, and maturity stages were obtained and these are compared with published data. A possible distribution constraint by the Antarctic Divergence is suggested.

The data set of krill-eating seabirds, while preliminary, is sufficiently large to compare with the data on plankton distribution especially of *Euphausia superba.* When this comparison is completed it is suggested that statistically significant positive correlations will be manifest.

By and large the results reported in this collection of papers on the descriptive aspect of the SIBEX investigation have reached a stage adequate to warrant embarking on the second, process-orientated phase with confidence in the background they provide.

fitoplankton se behoeftes voorsien word en dat dit derhalwe 'n belangrike rol by primêre produksie vervul.

Die voorkoms van natuurlike radioaktiewe nuklidiese ^{210}Po was vergelykbaar met wat in ander oseaangebiede gevind is. Dit is skynbaar effens hoër in monsters kril as wat vir ander eufousiiede gepubliseer is. Daar kan in dié stadium vanweë die eksperimentele metodes slegs 'n voorlopige opmerking hieroor gemaak word.

Dit lyk asof die fitoplankton 'n algemene kosmopolitiese groep is. Geen vermeldenswaardige eksotiese voorbeelde is teengekom nie, maar daar is 'n aantal spesies opgemerk wat as gematigdes beskou kan word. Hulle was waarskynlik oorblyfsels van 'n somerbevolking wat in 'n oorwegend herfs-/vroegwinterbevolking voorgekom het. Daar was skynbaar geen verband met die breuk in fisiese toestande by 64°S nie, maar aanduidings van 'n verandering in die gemeenskapstruktuur van wes na oos is wel gevind en kon nie aan fisiese parameters toegeskryf word nie. Daar was ook geen verrassings by die soöplanktonverspreiding nie en die omgewingstoestande was oor die algemeen skynbaar taamlik stabiel. 'n Lys is saamgestel van die fitoplanktonspesies wat teengekom is en daar is beramings gemaak van hoe volop elke spesie was. Tellings is uitgevoer vir 'n aantal soöplanktonspesies, naamlik die kopepode, ketognate, ostrakode en gastropodelarwes. Daar is sistematiese kommentaar oor die fitoplankton- sowel as die soöplanktonspesies gelewer.

Volgens waarnemings was daar geen oseaantoestande wat geneig het om kril, *Euphausia superba,* in die gebied te konsentreer nie. Sowel volgroeides as larwes was nie volop nie en die hidrologiese régime het skynbaar die verspreiding van larwes begunstig sodat die rekruteringsvlak laag was. Dit lyk dus asof die Prydzbaai-sirkulasiekolk wat met die konsentrering van kril sou saamhang van meer verbygaande aard is as wat tot dusver vermoed is. Heelwat waardevolle gegewens oor die doelmatigheid van nette, die verspreiding van volgroeide kril en larwes en oor groeistadiums is bekom en met die gepubliseerde gegewens vergelyk. Daar word aan die hand gedoen dat die Antarktiese Divergensie 'n beperkende uitwerking op die verspreiding het.

Hoewel die datastel oor krilvretende voëls slegs voorlopig is, is dit omvattend genoeg om met die beskikbare gegewens oor die verspreiding van plankton – veral *Euphausia superba* – te vergelyk. Wanneer die vergelyking voltooi is, sal statisties beduidende korrelasies vermoedelik aan die lig kom.

In breë trekke het die resultate in hierdie stel artikels oor beskrywende aspekte van die SIBEX-ondersoek 'n stadium bereik waar 'n meer prosesgeoriënteerde fase met vertroue aangepak kan word teen die agtergrond wat beskikbaar gestel is.