

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD  
FISHERIES LABORATORY, LOWESTOFT, SUFFOLK, UK

1990 RESEARCH VESSEL PROGRAMME

REPORT: RV CIROLANA: CRUISE 5 (JONUS 1)

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R Fichez - UEA	15-18	
C Ashcroft - NRA	)	13-14
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DURATION: 3-21 May 1990

Sailed, Lowestoft, 15.00 GMT, 3 May 1990

Docked, Lowestoft, 17.00 GMT, 20 May 1990

LOCALITY:

Humber, Wash, S North Sea

AIMS:

1. To identify and quantify the fate of river-borne nutrients entering the Wash and Humber Estuary, examining nutrient distributions and critical processes from the river inputs through to the North Sea in intertidal and subtidal sediments and the overlying water column.
2. To measure Ra-226 concentrations in filtered water as an indicator of potential anthropogenic sources of naturally-occurring radionuclides, prior to making use of such nuclides to quantify sediment processes.
3. To collect water samples in the S North Sea to examine the distribution of Sb-125, from the Cap de la Hague reprocessing plant.

NARRATIVE

This cruise marked the start of the Joint Nutrient Study (JONUS), set to run for 3 years with an anticipated shiptime commitment of 12 weeks per year. It was assumed that this cruise, JONUS 1, would provide a framework on which the future JONUS programme could be based. Accordingly, this Cruise Report presents a more detailed account of the fieldwork undertaken, and results obtained, than might normally be expected.

CIROLANA sailed from Lowestoft at 15.00 (GMT) on 3 May, following a 24 hour delay as a result of industrial action by the crew - in support of improved working conditions. The ship proceeded to the Humber, anchoring overnight at the Bull Anchorage whilst awaiting a pilot, before moving to the first sediment site off Killingholme. Surface water samples were collected enroute to the Humber for nutrients and salinity analysis. CIROLANA remained at anchor from 10.00 on 4 May to 14.00 on 6 May. Hourly CTD dips were taken, at intervals, with surface and bottom water collected for nutrients, salinity and suspended load.

A transect was run from CIROLANA to Trent Falls using the ship's Searider and the Diving Team's Searider: collecting water samples; taking surface and depth-profile readings of temperature, conductivity, turbidity, and dissolved oxygen; and collecting sediment samples with a Jenkins corer at Trent Falls. An additional transect was run from below Immingham to Hull on 5 May. Following the failure of the Searider-mounted Decca unit, the numbered buoys provided an efficient means of position fixing. A separate report on the sampling programme carried out by the 'mobiles' has been prepared for future JONUS cruises. Sediment samples for pore-water analysis, and incubation experiments (to measure oxygen uptake and nitrate flux out of the sediment), were successfully collected with an NERC-RVS Box corer (30\*30\*~100 cm).

CIROLANA left Killingholme at 14.00 on 6 May and proceeded to the Bull Anchorage, anchoring briefly in the Grimsby Middle to collect a large Box core for pore-water analysis. The ship remained at anchor from 16.00 on 6 May to 09.20 on 9 May. Series of hourly CTD dips were made at intervals throughout.

A transect of surface water samples and T,C, oxygen and turbidity was run from the Bull to Buoy no. 6 on 7 May and a number of cores and in-situ pore-water samples were collected from the tidal flats to the east of Grimsby Dock - using the Seariders. A similar exercise was carried out on the afternoon of 8 May along the Hawke Channel and Trinity Sand to Buoy no. 61. An area of very muddy sediment was discovered close to Spurn Head and cores were collected for pore-water analysis and an incubation experiment. This site could be sampled from the shore using an 'Argocat' or similar vehicle. There was no significant creek development. The Box core was unable to penetrate more than 10-20 cm in the fine sands of the Bull site. Sampling the muddy sediments, which tend to occur near the low-water mark, is best carried out about 1 hour before low water - to prevent the Searider becoming stranded on the fast falling tide; or, the site becoming inundated on the fast rising tide! This places severe restrictions on when certain operations can be carried out.

