Mussel Spat Collection and Cultivation Trials in Wales Using Bouchots 1987-89

Seafish Report No. 375

April 1990

SEA FISH INDUSTRY AUTHORITY

Seafish Technology

Seafish Report No. 375

Clive Askew

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SUMMARY

In order to investigate the commercial viability of using the French system of growing mussels on vertical poles, or 'bouchots', in South Wales, a trial set of bouchots was set up in the Spring of 1987. The area selected has close to the highest tidal amplitude in the British Isles. Growth was monitored for two summers, after which the mussels produced in the trial were harvested, purified, graded and packed in a commercial plant. They were then distributed to a number of wholesalers in order to obtain a trade view of their quality and a realistic valuation of the finished product. A minimum commercial length of 45mm. was used, corresponding with the preferred size of mussel on the French market, though smaller than the 50mm currently applied to wild caught mussels in the South Wales Sea Fisheries Committee District..

In response to commercial interest expressed by one of the companies cooperating in the trials, a complementary trial was established in the Menai Straits using modified methods to take account of the much smaller tidal amplitude of North Wales. In the first year horizontally suspended 'bouchots' made from plastic drainpipe were used at this site, and in the second year this was changed to horizontally suspended Italian 'pergolari' tubular mussel netting. An attempt to use pergolari suspended vertically from a scaffold structure at the South Wales site was discontinued after the scaffold was destroyed in a storm.

The source of mussel spat used for the main bouchot trial was Morecambe Bay, while for the pergolari, larger dredged seed from a commercial bed off Caernarfon was used. During the first two years of the study, seed collector ropes were set up in the vicinity of the bouchots in South Wales. During the final year efforts were concentrated on investigating the distribution of spatfall in more open waters around the south-west coast of Wales. Newly developed fibrilated polypropylene collector ropes were used in this part of the study.

A computer program was developed to model the combined form of the long term growth pattern of the mussels and the seasonal distribution of growth. This was used to extrapolate the growth data obtained, and to compare the growth performance of the seed at the two sites.

The trials have been used as the basis for a projection for a commercial unit in the area. It is possible that with good husbandry a yield of 20 Kg. per bouchot pole could be achieved. The mussels produced are of high meat yield, up to 38% and the trade response to them indicated that a conservative price of £450 per tonne would be realistic, despite some devaluation caused by external fouling of the shells by barnacles (*Elminius*).

For an investment of approximately £20,000 p.a., a return of £45,000 p.a is projected with sales starting at the end of the second year of operation. The area available to be farmed is, however, limited and the operation is seen as a supplementary activity to fishing in the area.

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1.0 BACKGROUND

The demand for high quality mussels is increasing rapidly both on the continent and in the home market, where Seafish funded market research has identified them as having very good potential for expanding sales. Coupled with live sales, the development of chilled, prepared mussel dishes and similar frozen products has led to an accelerated demand for mussels. France remains a net importer of live mussels, One important feature of this market is the two to three fold premium paid for quality bouchot grown mussels. Mussels grown off-bottom have the advantage of being grit free, and are generally much cleaner in appearance than wild or even bottom cultured mussels. They have thinner shells, resulting from the faster growth rate when suspended, and this reflects in a higher percentage meat yield, sometimes in excess of 40%, whereas wild mussels on the bottom rarely exceed 25% yield. Bouchot grown mussels have a further advantage because the aerial exposure they receive during spring tides strengthens their closing ability and this greatly increases their shelf life compared to mussels which have been grown permanently submerged. This can enable bouchot mussels to be sold even during the post-spawning period in May-June, when other mussels are too weak to be moved. At this time bouchot mussels are in strong demand and fetch very high prices.

Bouchot culture has very specific requirements, notably a large tidal amplitude so that tall poles can be used, protection from severe storm damage and stability of the seabed. The region of north Brittany where the method is most fully developed has a spring tide range of 10-11 m., and although it is an apparently wide open coastline, the very extensive shallow water offshore does effectively reduce the energy of storm waves, so giving protection. There are no areas in the British Isles offering comparable conditions. The only area with a spring tide range in excess of 10 m. is in

the upper reaches of the Bristol Channel, from a point midway between Cardiff and Swansea eastwards, but because the large tide here is generated by the narrowing of the channel, it is subject to extreme tidal scour. It also suffers from high levels of heavy metal pollution. Further west, the area around the Burry Inlet and Three Rivers comes close to the basic requirements, with a spring tide range of 8.5m..

2.0 INTRODUCTION

This report was undertaken by Seafish Technology and the South Wales Sea Fisheries Committee in response to their efforts to encourage better use of the mussel spatfall which occurs, sometimes on a massive scale, especially in Burry Inlet. In 1986 the Committee had undertaken relaying trials in the inlet, but these had suffered from scour and shifting sand banks, a feature of this area. In the light of this, discussions between the Committee, the Shellfish Association of Great Britain and Seafish centred on the possibility of establishing bouchots, which would be less subject to scour and would make better use of the 8 m. spring tide range to produce high value mussels.

At about the same time Myti Mussels Ltd. of Bangor had expressed an interest in the possibility of using dredged seed mussels from Carnarvon Bay for stocking bouchots or some similar structure in the Menai Straits. However, the spring tide range is much less in the straits, so normal vertical bouchots were not thought to be possible, and it was decided to experiment with horizontally hung plastic pipe 'bouchots' suspended between vertical scaffold poles as a comparison with the results from South Wales.

As any commercial venture would need to be assured of a regular seed supply, the final stage of the study concentrated on spat settlement, particularly in open water sites. This was done at a range of sites from Caldey Island westwards and around the coast to Fishguard, as well as at a number of sites in the upper reaches of Milford Haven.

The mussels produced during the trials were harvested and were put through a commercial purification, grading and packing plant. They were then distributed to a range of commercial outlets to assess their response to the quality of bouchot mussels.

The project therefore assessed the commercial viability of two experimental methods of mussel cultivation in two areas where there was an active interest in shellfish growing. If successful, these could become the basis of a viable industry and provide an additional source of income for local people.

3.0 OBJECTIVES

3.1 To investigate bouchot cultivation as a commercially viable method for growing mussels in the U.K..

3.2 To establish the potential of two locations as commercial on-growing areas for mussels utilising bouchot cultivation methods.

3.3 To establish the potential of a number of locations in South Wales as suitable seed collection sites.

4.0 SITE SELECTION

The sites initially considered for the study were those in which the Sea Fisheries Committee was aware of possible commercial interest and where a good spatfall of mussel seed was known to occur nearby. Conflicting interests such as navigation, and nature conservation had to be considered, as did access.

The area around Burry Inlet and Three Rivers comes closest in the U.K. in its tidal regime to meeting the requirements for bouchot culture. Examination of Admiralty Chart No.5058, (British Isles and Adjacent Waters, Co-tidal and Co-range Lines) shows the spring tide range to be 8 m. Only the inner part of Morecambe Bay and Solway Firth (8 m. and 7.5 m. respectively) come close to this. The Wash is shown as having a range of 6.5 m.

The significance of tidal amplitude for bouchot culture is central since the objective is for the mussels to remain entirely covered during neap tides, maximising growth, while being accessible at low water springs. Accessible means that they should dry or be left in only a few inches of water so that they can be positioned by a man standing beside a service boat or tractor. Anti-crab devices, such as polythene sheet or plastic barriers need to be nailed close to the bases of the poles, and kept clear of fouling, so these have to be within reach, even if not uncovered on every spring tide. In general, the neap tide range is approximately 50% of the spring tide range. The difference in level between low water springs and low water neaps is therefore about 25% of the spring tidal amplitude, say 2 m. in the area in question. This is therefore the maximum height of poles above LWOST which can be used without the tops uncovering on a neap tide. Above this level growth can be expected to decline rapidly.

Shelter from the worst storm damage and stability of the sea bed are the next important criteria. Experience in Brittany has shown that bouchots can be used in very exposed conditions, provided some of the wave energy has been reduced by shallow offshore water. Finding such conditions in combination with a stable seabed is not easy however. The offshore sand banks in the Burry Inlet/ Three Rivers area do absorb much wave energy, but they are extremely mobile and the topography can change entirely during a storm. For this reason, and because of the navigational hazard they would represent, these sites cannot be considered. Even within the estuaries (both Burry Inlet and the Gwendraeth) instability of the sand banks is a problem, and the necessity of not being too close to a steep gradient on the edge of a channel greatly reduces the area available.

There are areas within both Burry Inlet and the Gwendraeth where

bouchots could be set up. Both estuaries have known areas of good spatfall near their mouths, Burry Inlet at Whiteford Point and the Gwendraeth at St. Ishmael's Point. The potential area is greater in Burry inlet, but for the purposes of an experimental trial, not being tended on every set of spring tides, and recognising the amount of commercial activity in Burry Inlet, it was decided to base the trials on the Gwendreath Estuary. This does have a small commercial fishery, based on and around an area of rock outcrop at St. Ishmael's Head. This had been surveyed by Swarbrick in 1984 (Ref.2) and estimated to carry a stock of 525 tonnes. It was decided to use an area immediately to the east of this as a spat collecting area. At the time this retained water at low tide and remained as a pond. There were signs of small seed mussels around it and the rock shoal offered protection from the west. Because it was relatively high on the intertidal shore, however, it was decided to place some additional collector ropes at other points lower down the tide in the main channel. For the bouchot site itself, a site more remote from public access was chosen, on the southern shore of the estuary. During the week, access to this is restricted by closure of the beach off the Pembrey bombing range.

The site chosen for the comparative trial at Brynsiencyn in the Menai Striats was a ground used commercially by Mr.T. Roberts, who cooperated with Myti Mussel Ltd.in this project.

Spatfall in the South Wales area was known to occur in late spring/summer which would have been late for use in growth trials in the initial year. Also there was a considerable element of uncertainty in establishing seed collection successfully at the first attempt. It was decided, therefore, to back up the supply of seed for the bouchot trial with some from a further source. Morecambe Bay was chosen as it is known to have spatfalls during the autumn and winter, and assistance was available in collecting this at the site of the oyster farm run by Seasalter Shellfish (Whitstable) Ltd. During the second year of the trial (1988) when pergolari tube was used as a comparison with the bouchots, requiring larger seed not attached to ropes, dredged seed was provided by Myti Mussel Ltd., from a bed off Caernarfon.

The final stage of the study concentrated on spat settlement at open water sites from Caldey Island westwards and around to Fishguard and in the upper reaches of Milford Haven. The sites tested are those shown in Maps I-VI and were chosen with the advice of the Chief Fishery Officer. A plan to suspend collector ropes off the former Esso jetty at Milford Haven had to be abandoned because of the extent of the work being carried out at the time to dismantle the jetty.

5.0 METHODS

5.1 Collection of Spat: First Year

The immediate aim was to use techniques and materials already in commercial use rather than to attempt novel methods. Coir rope was used for collecting seed and this was set out on horizontal supports as used in France (*Photo 1*). Although coir is more expensive and less readily available than the polypropylene often used, it requires no weathering period and was thus available for immediate use. Later in the trials further effort was put into spat collection, by which time some newly developed fibrilated polypropylene ropes became available, specifically produced for mussel spat collection by Strathcord Ltd. following discussions with the consultant.

The first set of collector ropes was set out on trestles on 17/3/87 in the tidal pond at. St. Ishmaels. Two parallel sets of supporting trestles were erected, each line about 50 m. long with the ropes about 0.6m off the ground .(*Photo 1*). Twelve lengths of coir rope were laid out on one set of trestles, while on the other a 220m coil of polypropylene rope was set out to weather. A similar set of coir ropes totalling 600 m. was set out in Morecambe Bay at the low spring tide level south of Roosebeck. These were supported on existing oyster trestles which were not in use at the time. One line of oyster trestles which had previously been built as a low cost trial method by stretching ropes very tightly along a line of wooden supports by tractor and then anchoring the ends, already had a massive spat settlement from early February (*Photo 5*).

Later in the trial, following successful spatfall on the lower level monitoring ropes (*Photo 2*), the main set of collector ropes in the Gwendraeth was moved across the channel to a point adjacent to, but down stream of the bouchot site. The ropes were set out at the new site on 22/3/88. During the Spring and Summer however, these became largely buried by slumping of sand from the side of the channel.

In order to monitor the approximate time of spawning in the area, samples of the wild mussels from a chosen point at the seaward end of the tidal pond were examined for gonadal development and a percentage meat yield was taken during each visit to the site. The meat yield estimate was carried out using a standard method. After external cleaning and dabbing dry with kitchen tissue, 50 mussels were weighed. They were then boiled for 2 minutes, the meats removed and again superficially dried on tissue and weighed. The yield was recorded as the % meat weight to total weight. This method is useful for comparing mussels from a given site over a period of

time, but is less applicable in comparisons between sites as the result is sensitive to differences in shell thickness.

