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Coastal Lagoons of East Anglia, U.K.[1]

R.S.K. Barnes

Department of Zoology
University of Cambridge
Cambridge CB2 3EJ
United Kingdom

ABSTRACT

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Twenty-six remaining coastal lagoons in East Anglia, U.K., fall into six distinct categories on the basis of their origin, physiography, hydrography, and sedimentology, all six either created or heavily influenced by man: (1) pits or other excavations within shingle formations into which water percolates; (2) depressions remaining in reclaimed salt marshes into which springs discharge water retained within adjacent sand dunes; (3) shallow pools floored by clay and filled by water issuing to landwards from out of longshore shingle ridges; (4) streams or small rivers ponded back by low-lying barrier beaches; (5) short-circuited former estuaries; and (6) relict bodies of brackish water. From a world viewpoint, all but category (4) are aberrant in having neither any freshwater inflow (other than rainfall) nor any direct influx of sea water; in common with other northern Atlantic lagoons, all are further atypical in being confined behind barriers composed largely of shingle. Their rather limited macrofaunas and macrofloras, however, are characteristically lagoonal, although there is a wide variation in species from lagoon to lagoon, even between geographically adjacent systems. The precise species found in any given lagoon appear largely to be the result of stochiastic processes, there being no correlation of biotas with physiographic category or environmental type, with the partial exception of lagoonal salinity.

ADDITIONAL INDEX WORDS: *Barrier beaches, brackish-water fauna, coastal lagoons, East Anglia, U.K., geomorphology, reclamation, shingle ridges.*

INTRODUCTION

Coastal lagoons are an important element in the world's coastal environment. All continents, except Europe, have between 10% and 20% of their coastlines in the form of barrier beaches, spits, or islands enclosing lagoons to landwards (CROMWELL, 1971). Characteristically, the enclosing barriers are formed of sand and were constructed by wind-driven waves around the margins of microtidal seas, and typically the lagoons communicate with the parent sea through open channels (BARNES, 1980).

Europe is unusual in having only 5% of its coastline formed by lagoonal habitats, and European lagoons are common only around the shores of the microtidal Baltic, Mediterranean, and Black Seas. Nevertheless, lagoons do occur along the North Atlantic seaboard and around the North Sea, although from a world viewpoint they are aberrant in being enclosed behind barriers of shingle instead of sand. This has resulted from two circumstances: first, the prevalence of shingle as a coastal marine substratum in high latitude regions which have been subjected to glacial action; and secondly, the large tidal ranges typical of the North Atlantic. Large tidal ranges generate powerful tidal currents and these are capable of destroying any incipient barriers of sand created by wave action. Large masses of sea-bed shingle can be swept onshore by storm action, however, and shingle ridges can persist in the face of more vigorous water movements.

During the rise in sea level at the start of the present interglacial period, shingle masses were moved landwards and dammed several small drowned river valleys and estuaries (*e.g.*, LITTLE *et al.*, 1973). Where the enclosed region was subjected to large throughputs of tidal or river water, this flux sufficed (and still suffices) to prevent complete isolation from the sea, and the shingle ridges here take the form of spits partially enclosing estuaries.

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Where, however, the throughput of water was less (usually because of a relatively small freshwater input), complete isolation was effected, with outflow from the enclosed lagoon being only via percolation through the shingle barrier. Such lagoons rapidly evolved into coastal freshwater lakes, and most of the lagoons of the Atlantic coast of Europe are now in this state, sedimentation often having raised the bed of the one-time lagoon above the level of high water in the adjacent sea. Examples include Slapton Ley and (until 1826) Swanpool, in south-west England, and the Etang de Kergalan and Etang de Trunvel in Finistere, Brittany. Where the freshwater input is negligible and the bed of the lagoon is relatively low, brackish water in the form of a mixture of sea water and rain water which have both soaked into the shingle barrier can issue into the lagoonal basin through discrete springs orvia more diffuse discharges; here a more typical lagoonal habitat is maintained, as, for example, the Etang de Nerizelec in Finistere and various small lagoons entirely enclosed within some shingle-ridge systems, *e.g.* at Porlock in southwest England (BARNES, unpubl.). All such lagoons, however, are still further aberrant in lacking any direct connection with the sea. Only when the orientation of the coastline is such that the shingle barrier takes the form of a spit rather than a barrier beach (a rare occurrance in Atlantic Europe) does a more typical lagoon result, with an entrance/exit channel near the tip of the enclosing spit, as seen in The Fleet in southwest England.

In Britain, shingle occurs at various points around the coast, besides in the southwest (RANDALL, 1977), and lagoons or lagoon-like systems are accordingly scattered along the British coastline. East Anglia, however, possesses a more marked concentration of such features than most areas outside Devon and Cornwall, and this paper presents the results of a survey of these habitats from The Wash to the Thames Estuary, carried out under contract to the Nature Conservancy Council as part of a larger survey of Britain's remaining coastal lagoons. For the purposes of the East Anglian survey, a lagoon was considered to be a permanent coastal pond of saline or brackish water, isolated or semi-isolated from the sea but which nevertheless receives its salts from the sea as a result of natural causes. Artificial 'scrapes' constructed within bird reserves for waders and wildfowl—for example those created by the Royal Society for the Protection of Birds at Titchwell (Norfolk) and at Minsmere and Havergate (Suffolk)—were not included within this survey; neither were the linear, sluiced, former tidal creeks ('fleets') which are common in Essex, nor the drainage-dykes and borrow-ditches abundantly located immediately to landwards of the sea walls throughout East Anglia. Physiographically, these are in no sense lagoons, although they do contain a characteristically brackish-water biota (*e.g.* HOWES, 1939) and would repay survey and detailed investigation in respect of the occurrance of nationally rare brackish-water species. The same applies to a number of ornamental lakes, boating ponds, and swimming pools (many of them originating as lagoons) into which sea or estuarine water is now pumped artificially.

