BP

Sangachal seabed mapping survey

ERT 1610 – Draft 4

Client:

URS Dames and Moore

Produced by:

Environment & Resource Technology Limited
Azerbaijan

Contact:
Richard Wyness

Contact:
Bill Boulton
Tel: +994 12 974001/974002/974776
Fax: +994 12 974775
e-mail: Bill.Boulton@ert.baku.az

Produced by ERT CASPIAN

KVÆRNER

Contents

1 Introduction ... 1
2 Survey and data interpretation methods ... 1
2.1 Data acquisition ... 1
2.2 Data processing ... 2
2.3 Preliminary data treatment and quality control ... 2
2.4 Seagrass and macroalgae identification ... 3
3 Seabed biotopes in Sangachal nearshore area ... 3
3.1 Bathymetry ... 3
3.2 Seabed sediments ... 4
3.3 Marine flora ... 6
3.3.1 Seagrass ... 6
3.3.2 Macroalgae ... 8
3.3.3 Summary of seagrass and macroalgae importance ... 9
4 Seagrass and algae sensitivity to Phase 1 construction activities ... 12
4.1 Seagrass sensitivity ... 13
4.2 Macroalgae sensitivity ... 13
5 Summary ... 14
6 References ... 15

1 Introduction

The potential impact of existing and future operations at the Sangachal terminal on the presence of seagrass and red algae in the nearshore waters of Sangachal has raised concerns from a number stakeholders including the former Ministry of Environment and Natural Resources (MENR) and several NGO's. In order to address these concerns a study was carried out to map the distribution of seagrass, macroalgae and sediment types of the nearshore waters of Sangachal. Samples of seagrass and algae were collected for taxonomic identification and information provided on their general biology. The objectives of the survey were to:

- Identify the types of sub-littoral flora (marine plants) present in Sangachal Bay;
- Assess the abundance and distribution of the sub-littoral flora;
- Improve the understanding of the ecological importance of the sub-littoral flora;
- Provide information for the ACG Phase 1 Full Field Development ESIA to gain an understanding of the role of the sub-littoral flora in the maintenance of physical habitats and biological communities, and issues such as vulnerability and levels of contamination.

The field survey of the nearshore waters was completed between the 13 June 2001 and 21 June 2001. An Acoustic Ground Discrimination System (AGDS) was used to map seabed features. Simultaneous acquisition of ground truthing information using drop-down video and grab samples facilitated the mapping process. SeaMap, a research group affiliated with the Newcastle University in the UK, were responsible for the mapping and data interpretation. Samples of seagrass and algae were sent to Dr. Christine A. Maggs at Queen's University Belfast for identification.

2 Survey and data interpretation methods

The acoustic survey of the sea floor extended out a distance of approximately 4km. The tracks were variably spaced, but rarely greater than 200m apart. A ground-truthing sampling program using videography and grab samples was also undertaken over the area so that the AGDS data could be interpreted in terms of habitats and sediment types. In addition to the ground truth data collected during the 2001 survey, sediment data (PSA analysis) collected on previous surveys were also available for interpretation.

2.1 Data acquisition

Acoustic ground discrimination systems (AGDS) are based on single beam echo sounders and, apart from determining depth, are designed to detect different substrata by their acoustic reflectance properties. Hard surfaces produce strong echoes, whilst soft surfaces result in a weak signal. Additionally, rough surfaces will produce an echo that decays slowly, whilst flat surfaces result in a rapid decay of the signal. SeaMap use the RoxAnn™ AGDS together with an echo sounder operating at 200kHz. The system is portable and the transponder is strapped to the side of the survey vessel on the end of a steel pole. The RoxAnn data is logged, together with position from a global positioning system (GPS). RoxAnn uses analogue signal processing hardware to select two elements from the echo that relate to roughness/smoothness and hardness/softness. The strength of the decaying echo is termed Echo 1 (E1) and is taken to be a measure of roughness of the ground whilst strength of the first multiple echo is termed Echo 2 (E2) and is a measure of hardness. The raw data can be quite variable in quality due to environmental factors and the data is checked and edited prior to data analysis.