5.2 Growth on Bouchot Poles

The poles used for the bouchots were 2.5m long pine, 75-100mm diameter, with the bark still on. The first batch were sawn to points at the bottom, but this proved to be unnecessary when a water jet (*Photo 3*) was used to position them. A total of 93 poles was erected at the Gwendraeth site (See chartlet and *Photo 4*), three rows of 30 plus 3 in an outer row. The poles were spaced about 1 m. apart and the rows, parallel with the shore, also 1 m. apart. The water jet, powered by a 2 in. petrol driven pump floating in an inflatable dinghy, was used to blow a hole about 1.3m into the sand, working in shallow water. As the jet was removed from each hole, a bouchot pole was inserted and held upright for about 30 seconds while sand was kicked back into the hole. At the end of this time the pole usually held tight, and was set about 0.9m into the sand. The poles used in France are much higher at c. 4m and are set in the sand to about half of their length. Strips of polythene sheet, about 225mm wide were nailed around the bottoms of the poles, just above sand level, to prevent crabs from climbing them.

Both the Gwendraeth site and the Menai Strait horizontal 'bouchot site of Myti Mussels Ltd. were seeded on the low spring tide of 15/7/87, using seed from Morecambe Bay. The seeded ropes were lifted on the previous evening's low tide at Roosebeck, cut into lengths of about 2.5 m. and coiled six lengths to a fish box. A total of 180 lengths was loaded into an open truck, covered with wet sacking and a tarpaulin, and carried overnight to Wales. One half of this was handed over to Myti Mussel en route, for stocking the Menai site, while the remainder was taken direct to the South Wales S.F.C. depot at LLanelli for transfer to trailers for transport along the beach to the bouchot site. Each length of rope was nailed to the top of a pole and then spiralled down and attached at the bottom with a second nail.

The site was inspected on the evening of 16/7/87, by which time some seed had already begun to migrate from the ropes and embyss onto the poles. After this the site was inspected at roughly monthly intervals on spring tides. Length measurements were carried out on samples of 50 mussels, with individual measurements being made to the nearest mm. on a piece of graph paper protected in a polythene envelope. The bulk weight of the sample of 50 was taken before measurement.

The growth of mussels on the bouchots was followed through 1987 and 88 until the entire stock was harvested on 9/11/88. The mussels were

then graded, purified and samples sent to a number of shellfish merchants to obtain their response. This is described in a later section.

5.3 Site Selection

At the end of the 1987 growing season a number of points had become clear concerning the bouchots. Some aggregation of sand had taken place at the bases, caused by slowing of the current by the closely spaced poles, thus shortening their effective length. Observation of the level of the tops of the poles during a neap tide had shown them to be exposing to a height of about 150mm, so that higher poles would be liable to suffer greatly decreased growth. Because of the degree of sedimentation, it was considered that this would become a major problem for a larger, commercial sized operation, unless the poles were more widely spaced. It was decided, therfore, that during the 1988 growing season, in addition to the continued monitoring of the mussels seeded in 1987 a further trial would be made at the same site using the scaffold method of farming as widely practiced in the Mediterranean, with the difference that the scaffold would be submerged at high tide. This method, in which the seed mussels are suspended in 'pergolari' mesh tubes from a scaffold structure, was seen as offering a number of advantages. The much smaller number of posts would offer less reistance to the current and would cause less deposition of sand. The acceleration of the current beneath the pergolari might even reverse the situation. There would be much fewer points of contact with the ground by which crabs could invade. Dredged seed such as that being commercially fished by Myti Mussel could be used for stocking the pergolari, whereas this was not suitable for attaching to bouchot poles, not being embyssed onto rope.

This structure,(*Photos 12/13*) was built immediately upstream of the existing bouchots over 1st- 3rdJuly 1988. The uprights were 13.9m pine poles of 150-200mm diameter set in the sand using the same pump and water jet as in 1987, but inserting the jet to its full length into the sand so that the poles were set in to a depth of 1.2-1.5m. The horizontal bars were scaffold pipe located in V shaped notches sawn in the tops of the posts with a chain saw. Steel straps bent over the pipe and nailed into the sides of the posts with galvanised 150mm nails held the pipes in place. This structure was loaded with seed mussels in pergolari tubes on 19th- 20th July 1988. The seed used was dredged from Caernarfon Bar on 13/7/88, placed into the pergolari tubes at a loading of 5.6 Kg. per 2m. tube and suspended horizontally for 48 hours in the mussel purification tanks of Myti Mussel Ltd.at Bangor. This was to allow the mussels to clump together and attach

themselves to the meshes of the tubes. In this the team was assisted and advised by Mr. Gwyon Davies.

5.4 Brynsiencyn Trial

At the same time a much smaller experiment was set up at Brynsiencyn in the Menai Straits to replace the horizontal 'bouchot' which had suffered damage during the winter of 1987-88. At this location, a small number of pergolari identical to those used in South Wales were suspended horizontally at about 1 m. off the seabed between the existing posts which had been located at low water spring tide level to support the plastic drain pipe the previous year. This experiment provided a comparison between growth at the two sites.

5.5 Collection of Spat; Final Year.

For the final year of the study it was decided to concentrate efforts on the collection of spat in local waters, as by this time the potential of on-growing had been largely demonstrated, whereas seed collection had failed with the exception of the low level monitoring ropes.

Because the main reason for failure to obtain settlement on the collector ropes in the estuary appeared to be silting of the ropes (and burial of those on the south shore), and following reports from local fishermen and Sea Fisheries Committee officers of good spatfall on lobster pot lines offshore, it was decided to draw up a programme of spatfall monitoring at suitably sheltered sites around the area normally covered by the Committee's patrol vessel.

During the time these trials had been underway some new types of mussel seed collector rope had been developed by Strathcord Ltd. of Blantyre. After some initial discussions it was decided that two of these would be considered and tested during the trial. Both were fibrilated polypropylene; one (blue) was nominally 10 mm. diameter, the other (pink) nominally 18 mm. The 18 mm. was used as the standard for comparisons between sites, while at some sites these were backed up by 10 mm. to compare the effectiveness of the two types.

The collector ropes were set out as individual vertical risers from anchor weights made from 0.5m lengths of railway line. In order to keep the ropes reasonably taut at low tide without losing the marker buoy below surface at high tide, the ropes were provided with a second weight far enough up to remain off the bottom at low tide, but not heavy enough to sink the marker. An alternative is a small second buoy attached far enough down the line to be just below the surface at low tide, with the remaining line to the marker buoy long enough to have some slack left at high water.

Thirty separate ropes were laid between 27/4/89 and 4/5/89 in the positions shown in Appendix 1, provided by the master of the patrol vessel Cranogwen.

The ropes were examined visually by the ship's crew during visits to the various areas at times dictated by the pattern of routine patrol work. Three more intensive examinations were carried out around 26/9/89 (Tenby and Caldey Island Group), 13/11/89 (Milford Haven) and 29/11/89 (Solva, Dinas,Stack Rocks, Little Haven and Skomer). On these dates estimates of mussel weight per metre of rope were taken.

6.0 RESULTS

6.1 Spat Settlement and Seed Collection

A) 1987-88; Morecambe Bay and Gwendraeth Estuary

As previously mentioned, the seed which was used as the basis of the bouchot growth trials was brought from Morecambe Bay. A large settlement had already taken place there in early February 1987, before the collector ropes were laid. By placing the new ropes on the old rope trestles, much seed migrated across. By the time the ropes were moved to Wales in July the seed were appriximately 1.5 cm. long (See Table 1)

The first set of collector ropes established in the Gwendraeth estuary caught no spat at all. This was probably because of their high position on the shore. During the spring after they had been set out, the topography of the beach changed and the tidal pond, which had previously held water to about 3' deep now drained much lower, leaving the collector trestles dry for about half the tide. The wild mussels surrounding the site showed a visible decline in condition between 17/3/87 and 2/4/87, as noted by the SWSFC Chief Fishery Officer.

The low level monitoring ropes did obtain a good spatfall which was observed on 28/7/87 as ranging from 1.5-7.0 mm. in length, so the actual spatfall had taken place probably about six weeks earlier. Close to the support posts on the ropes all seed had been lost to crab predation, but the remainder of the rope had a complete covering of seed (*Photo 2*)

Following the moving of the collector ropes across the channel to the south shore for the 1988 season, with plastic discs threaded onto the ropes and retained close to the support posts by nails to prevent crabs moving onto them, the trestles became largely buried by slumping of the channel bank. Those lengths of rope not buried became badly silted with fine mud and caught no spat, though the nearby bouchots did acquire small seed among the attached mussels during the summer of 1988. These failures to obtain spatfall within the estuary let to the decision to concentrate efforts on offshore collection during 1989.

B) 1989; Offshore West Wales and Milford Haven

About two weeks after the collector ropes had been set, the entire area was subject to a massive plankton bloom of the colonial gelatinous alga *Phaeocystis pouchetii*. This secretes acrylic acid and polysaccharides into the water, making the water and any surfaces sticky. After this many of the ropes became fouled with filamentous algae. Where possible the ropes were

replaced by unfouled ones and the old ones taken ashore for cleaning. The complete failure of spatfall within Milford Haven (Lawrenny area) may have been due to this fouling. The results of the entire set of deep water collection trials is summarised below.

Location No.*	Area	Result
1-4	Lawrenny	Nil
5	Tenby Roads	Gone
6-7	N.E.of Caldey I.	Excellent, 8.1Kg/m. on 26/9
8	N.Caldey I.,inshore	Good set,later moved offshore, then lost.
9-10	W. of Caldey, inshore.	Good set.
11	Fishguard Harbour	Excellent set
12	W. of Dinas Head	Good set
13-14	E. of Dinas Head	Excellent, 2.4Kg./m on 29/11
15	Whitesand Bay	Gone
16-18	Ramsey Sound	Nil
19	Solva	Gone
20	Green Scar Rock,Solva	Good set- See Size Analysis.
21	S.E. of Solva	Gone
22-23	Little Haven	Slight set
24-25	S. St. Brides Bay	Good set, lost later.
26	Skomer I.	Gone
27-28	Skomer I.	Nil
29-30	Dale Area	?

* See Appendix 1 for location charts.

A size analysis of selected batches of spat is shown in Fig. 2

Rope Type and Size

There was no clear difference in the ability of the two types of rope to collect spat, and in fact the highest yield per metre(8.1 Kg. obtained N.E. of Caldey Island) was achieved on the 10mm. diameter blue rope. At the time of the final inspection of collector ropes on 29/11/89, the majority of remaining spat was found on the pink 18mm. ropes, this probably reflecting the stronger adhesion obtained on the larger surface area and rougher texture of this type of rope. In a commercial operation the aim would normally be to remove spatted ropes to the on-growing site as soon as possible, so this longer term adhesion would have no great advantage. The 10 mm. blue rope, which is approximately one third of the price of the 18mm pink rope would therefore seem to be satisfactory for the purpose.

6.2 Meat Yield of Mussels; St. Ishmael's Point(1987) and Bouchots (1988) Brynsiencyn (1988/89)

During 1987 the meat yield was monitored in mussels taken from a set point at St. Ishmael'sas an indicator of gonadal condition, any sudden decrease in yield being interpretted as spawning having taken place. The results are shown in Table 2. In 1987 a clear visual decline in meat content was reported between 17/3/87 and 2/4/87, later confirmed by the low meat yield recorded on 1/5/87.

Because the team was always engaged in work on the south shore at over low tide during all visits in 1988, it was not possible to sample the St. Ishmael's Point site. Percentage meat yield analyses were carried out on mussels from the bouchots instead. These are not directly comparable with those from the previous year because of the great difference in shell thickness between the wild mussels and the cultivated ones.

The results of the meat yield determinations on the mussels in the pergolari at Brynsiencyn for 1988/89 are shown in Table 4. The highest values recorded were the same at both sites (38%) in August and September. The low value in early March 1989 at Brynsiencyn indicates that spawning had occurred early in the year there.

6.3 Growth of Mussels on Bouchots and Pergolari.

1987

The mean length and weight of mussels at the two sites (Gwendraeth Estuary, S. Wales and Brynciencyn, Menai Straits is Shown in Tables 1, 3 and 4.

The main set of results relates to the batch of seed brought from Morecambe Bay, but Table 3 gives three measurements on the small quantity

of seed from the low collector ropes at St. Ishmael's. It was not possible to identify this batch in 1988, but extrapolation of its early growth rate using the von Bertalanffy equation with seasonal ajustment (See below) indicated that this seed grew at a faster rate than the Morecambe stock.

The rate of growth at Brynsiencyn during 1987 was slightly higher than the Gwendraeth, but this may have been caused by the thinning of the stock, as it appeared from the numbers remaining on the plastic drainpipe 'bouchot' were very reduced. The surface of the pipe offered much less adhesion than the rough wooden poles.

1988

During 1988, length and weight determinations were carried out on four dates during the main growing season at Gwendraeth. The pergolari seed was sampled only once, on the spring tides following its introduction when it was found to have suffered a very high mortality. This is thought to have been caused by overcrowding during the time the pergolari were suspended in the purification tanks at Bangor to allow clumping and attachment before they were hung vertically at the Gwendraeth site. When the site was visited for routine sampling on 9/9/88 the scaffold structure was found to have disappeared and was later found as a tangle of wreckage about 1 Km. upstream of its original location. There had been a severe north westerly gale about a week earlier and it is thought that this, combined with scouring of sand from the outer row of support posts had led to the collapse of the structure. As this had taken place near to the end of the growing season and as the original bouchots had provided good growth data, it was decided not to repeat the trial, but to concentrate effort during 1989 on spat collection.