Potential lagoons were identified from large-scale Ordnance Survey maps, from aerial photographs in the collection of The Committee for Aerial Photography in the University of Cambridge, as a result of personal communications from the various officers of the Nature Conservancy Council in East Anglia, and from the available published literature. A total of 40 coastal bodies of water or sites where such bodies had been reported

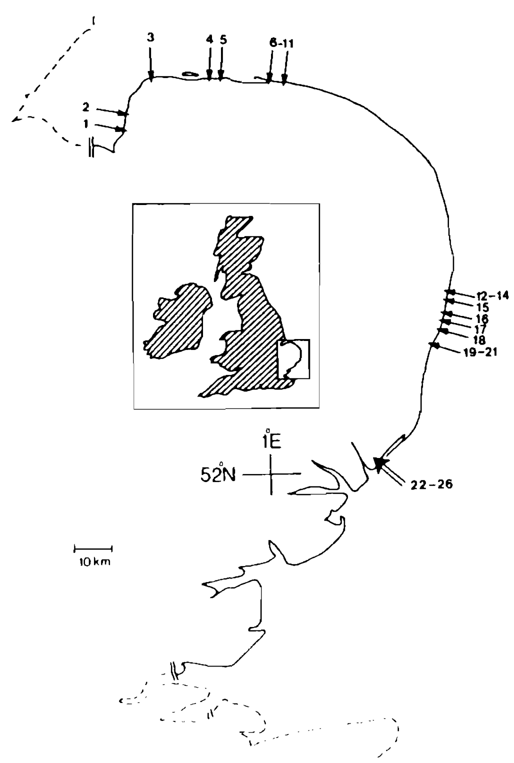

Figure 1. Sketch-map of East Anglia, showing the location of the 26 lagoons surveyed.

to occur were visited in 1984 (Norfolk) and 1985 (Suffolk and Essex), of which 26, all in a 200 km stretch of the Norfolk and Suffolk coastline (Figure 1 and Table 1), proved to fall within the definition of a lagoon accepted above. The majority of the other 14 sites were once lagoons but have now ceased to be so as a result of man-made changes. Information on the topography, geomorphology, hydrology, salinity of the water, bottom sediments, and dominant macroscopic organisms (submerged and emergent macroflora, and benthic and pelagic macrofauna) was recorded from each lagoon. It should be stressed, however, that the survey was extensive, not intensive in nature, and that the organisms recorded can in no sense be regarded as complete species inventories. Individual data-sheets on each site have been lodged with the Nature Conservancy Council, Peterborough, U.K.: this paper therefore concentrates on general features and presents an overview.

RESULTS: THE NATURE OF THE LAGOONS

The surviving lagoons of East Anglia fall into one or other of six distinct physiographic types.

1: Pits Located Within Shingle Formations

These are often created in whole or part as a result of the extraction of shingle for construction purposes (Figure 2 and Table 1: lagoons 1, 12, 13,

Table 1. *The coastal lagoons of East Anglia.*

Site	British National Grid ref.	Area water (ha)	Salinity at time of visit (‰)	Freshwater input (other than rainfall)	Means of seawater input
Pits located within shingle formations					
1 Snettisham	TF 649306-648333	18	17-20	-	percolation
12 NW Pool, The Denes	TM 535842	1.5	4-5	-	percolation
13 NE Pool, The Denes	TM 536840	2	24	-	percolation and overtopping of barrier
14 S Pool, The Denes	TM 536837	0.3	30	-	percolation and overtopping of barrier
22 'Lagoon 7', Shingle Street	TM 374437	2.5	31	-	percolation
23 'Lagoon 6', Shingle Street	TM 373437	0.3	30	-	percolation
24 'Lagoon 4', Shingle Street	TM 372433	0.8	31	-	percolation
25 'Lagoon 1', Shingle Street	TM 362419	0.8	31	-	percolation
26 'Lagoon 0', Shingle Street[nb]	TM 359408	3	27-28	-	percolation
Depressions in reclaimed salt-marshes					
3 Broad Water	TF 712446-720448	4.5	17-20	-	percolation (via springs)
4 Holkham Salts Hole	TF 886451	0.5	24	-	percolation (via springs)
5 Abraham's Bosom	TF 912452	1.5	28-29	-	percolation (via spring-fed stream)
11 Eastern Gramborough Hill lagoon	TG 087442	0.2	17-18	-	unknown
Ponded-back streams					
15 Benacre Broad	TM 532828	8	6-7	streams	overtopping of barrier
16 Covehithe Broad	TM 523808	0.5	11-12	stream	overtopping of barrier
17 Easton Broad	TM 518793	3	1-1.5	stream	former overtopping of barrier
Percolation pools to landwards of barrier shingle ridges					
6 Half Moon Pond	TG 049453	0.4	6	-	percolation
7 Arnold's Marsh lagoon	TG 062448	3.5	29-30	-	percolation
8 Salthouse Broad	TG 068446	4	29-31	-	percolation
9 Little Eye	TG 078444	0.4	32-33	-	percolation
10 Western Gramborough Hill lagoon	TG 083442	0.2	26-27	-	percolation
19-21 Pools N of Dunwich	TM 487729-485723	**each**<0.5	27-29	-	percolation
Former estuaries					
2 Heacham 'Harbour'	TF 654350-661362	4.5	3-5	river	direct inflow
Relict					
18 Southwold Pool	TM 510769	2	1	pumped	relict