2.2 Data processing

After quality control procedures, there are two main stages in AGDS data processing:

1. Interpolation: The AGDS data are point data saved at set time intervals along the survey vessel's tracks. Track point data, however, are both problematic to work with and produce maps that are difficult to appreciate and interpret by eye. The point data need to be transformed into a continuous digital image through a mathematical process termed interpolation. Interpolation works well when the track spacing is close and the ground relatively homogeneous (as was the case in Sangachal Bay);
2. Classification: The images of depth, E1 and E2 need to be processed together to derive classes attributable to specific sediments or biological communities. This can involve finding clusters of values within the data to derive acoustic classes and then attributing these to sediment type or community type (a process termed 'unsupervised classification'). Alternatively the ground truth data can be used to derive acoustic signatures typical of the main ground types which can then be used to interpret the whole image (a process termed 'supervised classification'). Both types of classification were employed in this survey.

2.3 Preliminary data treatment and quality control

The purpose of this stage was to ensure that the data were of sufficient quality to allow further analysis through data exploration and the removal of dubious data. Bad data is often typified by zero depths and depths greater than the maximum known depth in the survey area. These were removed. The data were then imported into *MapInfo* and displayed to show depth against time in non-earth co-ordinates to search for spurious jumps in depth records. These records were also removed. E1 and E2 were plotted against each other to check for outliers. Lastly the track data were plotted showing the three variables separately (E1, E2 and depth) to visually check for obvious values that did not conform to surrounding data. If it seemed appropriate, these data were also removed. In all about 4.5% of the data were removed from the data set. This is an acceptable percentage and many of the data that were removed came from a small number of tracks that were close inshore. The majority of the tracks required no data to be removed.

A video record was made at each sampling station, and grab samples were collected at a number of ground truthing stations to assess the main habitat/biota types and sediment types. BGS (British Geological Survey) and MNCR (Marine Nature Conservation Review) based classification schemes were used to characterise the video footage and make a qualitative assessment of the sediment types.

Representative frame grabs from the videotapes were taken to aid analysis and provide a reference to the commonly encountered habitats. The video footage required some manipulation in order to create successful ground truth points for image processing. Since the sea grass and algae could exist on a range of substrate types, it is clear that biotope categories and sediment types were not mutually exclusive and, when processed together, lead to a confused classification of the images. For this reason two ground truth data sets were created; one concentrated on the biotopes and the other on sediment types.

The biotope ground truth records were categorised into four classes (sea grass; algae; sea grass and algae; non-macro flora) whilst the sediments were categorised into 15 classes (see Figure 3.2).

A more complete description of the survey methodology is provided by Chivers *et al* (1990).