At the end of the 1988 growing season the entire crop on the Gwendraeth bouchots was harvested (9/11/88). On that occasion, separate samples were also taken from the top. middle and bottom thirds of the poles.

After harvesting, the mussels were packed into onion sacks and weighed. They were then sent to a commercial handling plant where they were machine graded, purified and packed for distribution to a number of merchants. A separate length analysis was carried out on a sample of 100 mussels from the final graded product. Samples of the finished product were distributed to a number of shellfish traders for their appraisal and valuation. One of these, Mr. Norman Etherson of Connel, Argyll, carried out an independent size and meat yield analysis after a further grading, and compared the mussels with Scottish rope grown stock (See attached letter).

Growth in the pergolari at Brynsiencyn was monitored throughout

1988/89 and the results are shown in Table 4. The length data have been extrapolated in the same way as for the Gwendraeth using the modified von Bertalanffy equation described below, and the resulting growth curves are presented in Fig 1. The growth rate was very fast at Brysiencyn. The growth constant which gave the best fit to the data was 0.95 (Gwendraeth 0.68), only slightly less than the value of 1.13 quoted by Dare and Davies (1975).

At the end of the growing season in September 1989, the entire crop was harvested and subjected to the same grading as applied to the Gwendraeth stock, i.e. the percentage of commercial sized mussels between 45mm and 62 mm length being assessed in terms of both number and weight.

The weight of mussels harvested from the Brynsiencyn pergolari was relatively low, corresponding to roughly the same weight as originally seeded. The large amount of seed which must have been lost was probably due to the exposure of the site to rough conditions, as was apparent from the damage to the plastic horizontal 'bouchots' in the previous year. Use of smaller mesh pergolari tubing should overcome much of this loss.

6.4 Extrapolation of Growth Data

In order to make fuller use of the results available from only two growing seasons it was decided to apply the length data to a growth model developed by the consultant. This enabled an estimate to be made of the growth which could be expected if the stock were left to grow for further years. It can also be used to assess the effect of seeding at different times of the year.

In this model the year-on-year increments are calculated using the standard von Bertalanffy equation in its linear form;

$$l_t = L_\infty (1 - e^{-K(t - t_0)})$$

The values used for the parameters were;

L_∞ 65mm (Mean of values of Dare 1975)

t_0 0.03yr.summer

0.04yr.winter(approx. duration of pelagic life)

K 0.6-0.95 (Fitted by trial)

An approximation to the seasonal pattern of growth was super-imposed on the annual values by splitting the annual increment into monthly values on the assumption that growth rates vary though the year as a sine wave. The peak of the sine wave would occur in June if growth is food limited (i.e. it would correspond directly with the cycle of insolation) but

about two months later if mainly controlled by temperature, as the cycle of temperature in the sea lags by this much.

Each monthly increment was calculated by multiplying the annual growth increments by;-

$(-0.5 \cos 2\theta)+0.5$

where θ is $90/12^{\circ}$

Thus for example, by end May θ is $5 \times 90/12^{\circ}$, or 37.5°. The value of $(-0.5 \cos 2\theta)+0.5$ is 0.37. If the year start and year end lengths predicted by the von Bertalanffy equation were 25mm and 35mm, then the increment added by the end of May would be 3.7mm., resulting in a predicted length of 28.7 mm.

The assumption that growth follows a sine wave though the year is a useful first approximation, which can be further refined to fit the observed data by introducing a period of zero growth in mid winter, or by displacing the sine wave by one or two months to allow for the time lag between the cycle of insolation and sea water temperature peaks. For the main set of data from this trial the model gives a fair fit without any such 'fine tuning', though the little data which was available for local seed showed a very fast autumnal growth rate, and this has been taken as suggesting that the minimum growth period is displaced later in the winter than December, reflecting the temperature lag.

The example shown in Curve ① of Fig.1 is based on spatfall first observed as small seed in February, as was the case in the present trials, which used Morecambe Bay spat from February 1987. During the trial a small quantity of local seed was settled on the extreme low collector ropes and was about 4mm at the end of July 1987. This had reached 21.2 mm. by early November and this figure has been used as the basis of a second example (Curve ②) in which it is assumed that the operation was stocked with local spat settled in mid June, as was the seed in question.

The rate of growth of this locally caught spat was extremely fast, and even allowing for the fact that the model gives a slight under-estimate of length through the first year of life, it would appear from the rapid late season growth (11mm-21.2mm between Sept.8th and Nov 5th)that growth is shifted towards the end of the year and that a two month displacement of the sine curve is appropriate, placing the annual cycle of growth from February to February. This has been assumed in the extrapolation shown for this batch of seed. Even with this ajustment, a very high growth constant (K=0.9) is indicated, which if maintained would mean that the local seed

would have overtaken the Morecambe Bay seed at the end of their second summer. Unfortunately it was not possible to identify this batch in the summer of 1988. It does appear, however, that using locally caught seed, a good market size of 50mm would be reached by the end of the following summer, even if spatfall is as late as June. The significance of this finding and the emphesis which it places on finding sites where spat collection can be obtained on a regular basis in the area are discussed later.

The highest growth rates found during the trials were at the Brynsiencyn site. Curve ⑤ is the computer fit of the set of data from the horizontal pergolari over 1988/89 (See Table 4 for original data). The growth constant K used to obtain this fit was 0.95.

6.5 Final Harvest of Mussels and Traders' Response to Finished Product

The entire stock of mussels which had been grown on the bouchots during 1987/88 was harvested on the low spring tide of 9th November. The decision had already been taken to terminate the growth trial at this time, so the bouchot site was cleared on that day. Some of the poles were stripped and the mussels collected into one polypropyene sack per pole. Because of the lack of time on the rising tide, however, the majority of the poles were completely removed, with the mussels still attached, either by manual extraction from the sand, of by sawing off low down with a chain saw. They were then stripped ashore, with again the crop from each being put in a sack for weighing.

The 73 poles harvested (20 of the original 93 being entirely bare) yielded 934Kg. of mussels, an average of 12.8 Kg. per pole. Individual poles ranged from 1.8Kg. to 25.3Kg. There was probably a further 200 Kg.left on the bottom after harvesting which would have been gathered in a commercial operation. Most of the poles had been effectively shortened by sand accretion at the bottom during the trial, and most had only c. 1.25m. of useful growing length. The average yield was therefore about 10Kg. per metre of pole. In commercial practice this would be considerably improved by regular maintenance and the addition of outer 'catinage' netting.

The sacked mussels were delivered to a commercial purification plant where they were purified graded and packed in 2 Kg. polythene bags. The declumping and grading machine used was normally used for largely un-clumped bottom dredged mussels, and difficulty was experienced in getting it to produce a consistent grade of the heavily embyssed bouchot mussels. A more appropriate machine, such as the Ets. Cochon brush grader used for bouchot mussels in France and Ireland, would be needed in practice. A

detailed breakdown of the final grade is given in the accompanying letter from Mr. Norman Etherson, one of the traders supplied with samples.

The quantity of finished mussels produced was 550 Kg.,which is 59% of the bulk weight harvested. That figure would be further reduced by more thorough grading, as indicated by Mr. Etherson's analysis.

Resposes to the finished ,packed mussels were obtained from Mr. S Ricketts of Burryport, Mr. David Davis of Poole, Mr. Tim Lucas, of Simsons Fisheries, Coulsdon and Mr. N. Etherson. Most comments agreed, being concerned with meat quality, shell appearance, and grading. It was recognized that grading would need to be improved in aiming for the premium market in which cultivated mussels should be sold. Without exception all agreed that the meat quality was the best seen, even in comparison with cultivated mussels from other areas. Shell appearance was not as good as other off-bottom mussels, mainly because of barnacle fouling. The presence of the New Zealand barnacle *Elminius modestus* in the area is a distinct disadvantage compared with more northerly areas not infested by this species. While some inprovement would be achieved by use of a brush grader, the whitish scars left after the barnacles have been removed would still be detrimental in a premium market, particularly if greater supplies of Scottish mussels become availalbe. Prices suggested for the product ranged from c. £500 per tonne to £1175 per tonne (£2.35 per 2 Kg bag), depending on the way in which they were marketed. Mr. Lucas mentioned that there is a prime selling period for bouchot mussels in early summer, when their greater strength and long shelf-life give them a great advantage at a time when other mussels cannot be moved. A typical price of £1000 per tonne was suggested for bouchot mussels during this period of the year by Mr. Lucas.

The total weight of mussels harvested from 9 pergolari tubes at Brynsiencyn was 48.5 Kg. (average 5.4 Kg. per tube). Individual tubes ranged from 3.0 to 7.5 Kg.. After grading, the yield of commercial sized mussels (>45 mm) was 65% or 3.5 Kg. per tube. As with the mussels from the Gwendraeth, fouling by barnacles (*Elminius modestus*) was a problem and the whitish scars left after removal of the barnacles would lower the commercial value of the mussels.

7.0 DISCUSSION

7.1 Site Selection

South Wales has been seen as offering among the best conditions in the U.K. for bouchot culture of mussels. It combines large tidal amplitude,

ranging on springs from 6m in Milford Haven, increasing eastwards to 10 m., together with some sheltered sites in Milford Haven, Three Rivers and Burry Inlet. Such a range means that poles of a height of 1.5-2.5 m. placed at low water springs will remain covered during neap tides, giving the best combination of growth and exposure. The exposure during low spring tides allows time for work to be carried out on the mussels and hardens them, giving them a much longer shelf life and consequently a higher value on the market.

Milford Haven is currently too commercialised to be a useful on-growing area, but was seen as a possible spat collecting area. Collectors laid in the upper reaches in 1990 were not, however, successful. Burry Inlet has much shellfish gathering, but many of the sand banks are very mobile. The Gwendraeth was considered to offer the best combination of shelter, security and stability, though the usable area is restricted. Good spatfalls are known to occur there, but because the regularity of this was not known it was decided to bring seed mussels from Morecambe Bay to begin the trials. Seed of 16mm.average length was put on the poles in mid July 1987, and grew to 33mm. by the end of October. By the end of the following growing season (1988) this was up to an average size of 47mm., a suitable size for the French market. The average yield of 10 Kg. per pole would be considerably improved on in commercial practice, and there are good grounds for using a figure much closer to the best poles (25 Kg.). In making an assessment of the economics of such an operation, account must be taken of the fact that only about 60% of the harvest was immediately marketable, the remainder being below the grade size. In the analysis shown in Appendix 2, it is assumed that the 15-18 month production cycle in fact represents two entire years, as the facilities of the farm have been utilised through the two growing seasons. Within this time, however, some of the sub-grade from one year's harvest would have grown on to marketable size. For this reason, the yield has been reduced by only 20% rather than the 40% found in the trials.

7.2 Spat Collection

Spat collection within the estuary was not successful, due to silting of the collector ropes. Subsequent trials at collecting spat in deeper open water, from Tenby round to Fishguard, carried out by SWSFC, resulted in good settlements in the Tenby (up to 8Kg. per m.of rope at the end of the season) area and off Fishguard (c.2.5Kg. per m. of rope), with a small later set in St. Brides Bay. The settlement at the first two sites was in June-July and these mussels reached a length of 20mm at the end of the season, too

small to make market size by the end of 1990. The later St. Brides set averaged 11mm.

7.3 Product Quality

The mussels produced at both sites had an excellent meat yield and were well received by the trade. However, their external appearance was spoilt by the amount of *Elminius* barnacles settled on them. Growth was good, and with use of local spat which had an even higher growth rate, a greater proportion would have reached market size at the end of the second season.

7.4 Advantages and Disadvantages

Advantages of using bouchot culture in the area

1) Good growth rates and excellent meat yield.

2) Favourable tides (L.W.springs are through the middle of the day)

3) Spatfall can be obtained locally

4) High value of product.

Disadvantages

1) Fouling by barnacles (*Elminius*) is heavy and will reduce the value.

2) Available area for bouchots is small, so unlikely to be able to produce enough to export to France where the value of bouchot mussels can be fully realised.

3) Shifting sand banks will be a risk.

The above comments also apply to hanging pergolari, but compared with bouchots these are more time consuming to seed, with the added complication of requiring a period of time for the seed to re-embyss. They are also more liable to storm damage. Whereas the growing clumps of mussels on bouchot poles can be supported and protected by an outer large mesh tube or 'catinage' as is normal practice in France, it would not be practical to add an outer mesh to the pergolari. Security against theft would be unlikely to present a serious problem on a commercial scale farm, as staff would be working on site over most low spring tides.

The two major problems which will confront potential commercial operators are the size of available sites and the degree of fouling by *Elminius*. The Gwendraeth estuary could sustain a small operation using an area of about 0.5 Ha.(c.1Km. long x 5 rows wide), which on 5,000 poles yielding 20 Kg. per pole would produce an output of 100 tonnes per two year cycle, i.e. 50 tonnes p.a.. With an anticipated price of £450 per tonne, this would generate sales of £22,500, which on the provisional costings shown in

Appendix II yield a small profit. It could be operated on a part-time basis by two men. In order to find a larger area to develop a full scale bouchot farm, with a minimum size of one hectare and with 10,000 poles, it would be necessary to look again at the larger Burry inlet, and locate an area of suitably stable sand. Although Burry Inlet was thought to have been too insecure for the small scale trials carried out in the present study, the security which would be afforded by the regular presence of staff maintaining a full scale commercial operation would minimise this problem.