RRS CHALLENGER anchored about a half-mile due east of CIROLANA from mid-morning to midnight on 7 May, collecting water samples for nutrients and metals as part of the PML Humber Plume study. Alan Morris (PML), the Principal Scientist of the cruise, agreed that much greater collaboration is required between DFR and PML. They were planning to sample off the Wash during the period we were to sample in the Wash and had another cruise to the area in July 1990, coinciding with JONUS 2.

An exchange of scientists took place on the morning of 9 May, using the ship's Searider, before commencing an offshore CTD transect for surface and

bottom nutrients enroute to the King's Lynn anchorage. CIROLANA remained at this site from 16.00 on 9 May until 12.15 on 12 May. A 13 hour anchor station was worked from 07.30 on 10 May. The Searider and the Zodiac collected water and sediment samples from the Lynn Channel and the margin of the Bulldog Sands. The danger of leaving the buoyed channel near low water was demonstrated when the Searider twice ran aground. Conditions were judged to be too rough on 11 May to launch the Zodiac (4/5 NW) but the Searider collected surface water over low water in the Cork Hole. Sea conditions deteriorated further (5/6 NW) and the return leg, and recovery of the personnel and boat, was made with difficulty.

It has become apparent that a major rethink is required on the sampling strategy to be adopted for future JONUS cruises, if the programme is to be successful other than in very calm conditions - most unlikely for much of the year. This should include the role of CIROLANA/CORYSTES; land-based alternatives; provision of sufficient measuring devices (S,T,Turb, diss oxy, etc)); and the most appropriate vehicle(s) for carrying out sampling on the inter-tidal flats. This will be the subject of a separate report. The 'new' survival suits appear to be much more effective than the 'old' models in rough conditions, but, at present, cannot be used for sediment sampling.

The Searider was run into King's Lynn on 12 May to obtain fuel and put ashore 1 scientist. Conditions were too rough for scientific work and the planned sediment sampling from the Zodiac was abandoned. CIROLANA moved position at 12.00 and Box cores were collected, at anchor, near the Roaring Middle Buoy for incubation/flux studies before anchoring close to the Bar Flat Buoy opposite the mouth of the Nene. A 13 hour tidal cycle CTD/nutrients station was worked on 13 May, and a number of Box cores were taken. The ship's Searider rendezvoused with Chris Ashcroft (NRA) and 2 scientists from UnicoMarine, a commercial outfit who have extensive knowledge of the Wash and are under contract to the NRA to carry out water quality surveys of this area. The NRA boat failed to start but a survey of the River Nene, for nutrients, S, T, and DO, was carried out at high and low water using the 'Starfish' (UnicoMarine) - a well equipped inflatable - up to the West Walton Sewage Works. The Searider worked out from Big Tom to no. 1 Buoy in a very choppy sea and the transfer back onboard was made with some difficulty. The Zodiac could not be launched because of the adverse conditions (4/5 N).

In very calm and sunny conditions on 14 May, the Searider collected water samples in the Wisbech Channel, whilst 'Starfish' and the Zodiac took cores, and pore-water samples, from Inner Westmark Knock over low water. Navigation is critical here and it is difficult to avoid becoming stranded for several hours. CIROLANA returned to the King's Lynn anchorage in the evening.

A French scientist, based at UEA, (R. Fischez, CEC funded) was transferred to CIROLANA from King's Lynn on the morning of 15 May. Hourly water samples were collected from Cork Hole and immediately ferried back to the ship to avoid degradation of the organic components. The Zodiac operated near Buoy 8 in the Lynn Channel, taking sediment samples in very soft mud, with a plastic duck-board used to prevent the scientists getting stuck. RRS CHALLENGER was seen operating about 3 miles to seaward.

A 13 hour CTD station was worked on 16 May, with sediment samples being taken from Peter Black Sand, using the Zodiac. Proceedings were enlivened by the presence of a film crew from the International Broadcasting Trust, making a series for BBC TV Schools on environmental issues. They seemed pleased with the exercise. The day's filming will amount to a 2-3 minute sequence! The Searider was used to effect the transfer. CIROLANA returned to the Bar Flat anchorage in the evening.