2.4 Seagrass and macroalgae identification

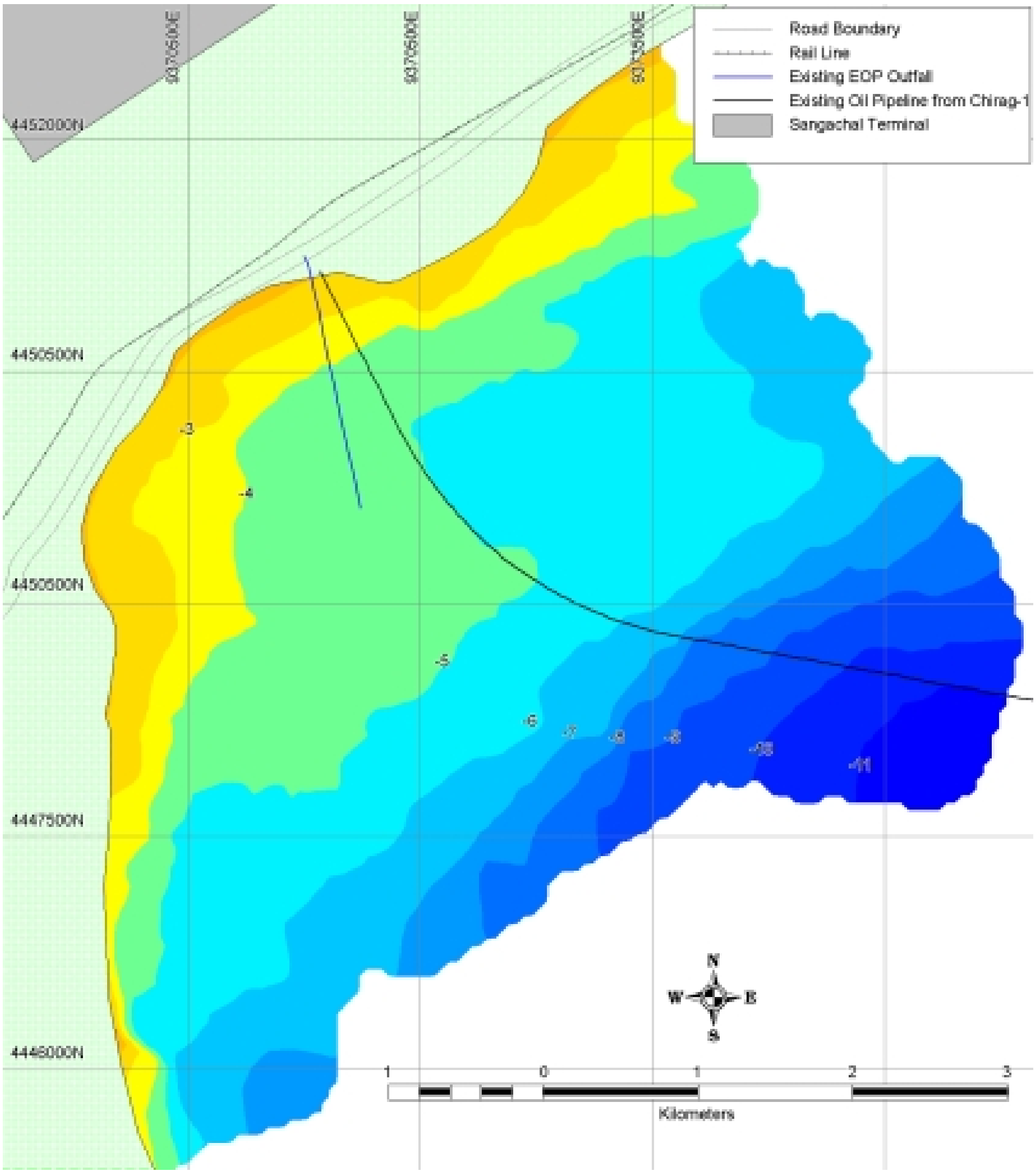
Seagrass and macroalgae were sorted from grab samples taken at 16 stations and either preserved in formalin-seawater (algae and seagrass) or transported live to Belfast (seagrass only). Samples were sorted under a dissecting microscope. All macroalgae samples were made into stained slide preparations for examination with a compound microscope. Identifications were made by reference to appropriate literature. Molecular taxonomy was used to confirm the identity of seagrass as *Zostera noltii* (dwarf seagrass). To achieve this, DNA was extracted from 12 seagrass samples and part of the chloroplast genome was amplified using the polymerase chain reaction with universal plant chloroplast primers and cut into species-specific fragments using restriction enzymes.

3 Seabed biotopes in Sangachal nearshore area

3.1 Bathymetry

Sangachal Bay is a shallow bay that gradually slopes away from the shore reaching a depth of 10 m approximately 3 km offshore. In the centre of the bay on the western side of the existing sub sea pipeline there is an accumulation of soft sediment. The recent acoustic survey of Sangachal Bay has provided the bathymetry chart shown in Figure 3.1.