While the presence of *Elminius* will necessitate use of a vigorous brushing machine, and will still leave the shells somewhat discoloured, this is not a problem unique to the area. The mussels produced in the trial were generally agreed to be of very high meat quality, and they would be marketed on the strength of this.

7.5 Commercial Development

The results from this trial indicate that bouchot mussels from this region are of good quality and can command a high price. However, commercial expansion of the trial would have to be cognizant of the inherent disadvantages of the region (few sites, limited production areas). The mixed and part-time nature of the local fisheries and shell fisheries would also need to be considered.

The most appropriate form of operation is likely to be a 'smallholding' capable of being run on a part-time basis, as much of the work could only be carried out over low water of spring tides.

Initially local sales could be developed, provided the operation was equipped with a small depuration plant. Expansion into larger scale markets including exports may require indirect selling via existing depuration plant operators.

If more extensive areas such as exist within Burry Inlet could be developed this could justify investment in a dedicated large scale depuration plant.

Appendix IV can be used as the basis of an action plan by anyone considering undertaking bouchot cultivation commercially.

8.0 CONCLUSIONS

1) Bouchot cultivation can be a viable method of mussel cultivation within the Gwendraeth area, with mussels exhibiting fast growth rates and excellent meat yields. Yields of 20 Kg. per pole are possible and meat yields of 38% have been achieved. The method may be suitable in a few other areas.

2) The tidal range and the timing of low water springs allows favourable access to the bouchots during winter daylight hours.

3) Spatfall can be obtained locally.

4) The quality of mussels produced was well received by the trade.

5) Barnacle fouling is heavy in the area and will reduce the value of the mussels.

6) The area suitable for bouchot cultivation in the Gwendraeth Estuary is only about one hectare, and no more than 10,000 poles could be established. This could produce a crop of 200 tonnes every two year cycle, i.e 100 tonnes per year. The area of productive water within the estuary which would be supporting this stock is about 1.5 $Km.^2$ at high tide, i.e.150 Ha. A standing stock of 200 tonnes of mussels would be well within the trophic capacity of the estuary.

7) Shifting sand banks could pose a risk by reducing the useful pole height, as well as increasing the amount of time required for maintenance work.

8) The limited area available and the tidally regulated pattern of working necessary on a bouchot farm mean that it would be suitable as a part-time activity which would fit in with mixed fishing and shell-fishing.

9) Bouchot mussels are suited to summer marketing, being better able to remain closed and thus having a longer shelf-life than bottom grown or raft/longline reared mussels. Initial sales could be aimed at this trade. Adequate depuration would need to be provided.

9.0 RECOMMENDATIONS AND FURTHER ACTION

1) Bouchot cultivation should be encouraged as a supplementary activity to fishing in the Gwendraeth Estuary.

2) Any interested party should seek the advice of South Wales Sea Fisheries Committee.

3) Other areas with large tidal amplitudes should be investigated for their potential for bouchots, e.g. Burry Inlet, Morecambe Bay, Solway Firth, the Wash and possibly small areas in North Devon and Cornwall.

4) Coliform and *E. coli* counts should be obtained on wild mussels in any area considered for establishing an operation. If no wild stock exists in close priximity, a small trial should be set up to ascertain the likely status under the pending EEC Regulation COM(89) 648.

5) The value of French handling machinery, graders and washers etc.and their suitability to the likely scale of any operation in the U.K. should be assessed.

6) A marketing study should be carried out to assess the likely extent of the local requirement and export opportunities.

REFERENCES

1) Dare, P.J. and Davies, G., 1975 Experimental suspended culture of mussels (*Mytilus edulis*) in Wales using spat transplanted from a distant settlement ground. *Aquaculture 6; 257-274.*

2) Swarbrick, J., 1984, Burry Inlet/Three Rivers; A Survey of Shellfish Stocks. SFIA Technical Report No.261.

TABLES FIGURES AND

PHOTOGRAPHS

TABLE 1

Mean Length and Weight of Mussels on Bouchot Poles at Gwendraeth over Period of Trial.

DATE	MEAN LENGTH (mm)	MEAN WEIGHT (g)
15/07/87	15.7	0.4
26/08/87	22.4	1.42
08/09/87	20.0	0.39
08/10/87	31.3	3.5
05/11/87	32.6	4.07
04/06/88	39.8	7.3
19/07/88	43.7	10.5
16/08/88	47.0	13.0
09/09/88	46.6	12.4
08/11/88	Btm. 48.5	–
	Mid. 46.6	–
	Top 44.8	–

TABLE 2

Percentage Meat Yield of Mussels at Gwendraeth

DATE	MEAN TOTAL WT (g)	MEAN MEAT WT (g)	MEAT YIELD (%)
19/03/87	18.4	3.22	17.5
01/05/87	22.0	2.59	11.8
15/05/87	21.6	2.89	13.4
14/06/87	21.3	3.47	16.3
01/07/87	20.8	3.91	18.8
17/07/87	20.5	3.89	19.0
08/09/87	19.5	3.50	18.0
05/11/87	16.2	3.87	23.9
*Measurements on bouchot mussels from this point on.			
04/06/88	7.3	2.03	27.8
19/07/88	10.5	3.25	31.0
16/08/88	13.0	4.42	34.0
09/09/88	12.4	4.71	38.0

TABLE 3

Length and Weight of Locally Caught Seed on Bouchot Poles at Gwendraeth.

DATE	MEAN LENGTH (mm)	MEAN WEIGHT (g)
28/07/87	4.0	- -
08/09/87	11.0	0.19 -
05/11/87	21.2	1.17 -

TABLE 4

Mean Length, Weight and Percentage Meat Yield of Mussels in Pergolari Tubes at Brynsiencyn

DATE	MEAN LENGTH (mm)	MEAN WEIGHT (g)	MEAT YIELD %
14/07/88	31.1	----	
16/08/88	34.8	3.76	38.1
28/09/88	43.9	----	
19/10/88	44.5	9.1	28.5
07/03/89	49.2	11.1	19.0
03/08/89	51.9	22.9	30.4
21/09/89	53.2	----	

FIGURE 1

EXTRAPOLATED GROWTH CURVES

① Morecambe Bay Seed on Gwendraeth Buchôts

② Local Seed on Gwendraeth Buchôts

③ Menai Seed in Pergolari at Brynsiencyn

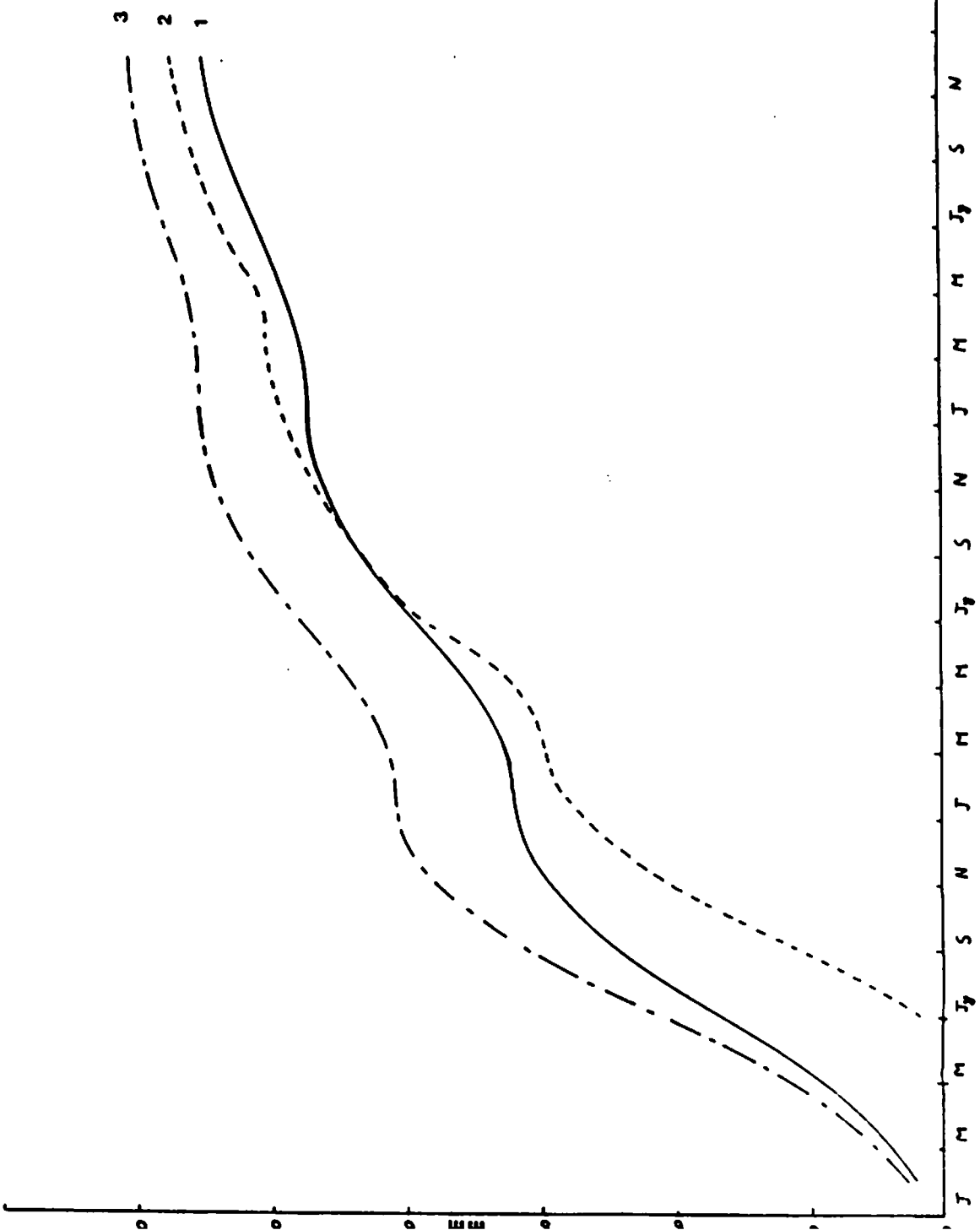
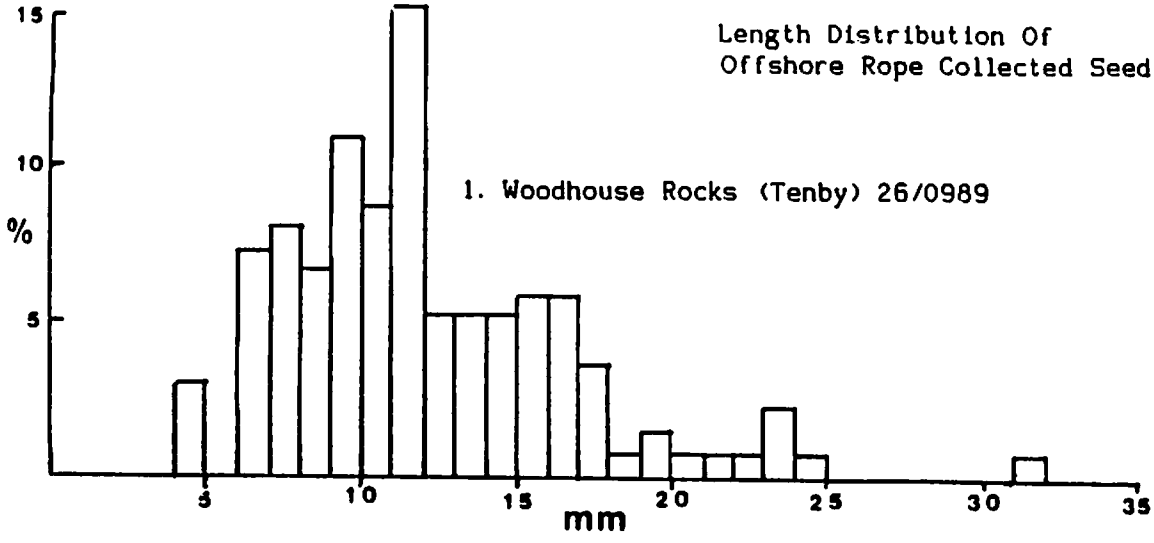
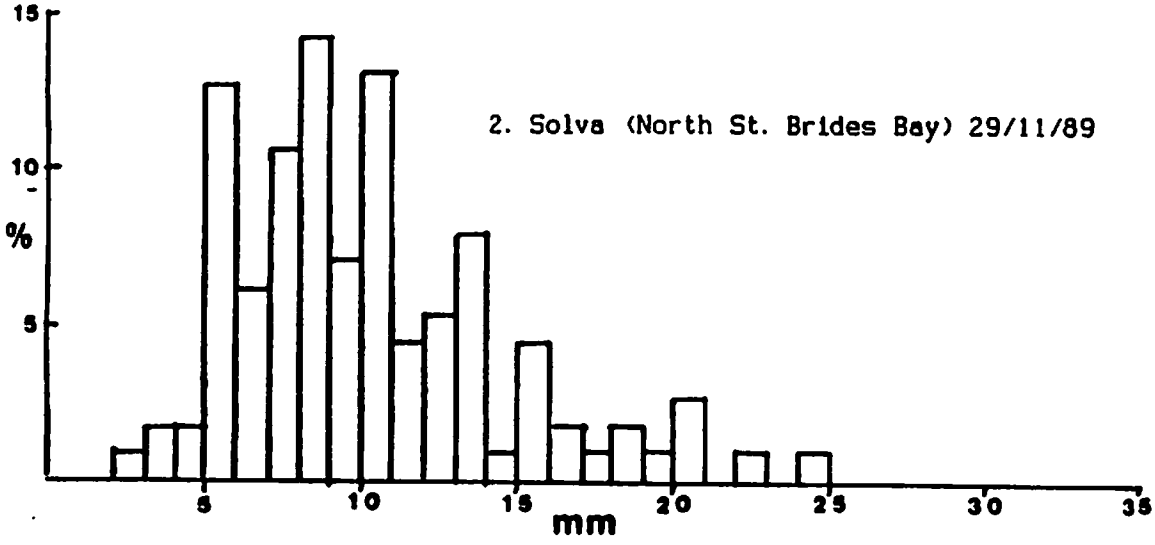
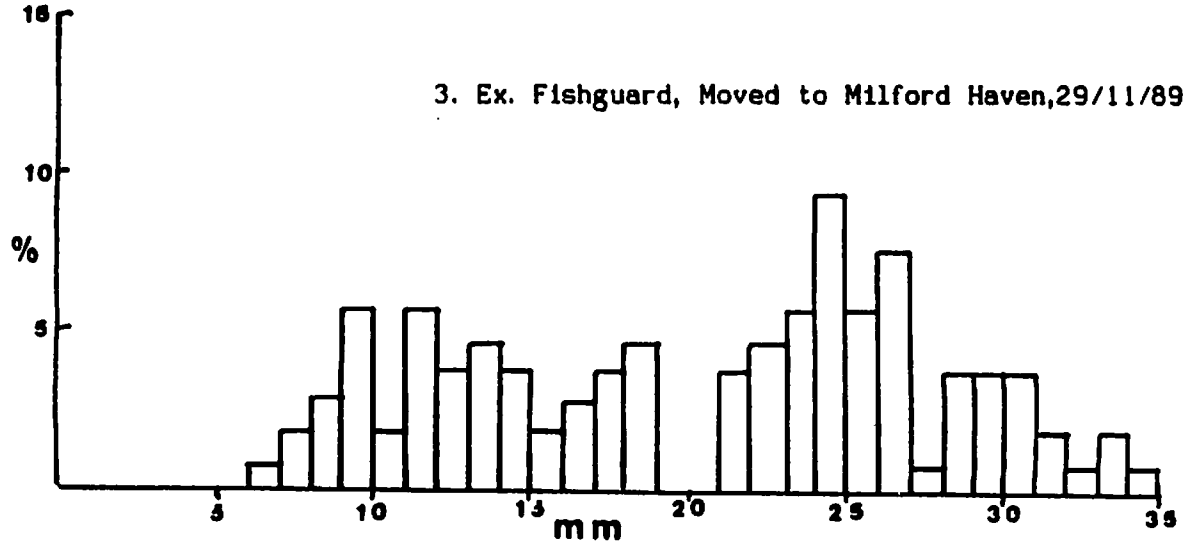