The Zodiac was used to collect cores from the flat-lying, runneled muds of the Breast Sand, on 17 May. This was carried out on a rising tide, to avoid becoming stranded, and proved to be quite entertaining - demonstrating the need for thigh-waders or immersion suits - but the operation could be more easily undertaken from the land. Whilst collecting water samples from the River Nene, the Zodiac party met a launch owned by the NRA ('CHALLENGER', approx. 20 ft), based in Peterborough and used by the Sea Defence Division. The boat looked well suited for inshore work and it should be possible to arrange its use for future JONUS cruises. The Searider ran in to King's Lynn to: collect fuel; take a crew member to hospital for an x-ray; and collect water for organics analysis. The Diving Team's Searider took water samples from the Freeman Channel, in the afternoon, then retreated in worsening sea conditions. CIROLANA weighed anchor at 06.15 on 18 May. A transect of CTD stations - to assess geostrophic currents - was completed across the mouth of the Wash, on a flooding tide, before moving to an anchorage in the Boston Deep. A 13 hour CTD station was worked and 3 scientists were put ashore in the Searider. Attempts to obtain Box cores were unsuccessful because the bed was too sandy.

The final Searider excursion took place on the morning of 19 May, with surface water collected, and T, S and DO measurements made, from the Lower Road and River Witham enroute to Boston, where 1 scientist was put ashore. CIROLANA weighed anchor at 11.30. The CTD transect across the mouth of the Wash was repeated on an ebbing tide. Surface water samples were taken underway off the Norfolk coast enroute to the Southern Bight.

Water sampling commenced at 03.30 on 20 May, with 3 large volume surface samples collected for  $^{125}\text{Sb}$  and  $^{226}\text{Ra}$  between Noord Hinder and South Falls. CIROLANA then steamed north and docked at Lowestoft at 17.00.

#### RESULTS:

##### 1. Sediment biogeochemistry.

###### (a) Sample collection

The Humber. Box coring was attempted at three sites, two of which were successful. At only one, HSP2 was a full range of sediment process work done. Small boat sampling was attempted at three sites, one at Trent Falls with the aid of the Jenkins corer and two by beaching and collecting material by hand. This method of sample collection was very effective but the discovery of very fluid mud, more a suspension, precluded any process study at the Trent Falls site and sampling had to be stopped at the site behind Spurn Head due to a rising tide. In all four different sediment types were sampled in the Humber survey (muddy sand, sandy mud, mud and fluid mud). Denitrification cores were collected at all sites but no determinations were made due to problems

with the gas chromatograph. Sediment/water flux experiments were conducted at three sites and X-ray radiographs obtained of sediment at three sites. Interstitial water samples were collected at two sites using the 'in-situ' sipper system and at one site by centrifugation of samples from a core. Sediment material from all sites was retained for analysis of grain size distribution, carbon and nitrogen as well as samples for natural series radionuclide determination.

The Wash. Box coring was attempted at five sites and cores were successfully recovered at four of these. Small boat sampling was attempted at five sites and cores were recovered at all of them, though with difficulty due to a rising tide at one. Across the Wash five different sediment types were sampled (sand, muddy sand with *Arenicola* sp., muddy sand, sandy mud and 'ridge-runnel' mud). Denitrification rate was determined at all sites following the resolution of problems with the gas chromatograph and the denitrification assay. Sediment/water flux experiments were conducted for six of the seven sites and interstitial water profiles were obtained at all sites with the 'in-situ' sipper system. Comparisons were made at five sites between interstitial water profiles obtained using the sipper system and using core samples.

(b) Sediment/water flux experiments

Sediment oxygen uptake rate, a measure of the total biogeochemical activity of the sediment, varied as expected with sediment type. The muddier the sediment the greater the rate of oxygen uptake.

Nitrate concentration, in the water overlaying the core, decreased with time in the muddier sediments except for the fluid mud samples of the Humber where there was no change with time. The sand sediments of the Wash showed an initial increase in nitrate concentration followed by a small decrease. The initial increase is probably due to the flushing of interstitial nitrate from these more permeable sediments.

The concentration of phosphate varied little with time at all sites with the one exception of the soft mud from the Spurn Bight which showed a significant flux of phosphate out of the cores. Silicate concentration increased in all sediment types tests.