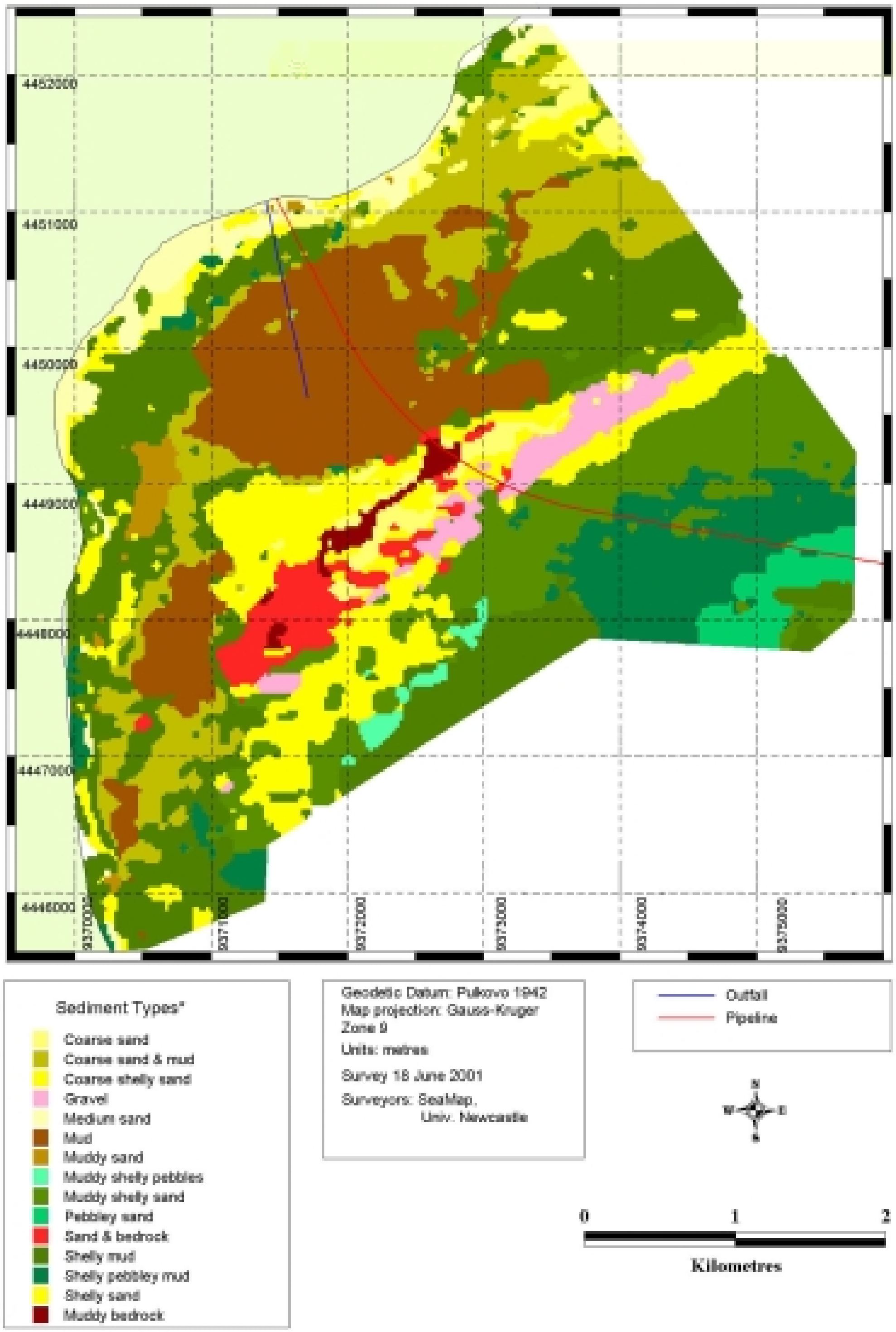
Figure 3.1 Bathymetry of Sangachal Bay (depths in metres)



3.2 Seabed sediments

The nearshore sediments of Sangachal display a patchy mosaic of different sediment types ranging from hard concretions to very soft and mobile silty muds (Figure 3.2). The most common sediment type is a poorly sorted mixture of silt, clay, sand and shell fragments. This type of sediment is found close to the shoreline, around the perimeter of the whole of the bay, and in the deeper water areas. The central area in the immediate vicinity of the terminal outfall is composed of very mobile soft silt and mud. In deeper water (greater than 5m) rock outcrops and hard concretions are present as well as coarse sands and gravel.