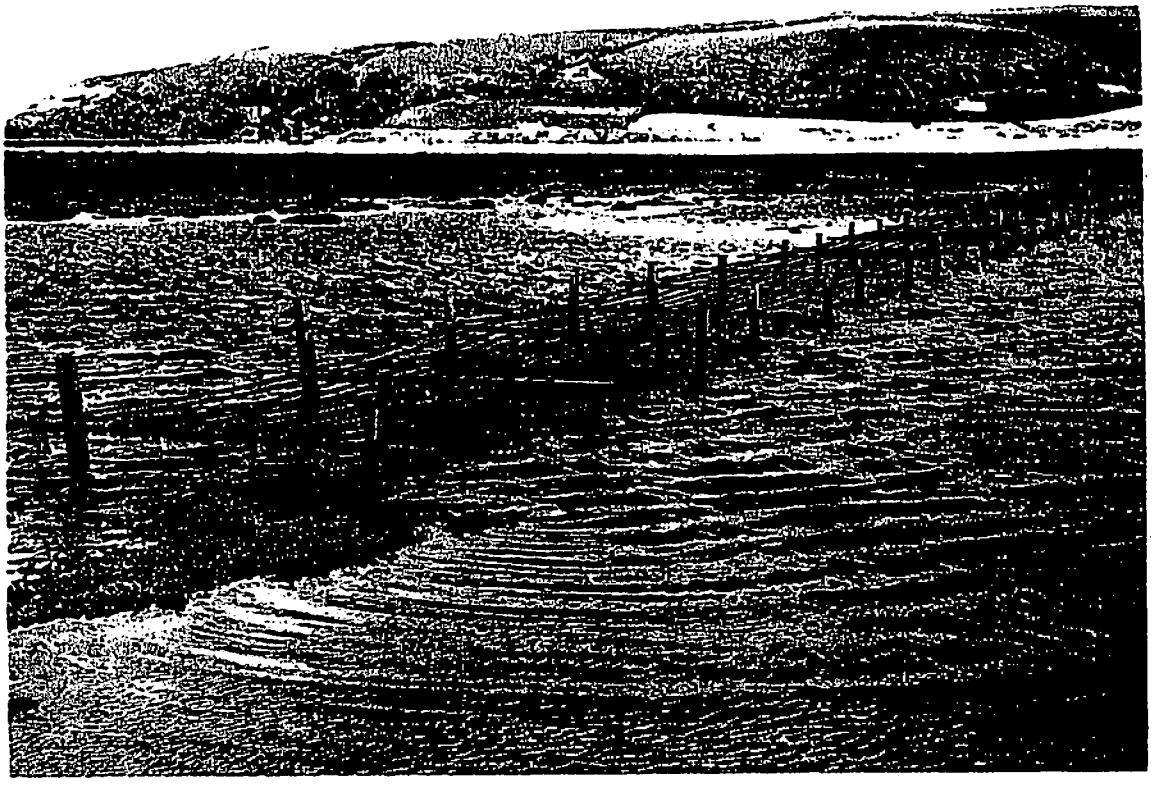
FIGURE 2

Length Distribution Of
Offshore Rope Collected Seed





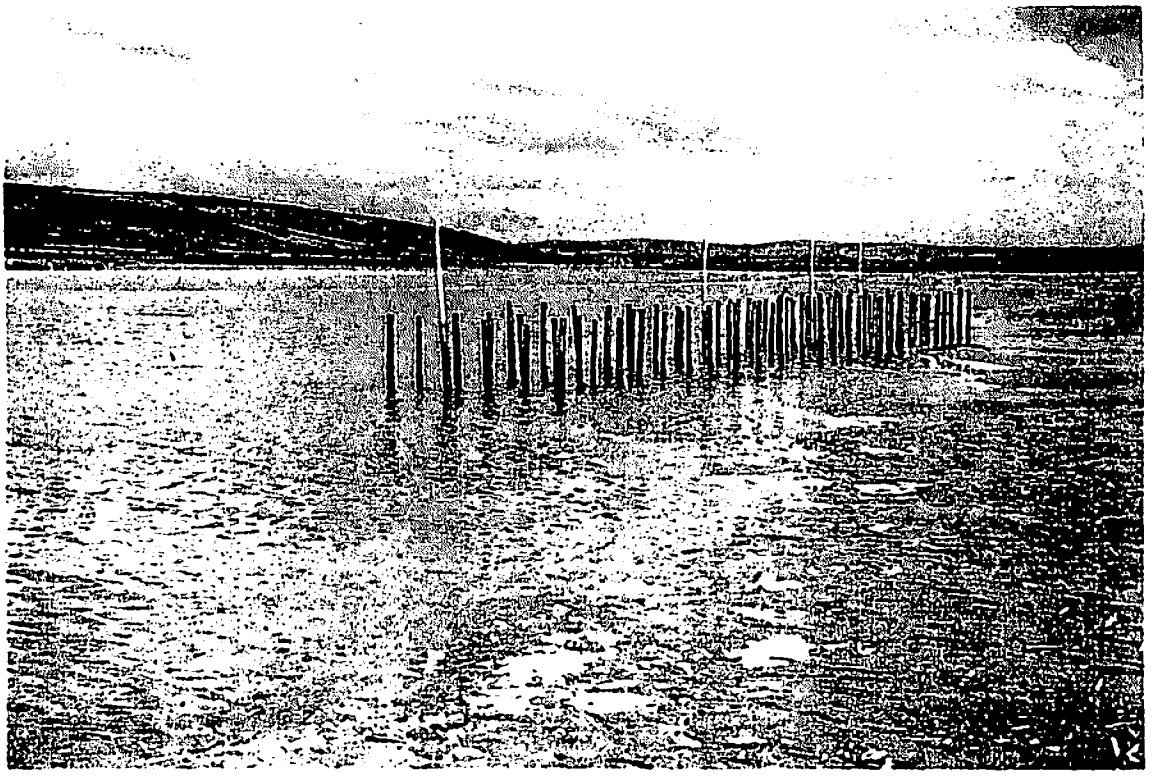




1. Collector ropes on trestles at St. Ishmael's Point: March 1987.

2. Spat set on low level collector rope at St. Ishmael's: September 1987.

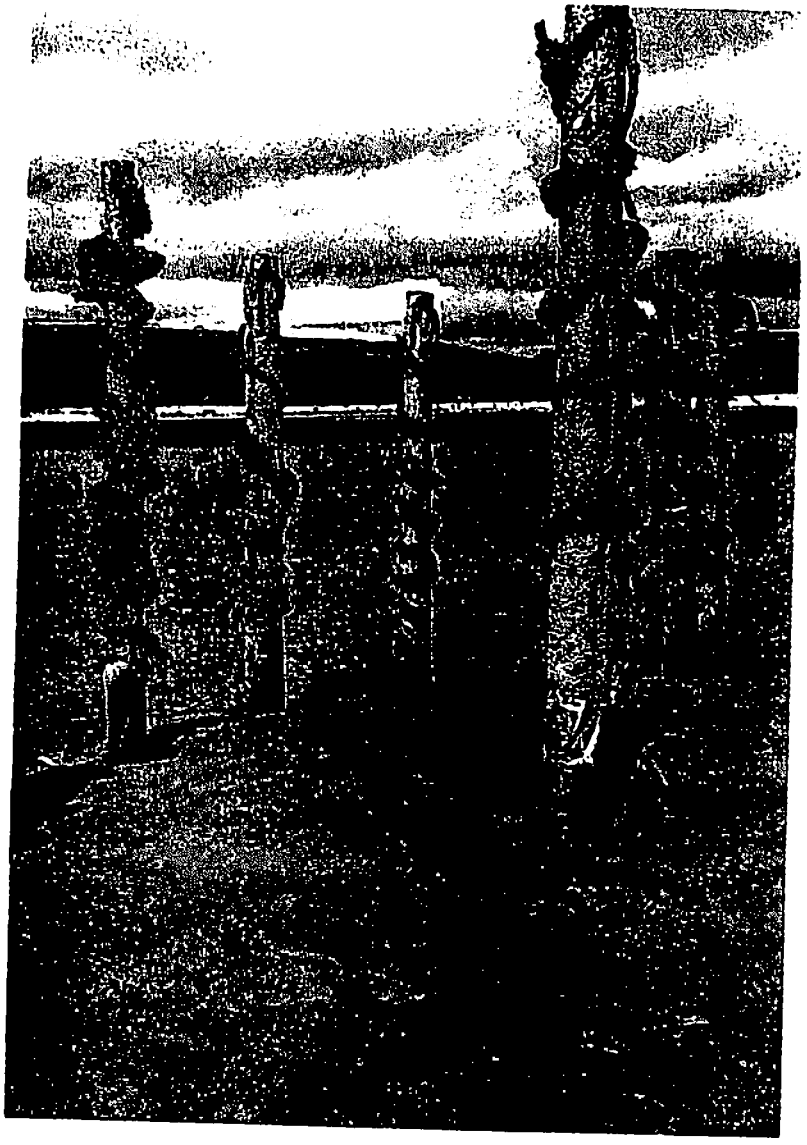
3. Water jet and pump used for inserting buchôt poles.



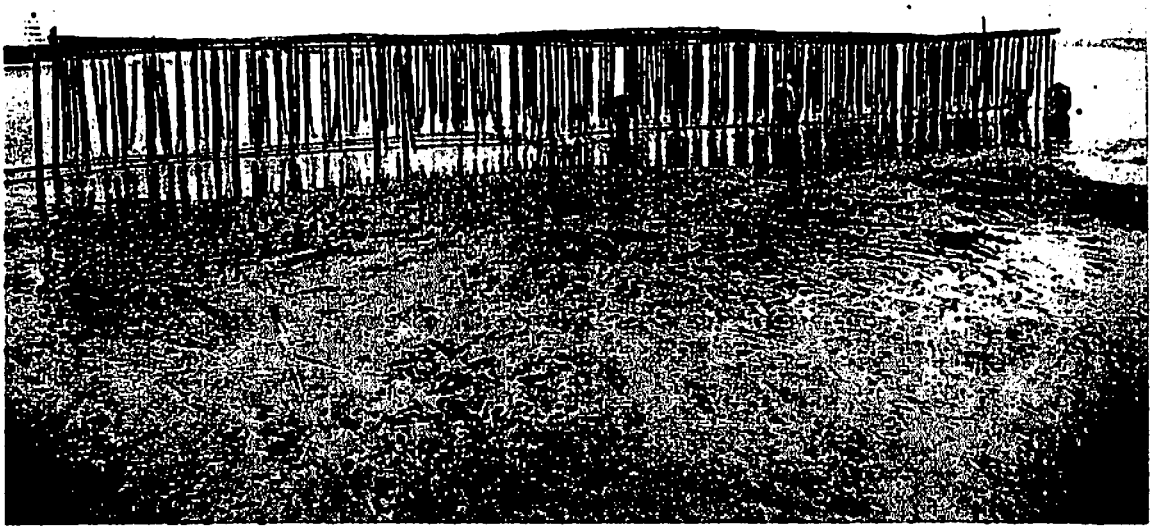
4. Buchôt poles prior to seeding. July 1987.