(c) Interstitial water profiles

'In-situ' sipper profiles and core profiles were compared at a number of sites. At most sites, although the profiles were similar, the concentration particularly of iron and manganese were lower in the core samples than in the sipper samples, this is almost certainly due to oxidation of the core samples during their initial handling. Profiles of iron and manganese usually show one or more peaks in concentration associated with the prevailing redox profile. Nitrate concentration profiles vary greatly from site to site but generally higher concentrations are found in the muddier sediments. The concentration of nitrate usually decreases with depth in the sediments which is not compatible with the sediments being a significant sink of this form of nitrogen, however, the sediment/water flux experiments suggest such a sink but only when the concentration of oxygen in the overlaying water

is decreasing. Denitrification may be taking place in the sediments but the source of the nitrate is most likely to be nitrification in the surface sediments. The indication appears to be that the sediments studied so far in the Humber and the Wash are a source of nitrate.

#### (d) Denitrification rate

There are no denitrification rate determinations for the Humber sediments. In the Wash sediments, positive rates of acetylene-inhibited denitrification were measured which were qualitatively higher in the muddier sediments than in the sandy sediments. Final quantitation of the results remains to be made.

## 2. Nutrients analysis.

In the region of 450 water samples were analysed for nutrients during the cruise. These included river and sea water, sediment pore water, and samples from the on-board flux experiments. Generally, the offshore waters were depleted in nitrate, with abundant phytoplankton leading to long filtration times. Water samples from within the Humber were characterised by high suspended loads, presumed to be predominately inorganic, and relatively high nitrate concentrations. The latter were significantly higher on the ebb tide, both at Killingholme and the Bull anchorage. Samples with elevated nitrate concentrations, and containing appreciable nitrite, were taken from the inner Humber, Great Ouse and Nene. The maximum nitrate concentration ( $540 \text{ umol l}^{-1}$ ) was measured in a sample from the Nene, near the West Walton Sewage Treatment Works.

## 3. Particulate organic matter.

Water samples were collected from the Great Ouse, Nene and Freeman Channel over high water, and from the mouth of the Wash during the flood. In addition, 2 tidal cycle stations were run in the Ouse. These were filtered and will be analysed at UEA for: organic carbon and nitrogen, chlorophyll a and pheopigments, carbohydrate, proteins, lipids and  $^{13}\text{C}$ . It was noted that the 'Clean Salt Supply' pumped water contained a much higher proportion of ruptured biogenic particles compared with water collected using both the UEA displacement sampler and Niskin bottles.

## 4. $^{226}\text{Ra}$ analysis.

Samples of surface water were collected from the Humber, Wash and offshore. Analysis by the radon emanation technique was carried out onboard. The results for 4 Humber and 2 offshore sites have been confirmed, preliminary results for 5 Wash sites are available, and a further 5 Wash and 3 offshore samples will require analysis in Lowestoft. The  $^{226}\text{Ra}$  concentrations in the Wash were unvarying, at  $2 \text{ mBq l}^{-1}$ , with no evidence of enhancement due to agricultural run-off.

In contrast, water samples from the Humber showed a significant enhancement in the  $^{226}\text{Ra}$  concentration compared with the Wash and offshore waters (approx.  $2 \text{ mBq l}^{-1}$ ), with the maximum concentration occurring off Killingholme ( $6.8 \text{ mBq l}^{-1}$ ). It can be inferred that the elevated levels are due to industrial inputs, which must be taken into account before making use of natural-series radionuclides to study estuarine processes.

5. <sup>125</sup>Sb analysis.

Water samples were collected from the UK sector of the Southern North Sea as part of an analytical method development exercise. The aim is to use radiotracers released by the Cap de la Hague reprocessing plant to assess water movement in this region.

6. A computer data base was used to keep track of what had been carried out at which sites and for what purpose, using 'Foxbase' on an 'Apricot Qi'. There will be a need for some such systems as the JONUS programme develops. The data entry was based on the log sheets used for the small boat work and was quite 'user-friendly'. However, the format adopted only allowed a single value (eg a DO reading) per record, resulting in an excessive amount of keying in, and increasing the likelihood of errors. It was decided to exclude 'results' and simply indicate what operations were performed at each site and station. The system needs to be redesigned with the end user consulted. Determinand values are best stored in a format, such as a spreadsheet, which is flexible enough to allow data to be manipulated and plotted out.

Dr P J Kershaw  
(Scientist-in-Charge)  
20 June 1990

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