[nb] Nomenclature of the Shingle Street lagoons (nos. 22-26) is after COBB (1958)

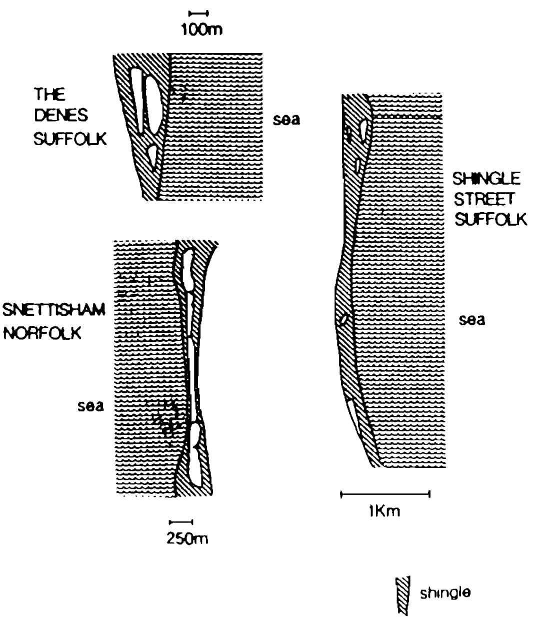

Figure 2. Topography of East Anglian lagoon systems enclosed within coastal shingle formations.

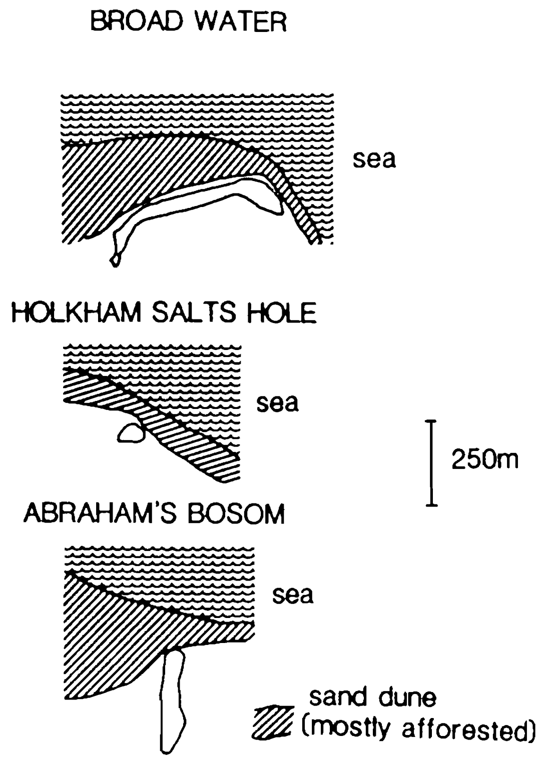

Figure 3. Topography of East Anglian lagoons formed in depressions remaining in reclaimed salt marshes.

14, 22, 23, 24, 25, and 26). The pits do not receive freshwater input except for rainfall (including that which has soaked into the surrounding shingle). The seawater influx occurs by means of percolation through the shingle barrier seawards, supplemented somewhat by the overtopping of the barrier during storms occurring at times of high water. This category includes the deepest of the East Anglian lagoons (greater than 1 m). All are floored by shingle with a superficial covering of silt.

2: Depressions in Reclaimed Salt Marshes

These features were originally part of the beds of saltmarsh creeks into which water now issues from dune-capped shingle ridges (Figure 3 and Table 1: Lagoons 3, 4, 5, and 11). During high tide in the adjacent sea, seawater soaks into the sand and shingle barrier where it mixes with freshwater derived from rainfall. During low tide, some of this brackish water discharges seaward along the fronting beach. If the region is low-lying, some discharge is also through springs on the landward side of the barrier and it can collect in any appropriately located basin (see HUNT, 1971). The freshwater component of this brackish influx is the only direct freshwater input into these lagoons, other than rain falling on the surface. Their substratum is sandy, together with variable amounts of surface silt.