5. Summer and Winter spat on collector ropes in Morecambe Bay: March 1987.

6. Pergolari tubes loaded with seed mussels from Menai Straits being suspended in purification tanks to re-embyss. July 1988.



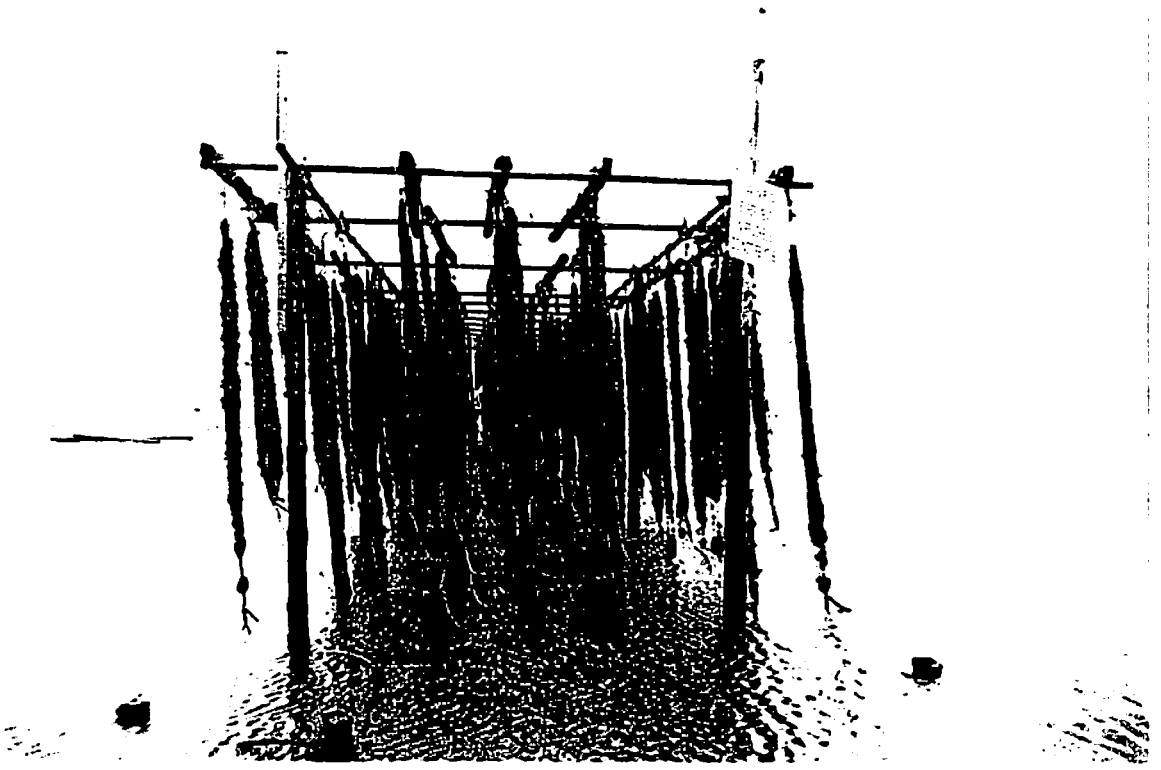
7/8. Buchôts on spring tide following seeding: July 1987.



12

Scaffold newly loaded with pergolari tubes:
Gwendraeth Estuary: July 1988.

13



APPENDICES

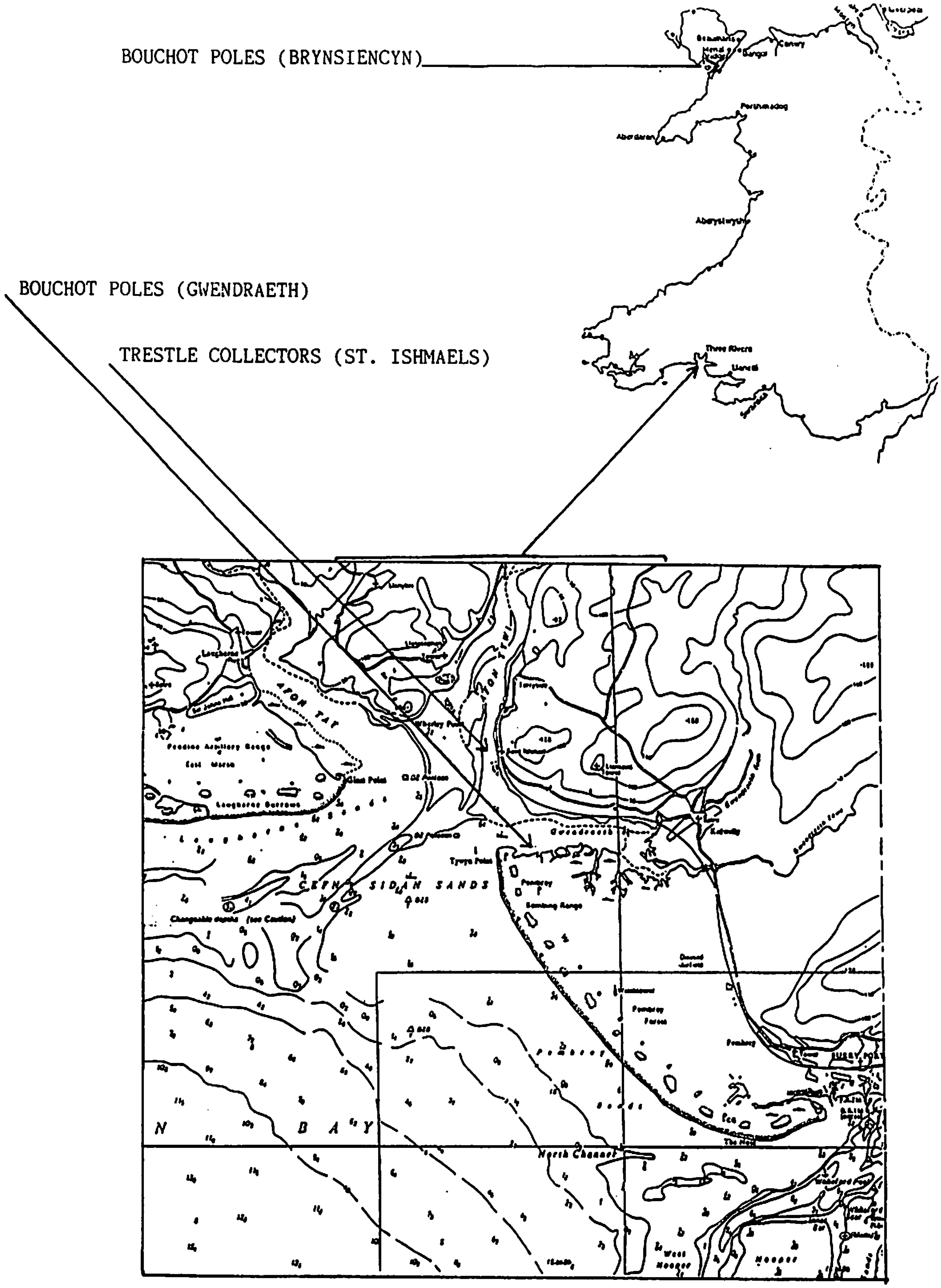
I Location of Bouchot Poles and Spat Collectors.

II Estimated Costs and Returns; 1 Hectare Bouchot Site.

III Report on Finished Product; Mr. N. Etherson.

IV Check List of Points for Consideration in Planning a Bouchot Farm.

APPENDIX I



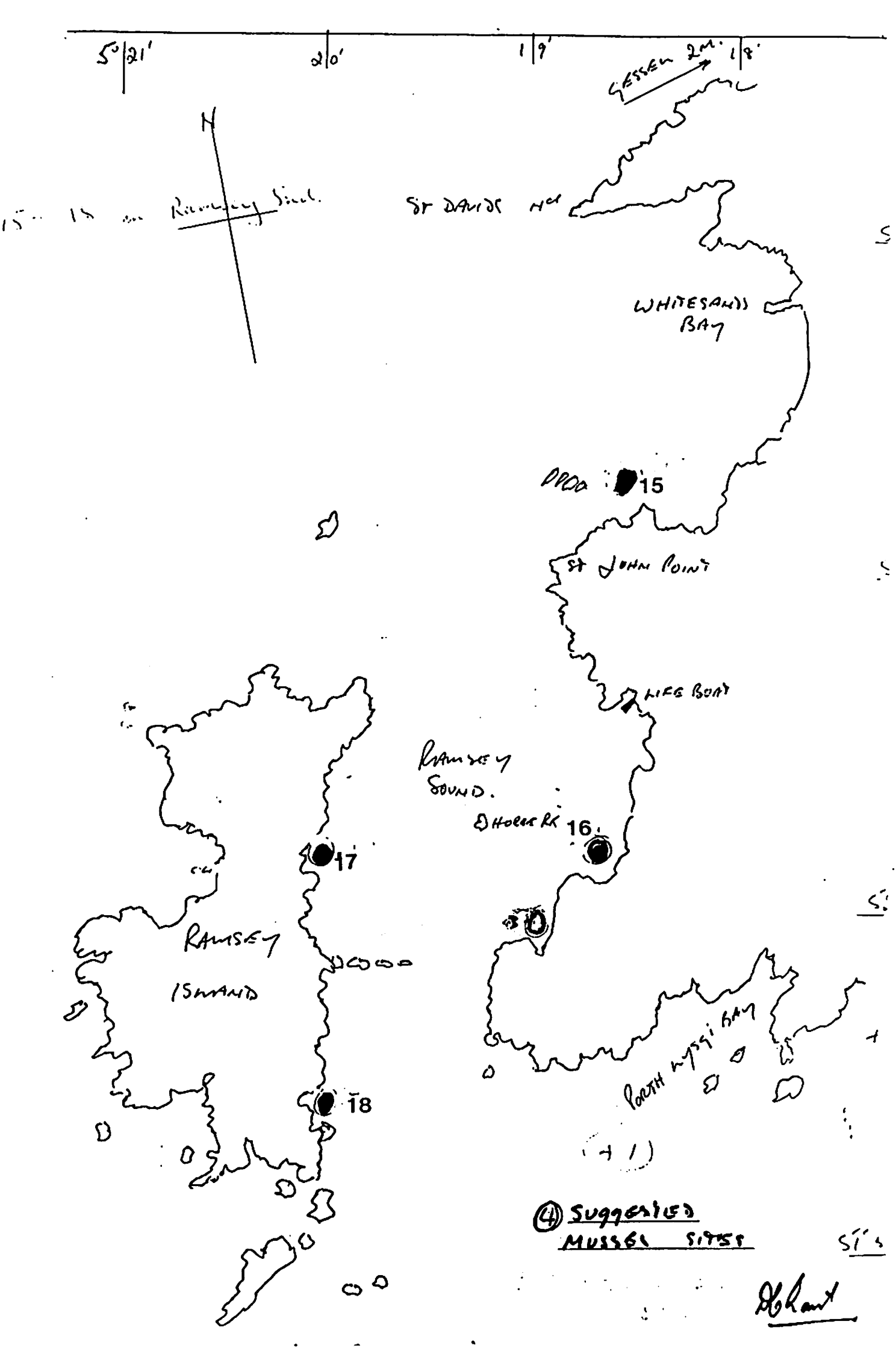
Chartlet describes location of Bouchot Poles and trestle collectors within the Three Rivers area and Menai area.