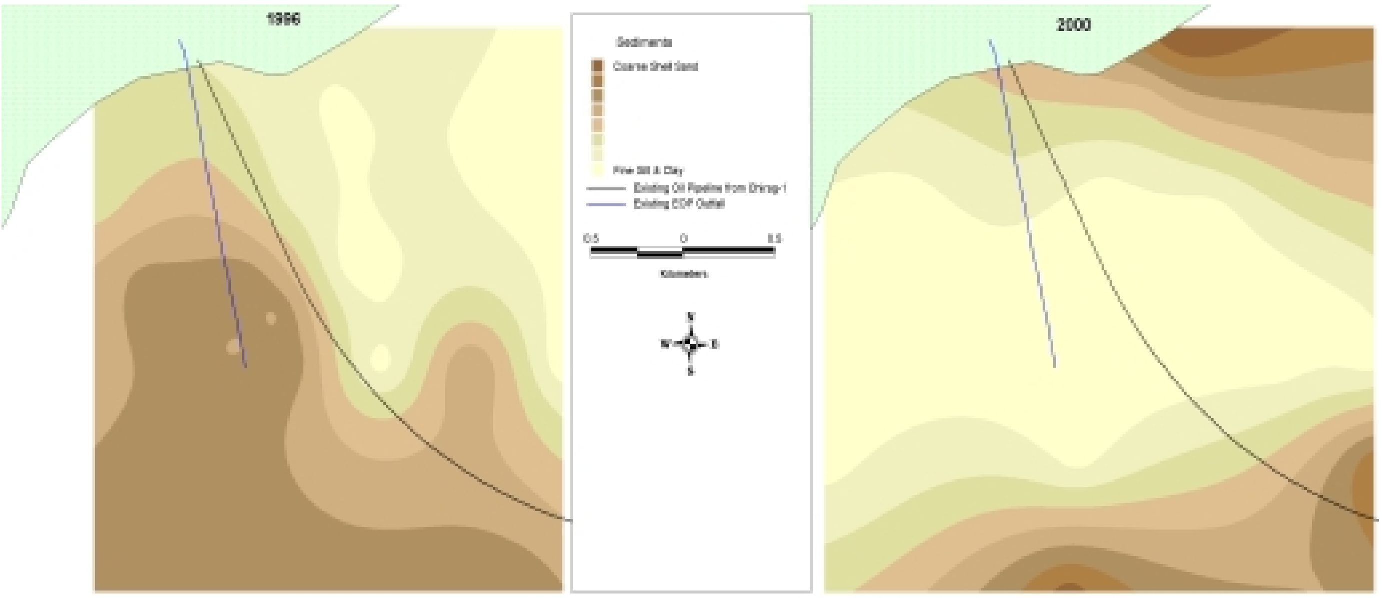
Figure 3.2 Seabed sediment types



* based on BGS and MNCR clasification scheme

Sediment types and distributions identified in the 2001 survey are similar to those found in the 2000 survey. A comparison of mean sediment particle size between 1996 and 2000 indicated a change in sediment distribution during this time (Figure 3.3). In 2000, a band of fine sediments existed in the centre of the bay, with coarser, poorly sorted sediments close to the shore and in deeper waters to the south. In contrast to this, in 1996, the finest sediments were located closer to the shore with particle size increasing with distance from the shore.

Figure 3.3 Comparison of sediment mean particle diameter between 1996 and 2000



In both surveys, however, the same relationships were observed between particle size, carbonate, silt/clay, and organic content. It is thus reasonable to conclude that the sediments of the shallow Sangachal area are highly mobile, and may regularly be re-distributed by wave action.