3: Ponded-back Streams or Small Rivers

These ponded streams and small rivers built up reed-fringed lakes behind low-lying sand and shingle barriers and rose in level as sedimentation filled the basin (Figure 4 and Table, lagoons 15, 16, and 17). Seawater enters these systems by overtopping of the low barriers during particularly high tides. Lagoon water leaves by evaporation and percolation through the barrier. Seawater cannot enter by percolation because of the high level of the lagoon relative to that of the sea. The salinity of these lagoons is therefore a reflection of the frequency and magnitude of the seawater inflow. All the East Anglian examples of this type of lagoon are experiencing erosion and landwards movement of the confining barrier; these are rapidly reducing the area of each lagoon. In Easton Broad, the height of

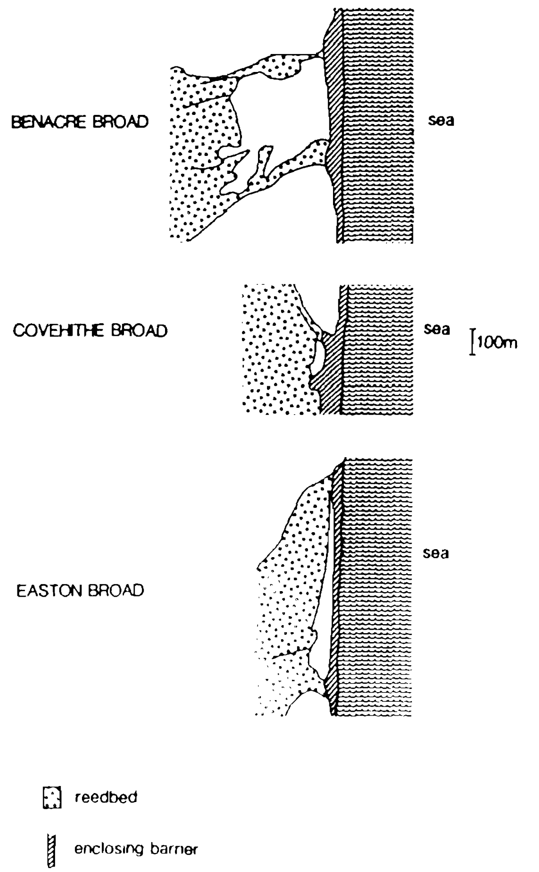

Figure 4. Topography of East Anglian lagoons formed by the damming of small rivers by coastal barriers.

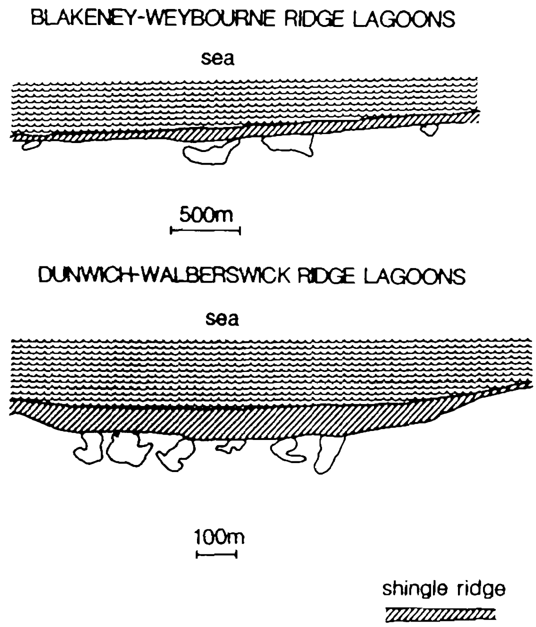

Figure 5. Topography of East Anglian lagoons receiving the landwards discharge of water by percolation from out of longshore shingle ridges.

the barrier has recently been increased artificially by bulldozing, which results in a low salinity (c 1°/oo). The extensive reedbeds contribute much organic debris to the basic sand and silt substratum.

4: Shallow Pools with a Clay Substratum Immediately to Landwards of Barrier Shingle Ridges

These shallow pools, often occurring in former grazing marshes, collect the water which issues from shingle ridges. Such lagoons characteristically occur in linear series along the length of longshore shingle ridges and range in size from small puddles to over 4 ha (Figure 5) and Table 1: lagoons 6, 7, 8, 9, 10, 19, 20, and 21). These possess no source of freshwater input other than that discharging out of the shingle and their salinities are normally only slightly below that of seawater. In several cases, the lagoonal water is prevented from draining away laterally by old embarkments dating back to earlier attempts to drain former fresh- or salt marshes landwards. Generally, the clay substratum is overlain by a layer of silt.

5: Former Estuaries

Heacham 'Harbour' (Figure 6 and Table 1: lagoon 2) was the estuarine section of the original bed of the Heacham River. The river was diverted naturally some 3 km by southwardly moving sand and shingle along the eastern shore of The Wash (STEERS, 1964). The present discharge point of the river is an artificial culvert through a sea wall 2 km upstream from the original mouth, which is now closed by sea defences. The lagoon is therefore an elongate backwater of the Heacham River (2.1 km long, but only 3-30 m wide) in the form of a diverticulum continuing the line of the present river beyond the discharge point. During the extreme high water of high spring tides, water flow in the culvert is reversed and seawater enters the river

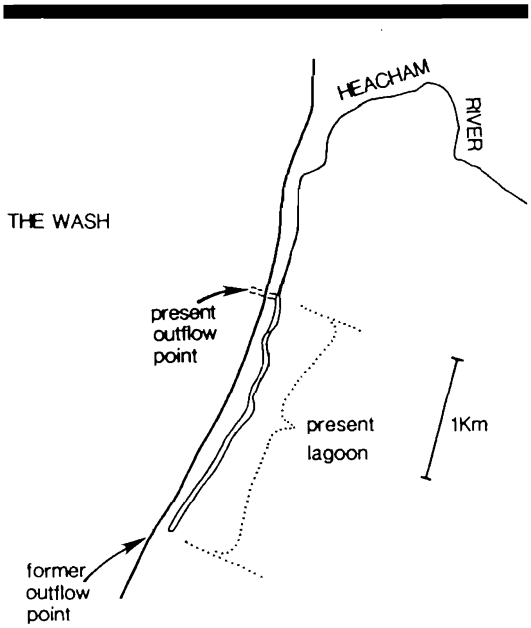

Figure 6. The topography of Heacham 'Harbour' in relation to its origin.

system. Being lower than the present artificial mouth, it is the lagoon which receives most of the seawater influx. The salinity is reduced in the process of admixture with the river water.