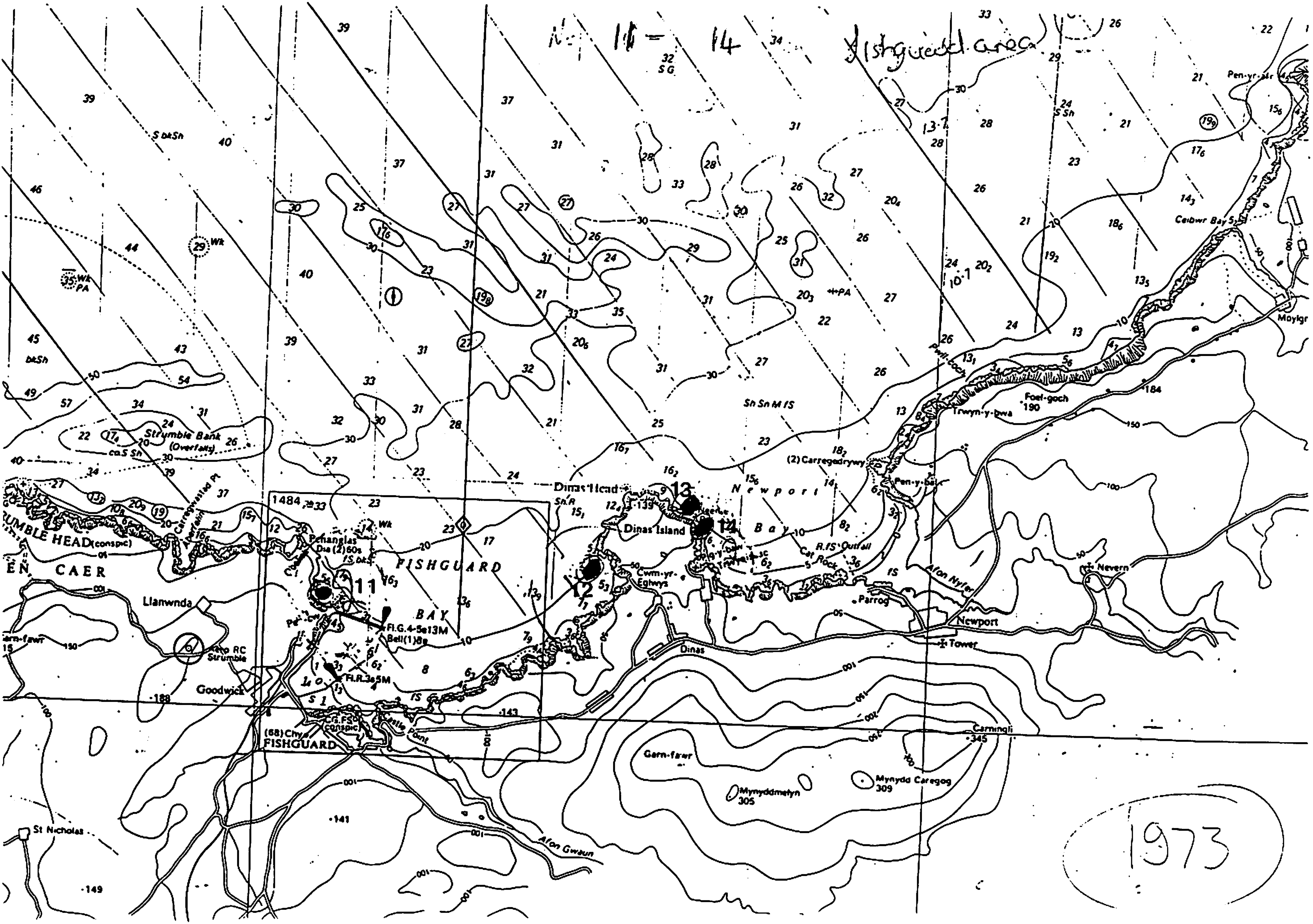
Location of Spat Collection Ropes

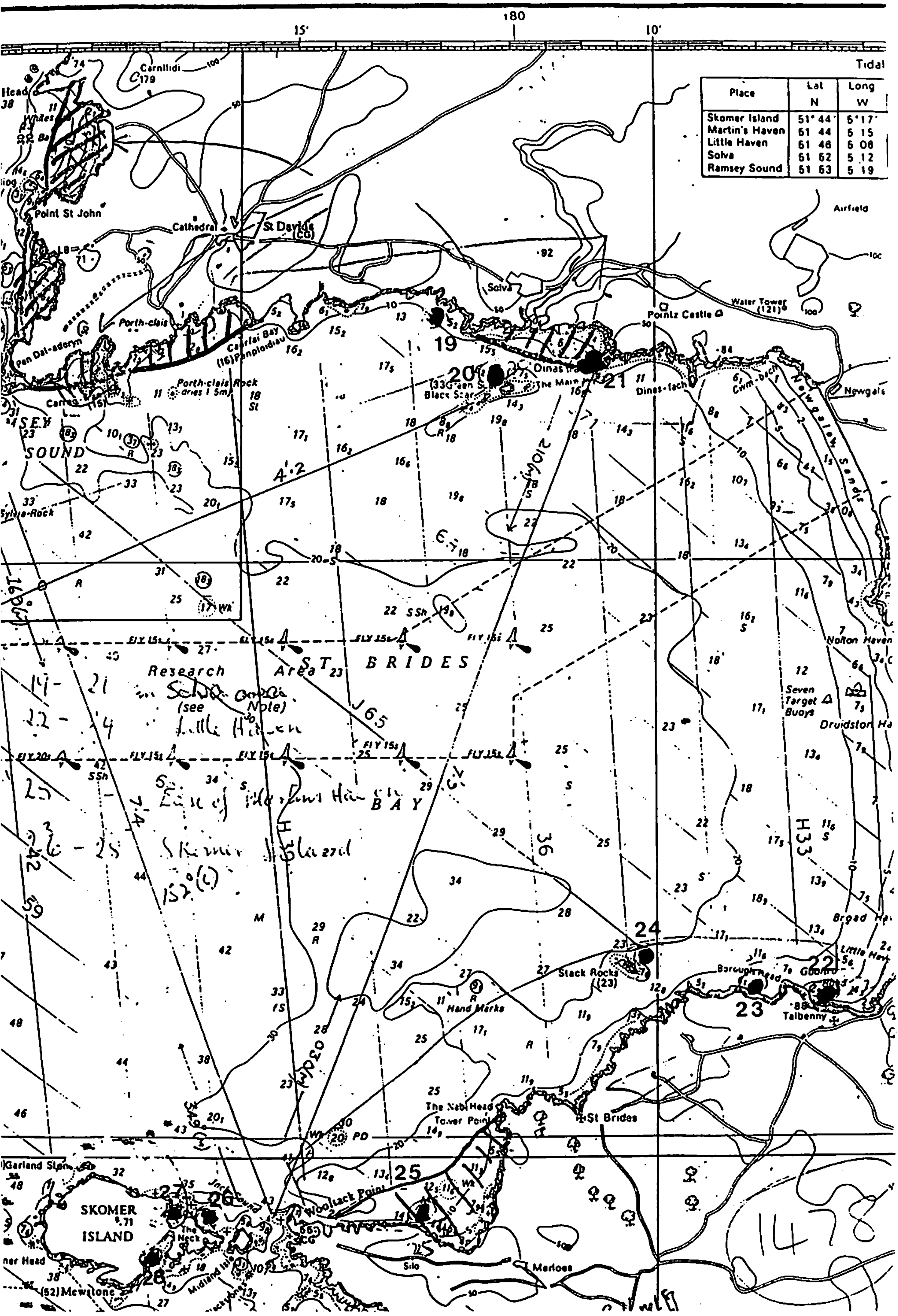
The following maps indicate the approximate positions of the spat collection ropes from Fishguard to Tenby.

1 - 4	Lawrenny area
5 - 10	Tenby, Caldy Island
11 - 14	Fishguard, Newport Bay
15 - 18	Ramsey Island
19 - 21	Solva
22 - 24	Little Haven
25	East of Martins Haven
26 - 28	Skomer Island
29 - 30	Musselwick Point, Watch House Point, Dale area

All ropes laid between 27.4.89 and 4.5.89.


5° 21'
2|0'
1|9'
1|8'
GESSEN 2M.
N
St DAVIDS HD
WHITESANDS BAY
PROA
15
St JOHN POINT
LIFE BOAT
RAMSEY SOUND.
HOGAN RK
16.
17
RAMSEY ISLAND
18
PORTH MAWR BAY
(41)
④ SUGGESTED MUSSEL SITES
SI's

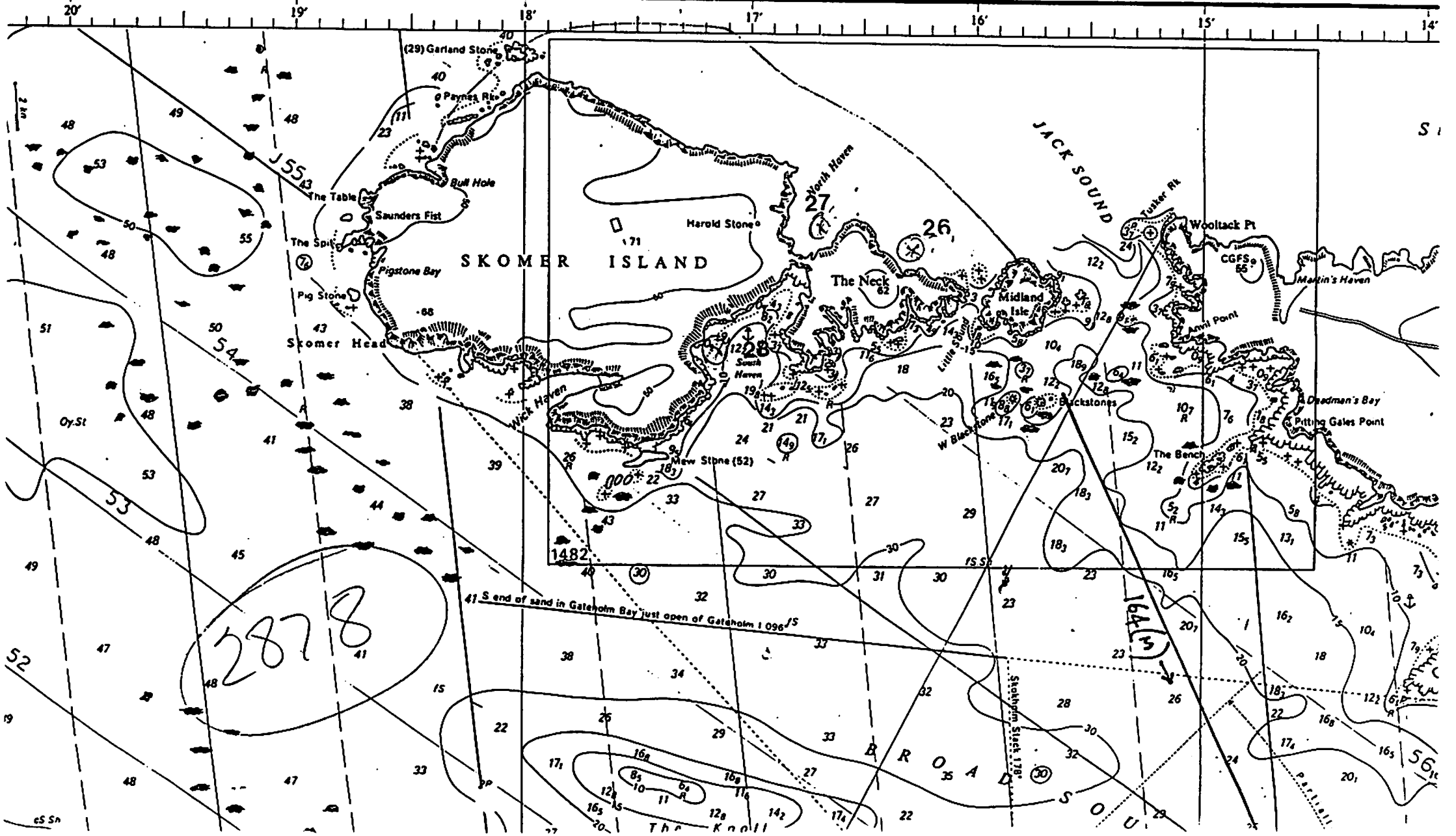

No 11 – 14 Fishguard area
1973
Dinas Head
Dinas Island
Newport Bay
FISHGUARD BAY
FISHGUARD
Goodwick
Llanwnda
STRUMBLE HEAD (conspic)
Strumble Bank (Overfalls)
Carregwastad Pt
Pen-anglas
Cwm-yr-Eglwys
Carregedrywy
Pen-y-bal
Pwll-coch
Trwyn-y-bwa
Foel-goch
Ceibwr Bay
Pen-yr-Afr
Moylgr
Nevern
Newport
Parrog
Tower
Afon Nyfer
Cat Rock
Dinas
Carningli
Garn-fawr
Mynyddmelyn
Mynydd Caregog
Afon Gwaun
Castle Point
St Nicholas
Garn-fawr
Aero RC Strumble
Fl.G.4-5s13M
Bell(1)8s
Fl.R.3s5M
(68) Chy
C.G.F.S. (conspic)
Dia (2) 60s
R.I.S. Outfall
11
12
13
14