6: Relict Systems

The final lagoon (Table 1: lagoon 18) is entirely artificial. It is an excavation in a coastal reedbed into which seawater was once pumped to produce a boating lake. This pumping no longer takes place, having been replaced by a freshwater source. The salinity is 1 °/oo. Such salts as remain are relict.

Field evidence exists for the former occurrance of further lagoons. It is quite probable that others have long since disappeared, particularly in areas of land reclamation. At least two lagoons (at Shingle Street, British National Grid refs. TM 365423 and 368428) have been lost as a result of coastal erosion. A further one at Shingle Street (TM 371434) has filled in with sedimentation. Some lagoons have been drained (*e.g.* at Titchwell, TF 765448 and at Jaywick, TM 161133). Others have become freshwater pools, largely if not entirely occluded by reeds (*e.g.* at Overy Staithe, TF 855450, and at Weybourne Hope, TG 109436). A number have been sheathed in concrete to form paddling pools, boating lakes, etc. (*e.g.* at Clacton, TM164135). The former lagoon at Titchwell was studied by WILLIAMS (1972).

RESULTS: MACROFAUNA AND MACROFLORA

The survey recorded a total of 4 macroalgal, 10 plant, and 44 animal species from the lagoons of East Anglia (Table 2), together with one taxon (chironomid larvae) not identified to species. Two further animal species—the hydroid *Cordylophora caspia* Allman and the bryozoan *Conopeum seurati* (Canu)—were also recorded, 'accidently', in that their habitat (attached to the submerged portions of *Phragmites* stems) was not one specifically sampled by the survey. The bryozoan is of some interest in that it is an anascan known from lagoonal habitats in the Mediterranean, but hitherto in Britain only from estuarine and fleet localities (RYLAND and HAYWARD, 1977).

Although the total species list was large, each individual lagoon, however, contained relatively few animal species (mean number 8, median 7, range 2-17). No correlations were evident between the number of species per lagoon and (a) lagoonal salinity ($p > 0.05$), (b) the presence or absence of fringing macrophytes ($p > 0.9$), (c) the physiography or hydrographical characteristics of the system ($p > 0.05$), or (d) the area of the water body ($p > 0.05$). Some species were present in more than half of the lagoons (*Nereis diversicolor*, *Arenicola marina*, and *Idotea chelipes*, for example) and at least half of the lagoons contained one species of *Corophium*, at least one other amphipod species, and one mysid, hydrobiid gastropod, burrowing bivalve and small fish, although the precise species in these groups varied from lagoon to lagoon. In respect to the mysids, no more than a single species occurred in any one lagoon, the three species found in total being differentially distributed with salinity (Kruskal-Wallis $0.05 > p > 0.02$), with *Neomysis* occurring in the least saline systems (mean 11°/oo; range 1-30), *Praunus* in somewhat more concentrated waters (mean 26°/oo; range 18-31), and *Paramysis* being restricted to near seawater conditions (30-32°/oo). *Paramysis* was also confined to a small geographical area, occurring only in two adjacent north Norfolk lagoons. No such effect of salinity was evident in the distributions of the two small fish ($p > 0.05$): *Pomatoschistus* 4-29°/oo; *Gasterosteus* 6-31°/oo.

Although fourteen of the lagoons supported hydrobiid gastropods, in only two did more than one

Table 2. *The benthic and pelagic macroflora and macrofauna recorded from the East Anglian lagoons.*

Chlorophyceae:	
Ulva lactuca (L.)	*Enteromorpha intestinalis* Link.*
Rhizoclonium sp.	*Chaetomorpha* sp.
Tracheophyta:	
Potamogeton pectinatus L.	*Ruppia cirrhosa* (Petagna)
Zostera marina L.	*Zostera angustifolia* (Hornem.)
Zannichellia palustris L.	*Juncus maritimus* Lam.
Juncus gerardii Lois.	*Scirpus maritimus* L.
Phragmites australis (Cav.)*	*Ceratophyllum demersum* L.
Anthozoa:	
Sagartia troglodytes (Price)	
Nemertea:	
Lineus ruber (Müller)*	*Amphiporus lactifloreus* (Johnston)
Polychaeta:	
Nereis diversicolor (Müller)*	*Scoloplos armiger* (Müller)
Pygospio elegans Claparède*	*Arenicola marina* (L.)*
Ampharete grubei Malmgren	
Oligochaeta:	
Tubificoides benedeni (Udekem)	
Isopoda:	
Jaera albifrons Leach	*Idotea chelipes* (Pallas)*
Cyathura carinata (Krøyer)	*Sphaeroma rugicauda* Leach
Sphaeroma hookeri Leach	
Amphipoda:	
Corophium volutator (Pallas)*	*Corophium arenarium* Crawford
Gammarus salinus Spooner	*Gammarus duebeni* Liljeborg*
Gammarus zaddachi Sexton	*Gammarus locusta* (L.)
Melita palmata (Montagu)	*Microdeutopus gryllotalpa* Costa
Dexamine spinosa (Montagu)	
Mysida:	
Praunus flexuosus (Müller)	*Neomysis integer* (Leach)*
Paramysis nouveli Labat	
Decapoda:	
Palaemonetes varians (Leach)*	*Carcinus maenas* (L.)
Polyplacophora:	
Lepidochitona cinerea (L.)	
Gastropoda:	
Hydrobia ulvae (Pennant)	*Hydrobia ventrosa* (Montagu)*
Hydrobia neglecta Muus	*Potamopyrgus jenkinsi* (Smith)
Littorina saxatilis (Olivi)	*Retusa obtusa* (Montagu)
Bivalvia:	
Cerastoderma glaucum (Poiret)*	*Abra tenuis* (Montagu)*
Mya arenaria L.	
Insecta:	
chironomid larvae	*Sigara concinna* (Fieb.)
Sigara stagnalis (Leach)	*Notonecta glauca* (L.)
Echinodermata:	
Amphipholis squamata (Delle Chiaje)†	
Osteichthyes:	
Gasterosteus aculeatus (L.)*	*Pomatoschistus microps* (Krøyer)*

*occurring in at least one-third of the lagoons
† recorded by BARNES and HEATH (1980) from Lagoon No. 24, though not seen during the present survey

species co-exist, and even then one species was scarce whilst the other was abundant. In contrast to the situation in other areas (see, *e.g.*, MUUS, 1967), except in respect to *Potamopyrgus*, which was confined to low-salinity habitats (0-4°/oo), the differential occupation of the various lagoons did not appear influenced by salinity (Kruskal-Wallis; $p > 0.8$).

The most widespread species, *Hydrobia ventrosa*, occurred over a range of 1-31°/oo in the ten sites inhabited, although most of its stations were within the range 18-30°/oo exactly the same as that shown by the other species, *H. ulvae* and *H. neglecta*, over the three lagoons in which each species was found. (In a more extensive survey of the distribution of these four hydrobiids through East Anglia (including non-lagoonal habitats), CHERRILL and JAMES (1985) recorded field tolerance ranges of, *P. jenkinsi*, 0-19°/oo; *H. ventrosa*, 3-36°/oo; *H. ulvae*, 9-40°/oo; *and H. neglecta*, 13-35°/oo. *The record of H. ventrosa* (at Southwold, Table 1, lagoon 18) flourishing in water of 1°/oo is therefore noteworthy.)

Apart from the expected (NAYLOR, 1972) differential distribution of the two species of *Sphaeroma* along the salinity gradient (*S. hookeri* 1-6°/oo; *S. rugicauda* 24°/oo), and the position with respect to the mysids mentioned above, lagoonal salinity appears to play little role in the presence or absence of particular species from the East Anglan lagoons; neither (see above) does it influence overall species diversity. Yet a classification of the faunas and floras of the individual lagoons using CLUSTAN 2, presence/absence data and the Jaccard coefficient as modified by BARNES (1968) reveals the similarity dendrogram displayed in Figure 7. Three broad clusters and four outlying lagoons are evident. These clusters bear no relationship to the physiographic and hydrographic nature of the lagoons as identified in the previous section: indeed, each cluster contains lagoons of three or four different historico-environmental types. The only feature which correspond to any extent with these clusters based on biotic similarity is lagoonal salinity. Cluster C and related outlier A are all low salinity systems (<13°/oo), although lagoon 18 with a salinity of 1°/oo falls into Cluster B; and Cluster D includes only high salinity lagoons (<23°/oo). This notwithstanding, joining the lagoons together by means of a multiple-linkage system (a Prim Network, using the algorithm of FARRIS, 1970) indicates that Cluster C is 'polyphyletic', its two components being allied to different sections of Cluster B (Figure 8). The lagoons receiving a direct influx of seawater, even if only sporadically, are all in Cluster B, but also contained in that cluster are systems without any such input.

DISCUSSION

The faunas and floras of the sites surveyed are typically lagoonal (BARNES, 1980) and they in-