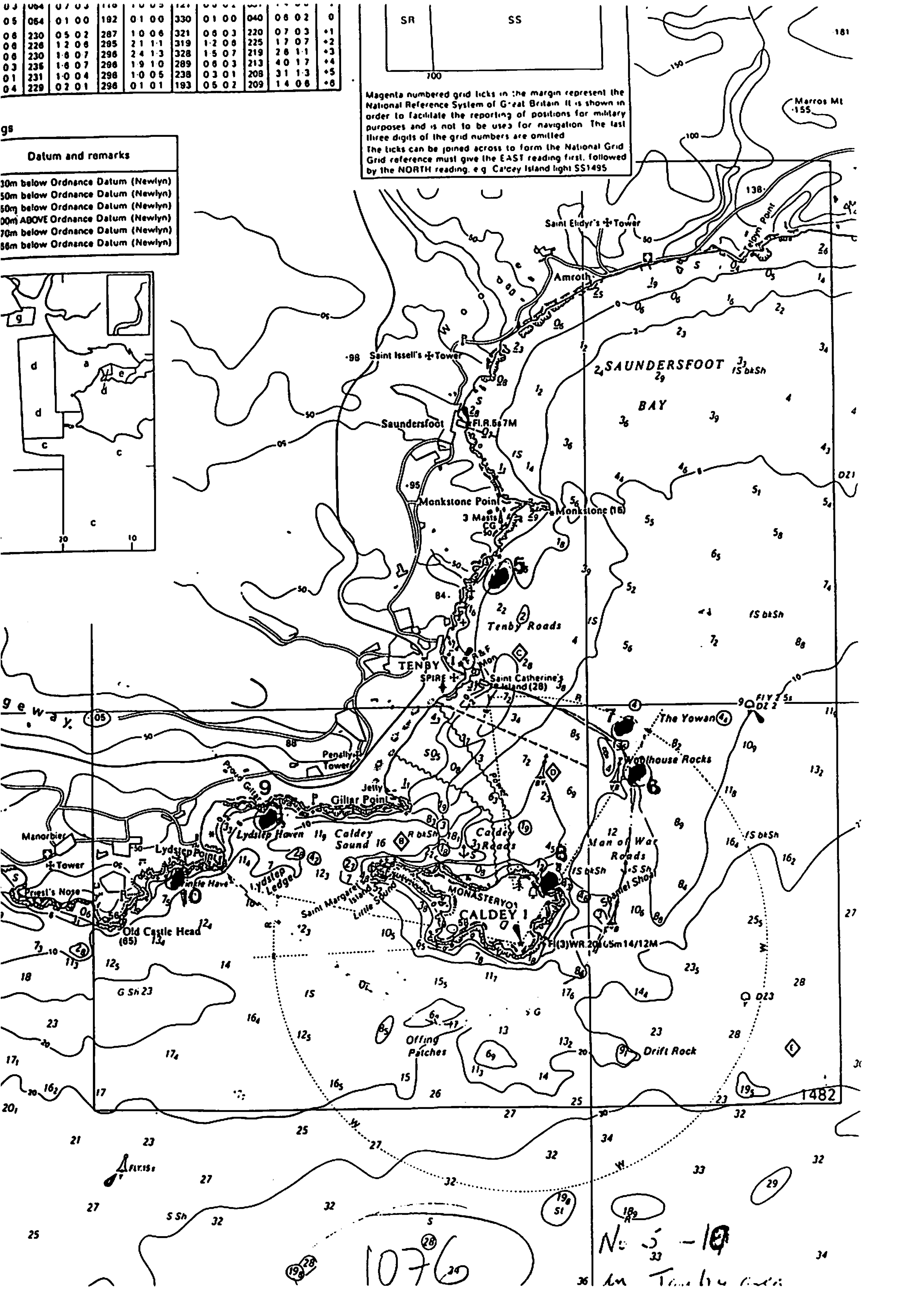


180
15'
10'
Tidal
Place | Lat N | Long W
Skomer Island | 51° 44' | 5° 17'
Martin's Haven | 51 44 | 5 15
Little Haven | 51 46 | 5 06
Solva | 51 52 | 5 12
Ramsey Sound | 51 53 | 5 19
Carnllidi
Point St John
Cathedral
St Davids (CG)
Solva
Porth-clais
Pen Dal-aderyn
Caerfai Bay
(16) Penpleidiau
Porth-clais Rock
Black Scar
Dinas-fach
Dinas Head
The Mare
Cwm-bach
Pointz Castle
Water Tower (121)
Airfield
Newgale Sands
Newgale
Sylvia Rock
SOUND
St Brides Research Area (see Note)
BRIDES
BAY
Nolton Haven
Seven Target Buoys
Druidston Haven
Broad Haven
Little Haven
Borough Head
Goultrop Roads
Talbenny
Stack Rocks (23)
Hand Marks
The Nab Head
Tower Point
St Brides
Wooltack Point
Jack Sound
SKOMER ISLAND
Garland Stone
The Neck
Midland Isle
Mewstone
Silo
Marloes
19
20
21
22
23
24
25
26
27
28
1478

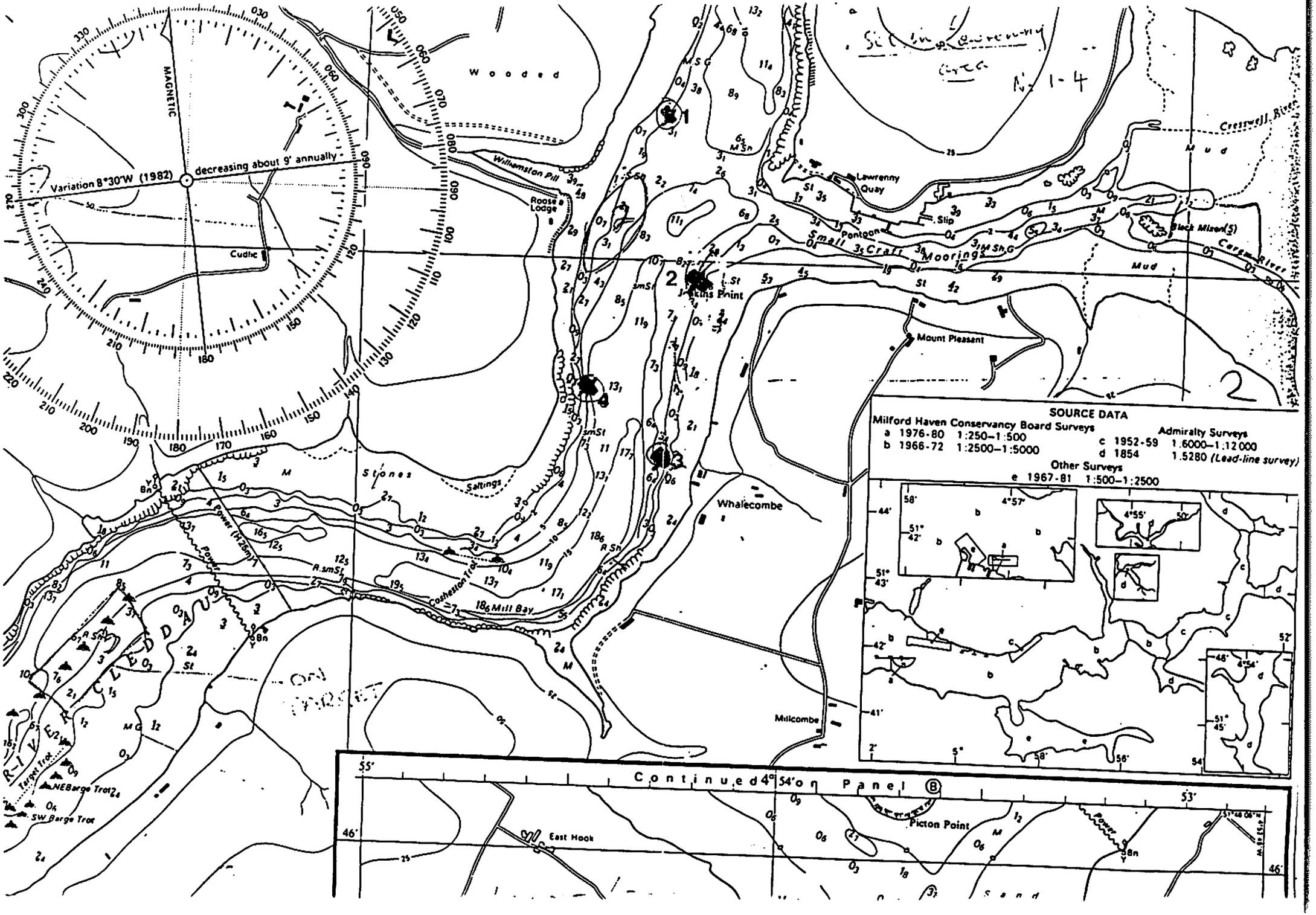
DEPTHS IN METRES

LARGER SCALE CHARTS (LATTICED OR UNLAT





Datum and remarks
30m below Ordnance Datum (Newlyn)
50m below Ordnance Datum (Newlyn)
60m below Ordnance Datum (Newlyn)
00m ABOVE Ordnance Datum (Newlyn)
70m below Ordnance Datum (Newlyn)
86m below Ordnance Datum (Newlyn)
SR
SS
Magenta numbered grid ticks in the margin represent the National Reference System of Great Britain. It is shown in order to facilitate the reporting of positions for military purposes and is not to be used for navigation. The last three digits of the grid numbers are omitted.
The ticks can be joined across to form the National Grid. Grid reference must give the EAST reading first, followed by the NORTH reading, e.g. Caldey Island light SS1495
Marros Mt
Saint Elidyr's Tower
Amroth
Saint Issell's Tower
SAUNDERSFOOT
BAY
Saundersfoot
Fl.R.6s7M
Monkstone Point
Monkstone (16)
3 Masts
Tenby Roads
TENBY
SPIRE
Saint Catherine's Island (28)
The Yowan
Woolhouse Rocks
Penally Tower
Giltar Point
Lydstep Haven
Caldey Sound
Caldey Roads
Man of War Roads
Lydstep Point
Lydstep Ledge
Manorbier
Tower
Priest's Nose
Old Castle Head (65)
Saint Margaret's Island
Little Sound
MONASTERY
CALDEY I
Fl(3)WR.20s65m14/12M
Offing Patches
Drift Rock
Spaniel Shoal
1482
1076
No 5 - 10


MAGNETIC
Variation 8°30'W (1982)
decreasing about 9' annually
Cudric
Roose Lodge
Williamston Pill
Wooded
Lawrenny Quay
Slip
Pontoon
Small Craft Moorings
Jenkins Point
Mount Pleasant
Cresswell River
Mud
Carew River
Black Mixen(s)
SOURCE DATA
Milford Haven Conservancy Board Surveys
a 1976-80 1:250–1:500
b 1966-72 1:2500–1:5000
Admiralty Surveys
c 1952-59 1:6000–1:12 000
d 1854 1:5280 (Lead-line survey)
Other Surveys
e 1967-81 1:500–1:2500
Stones
Saltings
Power (11.25m)
Cohesion Trot
Mill Bay
Whalecombe
Millcombe
Target Trot
NE Barge Trot
SW Barge Trot
East Hook
Picton Point
Continued 4°54'on Panel 8

APPENDIX II

ESTIMATED COSTS AND RETURNS: 1 HECTARE BOUCHOT FARM

Assumptions

1 Ha.= 10,000 square metres.

Pole spacing;- 1 pole per square metre.

Yield per pole;- 25Kg. less 20% grading loss, i.e. 20Kg.

Production per two year cycle;- 200 tonnes.

Selling price;- £450 per tonne.

Materials and Labour	**Annual Cost £**
10,000 Poles @ £1.20 (Capitalised 5 years)	2400
Collector ropes (Seeded)	2500
Labour to install poles. 400 Hours @ £2.50/hr. over 5 years.	200
Labour to set seeded ropes 800 Hours @ £2.50/hr.	2000
Lease and overheads	2000
Tractor and ancillary equipment	3000
Labour for inspection, thinning etc. 500 Hours @ £2.50/hr.	1250
Harvesting, grading, packing and transport £50 per tonne.	5000
Total	18,350
Sales	
100 Tonnes p.a. @ £450	£45,000

N.B. A depuration cost may need to be incorporated. The local Environmental Health Department and Seafish should be consulted on requirements.

APPENDIX III

REPORT ON COMPARISONS BETWEEN BUCHOT CULTURED MUSSELS FROM SOUTH WALES AND ROPE CULTIVATED MUSSELS FROM LOCH ETIVE, SCOTLAND

A consignment of buchot cultivated mussels from South Wales were received in November 1988: they weighed 2.28 kilos and were ungraded. The mussels were graded to marketable size i.e. between 45 cm. and 62 cm. making 88 in total and weighing 1.53 kilos. 63 of these were clean and 25 had barnacle fouling. After removal of barnacles a kilo sample was compared with a sample of rope grown mussels from Loch Etive, Scotland; both samples had been out of the sea for four days.

	Buchot mussel	Rope grown mussel
Weight of sample	1 kilo	1 kilo
Number of shells	58	60
Cooked meat yield	31%	29%
Empty shell weight	31%	38%
Liquid content	38%	33%

Summary

The shells of the rope grown mussels were cleaner and more attractive but the meats of the buchot mussels were slightly plumper. Both samples were of excellent taste and free from grit or pearls.

APPENDIX IV

The following guide is a check list of considerations to be taken into account when planning a bouchot farm.

1)	Site Selection	Tidal range, access, substrate stability pollution, boundaries of nature reserves, security, spat availability.
2)	Scale of Operation	Size of site, manpower, degree of mechanisation.
3)	Consultation With	Local Sea Fisheries Committee, Environmental Health Department, Crown Estates Commission, MAFF.
4)	Markets	Existing markets and competition, Holding/depuration facilities, Preparation, packing and transport.
5)	Precautions	Public liability insurance, Likely EEC water quality classification.
6)	Grant Availability	Regional Grants, FEOGA.
7)	Advice	Local Sea Fisheries Committee, Seafish, MAFF.