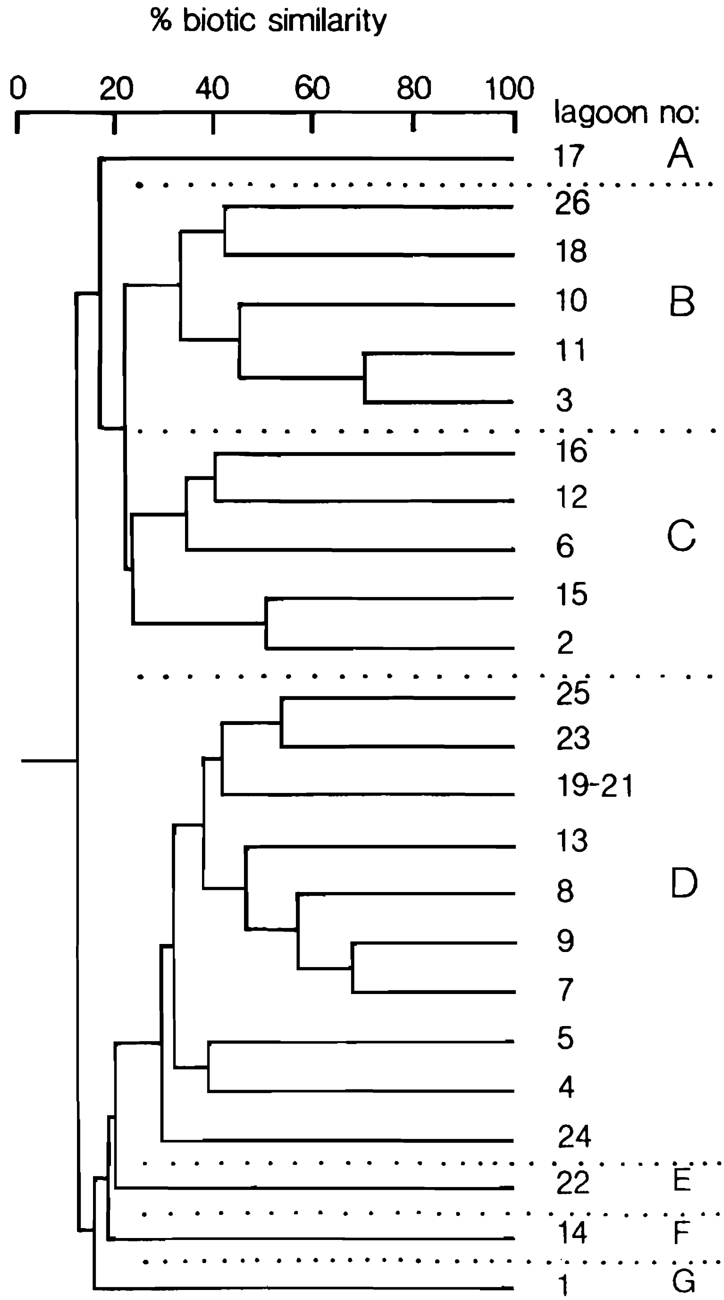

Figure 7. The similarities of the biotas of the various lagoons as shown by a dichotomously-branching dendrogram derived from modified Jaccard Coefficients (linkage by highest group average values).

clude few, if any, surprises. What is more surprising, however, is the wide variation in species from lagoon to lagoon, even with regard to geographically adjacent systems: the mean similarity coefficient between any two lagoons was less than 20%: and that between adjacent lagoons only averaged

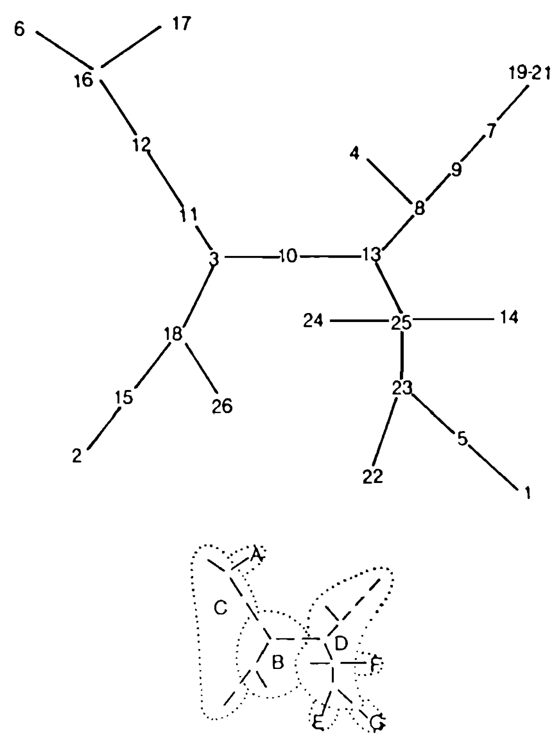

Figure 8. The similarities of the biotas of the various lagoons as shown by a polychotomously-branching Prim Network derived from modified Jaccard-Coefficient complements. (The angles between the connecting lines are arbitrary, but the lengths of the lines are proportional to similarity.)

30%. Equally counter-intuitive is the lack of correspondance between lagoonal biotas and the physiographic category of the lagoon, since the latter affects both the hydrographical regime and the nature of the bottom sediments *inter alia.* As emphasized above, this survey was extensive rather than intensive, and therefore both the total biota recorded and those from individual lagoons must be regarded as referring only to the more abundant organisms. This will particularly be so in respect to the larger systems, most of which were inaccessible by virtue of a fringe of dense reedbeds (*e.g.* Benacre Broad): here sampling was of necessity limited to localized regions. On the other hand, the surveyed organisms of the smaller lagoons probably give a fairly accurate indication of the total microbiota. The survey , for example, recorded 17 of the 19 species of benthic and pelagic macrofauna described from Holkham Salts Hole by PANTIN (HUNT, 1971) in his much more intensive survey which extended over several years, including all dominant ones. The phenomena highlighted above are therefore almost certainly real.

Part, at least, of the explanation probably lies in the means by which organisms can colonize the lagoons of East Anglia, which are aberrant in lacking free connections with the adjacent marine water mass (the North Sea) and, in the majority, in lacking any direct freshwater input other than rainfall. HUNT (1971) considered that the fauna of one of the lagoons formed from part of an original salt-marsh creek was a relict marine one, and this may be so for a few of the elements in its fauna. But many of the species recorded from that and the other lagoons do not occur in salt-marsh creeks or even in salt marshes and must have been later arrivals. Most of the East Anglian lagoons have never been part of the sea bed and cannot contain any relict species. Yet species such as *Nereis, Arenicola, Pygospio* and *Lineus* occur in these to the same extent as they do in the lagoons originating as parts of salt marshes. Some species may have gained access to some of the lagoons via sea water overtopping the barriers during storms, *etc.*, but many lagoonal species (*e.g.*, *Cerastoderma glaucum* and *Hydrobia ventrosa*) do not appear to be present as pools of potential colonizers in the open North Sea around East Anglia. It is therefore by no means obvious how animals of essentially marine ancestry and unable to withstand fresh water can gain access to land-locked lagoons. The oft-quoted explanation, dating back to Charles Darwin, is largely apocryphal: filamentous algae containing the juvenile stages of lagoonal species are suggested to be transported from lagoon to lagoon wrapped around the feet of birds, but there has been no systematic survey of the extent to which this phenomenon actually occurs. Such is known to be the case with respect to the animals inhabiting temporary bodies of fresh water (PROCTER,1964), but lagoonal species do not possess the resistant stages which characterize members of that fauna (see, *e.g.*, TALLING, 1951). In any event, it would appear highly likely that there is a large stochiastic element to colonization, which is reflected in the dissimilar faunas of adjacent land-locked lagoons.

Overall, the dominant characteristic of the lagoonal habitats of East Anglia is that, in whole or in part, they have been created unintentionally by man, either by excavation for gravel, by salt-marsh or other reclamation works, or by the construction of sea-defense systems. Only the dammed streams of the north Suffolk coast (Benacre, Covehithe, and Easton Broads) appear to be natural in origin, although even here the isolating barriers have been reinforced by man, in some cases as part of coastal protection schemes. And judging from the number of lost systems, what man has created unwittingly, he has later highly modified or eliminated. More recently, however, the future of several of the remaining lagoons has been safeguarded largely, if not entirely, by the bird-watching fraternity as a consequence of the use of lagoons as flight ponds by waders and wildfowl. Indeed, large numbers of additional lagoon-like 'scrapes' have been created in East Anglian bird reserves to encourage waders (see, *e.g.*, AXELL and HOSKING, 1977; BISHOP, 1983). Since it appears that irrespective of their heavily human-influenced origin and environment, the existing lagoons of East Anglia all contain as characteristic a suite of lagoonal organisms as do more natural lagoonal systems elsewhere, there is every reason to believe that these 'scrapes' will have been similarly colonized. Further the possibility clearly exists of creating lost lagoonal habitats in areas which have suffered more severe losses than East Anglia.

Of the different East Anglian lagoons, a very large proportion are included in some of form of nature reserve and hence are safeguarded, to various degrees, against 'development'. Only the boating lake at Southwold (lagoon 18) has no conservation status at present. The widespread inclusion of these sites in nature reserves is reflected in their environmentally healthy state. This notwithstanding, part of the shoreline of the Snettisham lagoons, of Heacham 'Harbour' and of Abraham's Bosom is surrounded by caravan parks, and Abraham's Bosom, at least, is still as visibly polluted over most of its area now as it was ten years ago (HAMOND, 1972; WILLIAMS, 1973). The absence of several otherwise widespread species from this lagoon (*e.g.*, *Nereis*, *Idotea*, *Palaemonetes*, hydrobiids, amphipods, *etc.*) may well be a consequence of the use of herbicides to control the submerged vegetation for the benefit of pleasure boating, and/or of the input of material from the permanent and temporary caravan sites (local residents report the presence of considerable quantities of toilet paper in the lagoon in the past).

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□ ZUSAMMENFASSUNG □

Die übrige 26 küstliche Lagunen Ost-Anglias (UK) lassen sich in 6 verschiedenen Klassen, die seine Herkunft, Physiographie, Hydrographie und Sedimentologie zugrunde lesen, zu ordnen: (1) Löche oder Ausgrabungen in Schindelformationen, worin Wasser durchtropft; (2) Senken in wiedergewonnenen Salzsumpfen, worin Entladungswasser von nahliegenden Dünen fliesst; (3) seichte Teiche mit Tonboden und mit Wasser von Schindelkämme gefüllt; (4) Bäche oder kleine Flüsse, die von Barrierestrände gedämmt werden; (5) kurzfristige vorige Trichtenmündungen; und (6) uralte salzige Wasserkörper. Alle Klassen (abgesehen von (4)) sind aussergewöhnlich; sie haben keine Süsswasserquelle (Regen ausgenommen) und auch keine direkte Meerwasserquelle; wie andere nordatlantische Lagunen sind sie auch aussergewöhnlich, weil sie werden von Schindelformationen begrenzt. Seine Makroflora und Makrofauna sind andererseits typisch, obwohl gibt es weite Unterschieden dieser Pflanz- und Tierwelten untern Lagunen (in ein Paar Fälle gibt es Unterschieden zwischen geographisch anliegenden Lagunen).--*Stephen A. Murdock, CERF, Charlottesville, Virginia, USA*