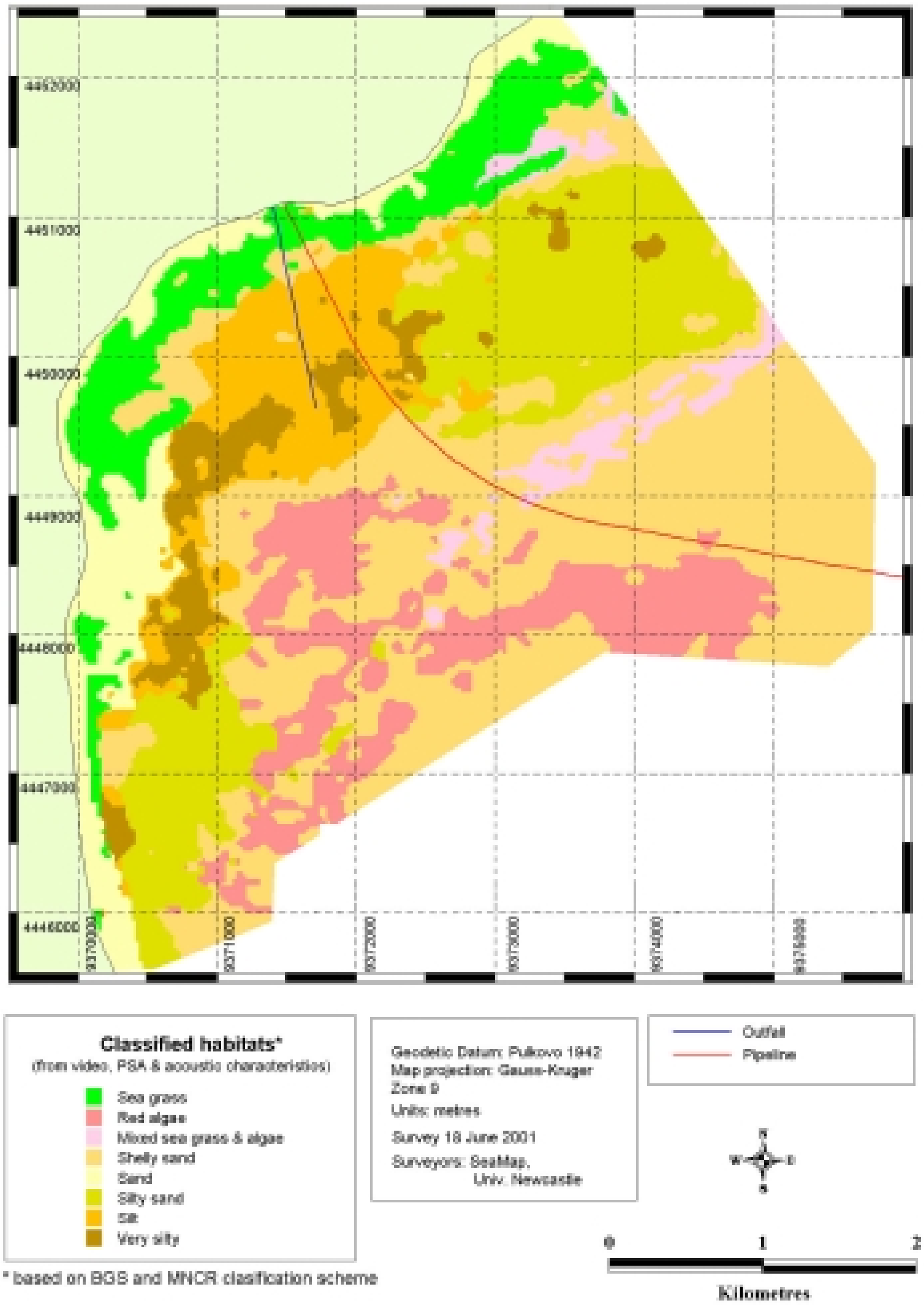
3.3 Marine flora

3.3.1 Seagrass

Presence and distribution

A single species of seagrass (*Zostera noltii*) was recorded during the recent seabed mapping survey. *Z. noltii* was found growing on a number of different sediment types, that included shelly mud, coarse shelly sand as well as gravel (Figure 3.4). Dense beds of seagrass were present close to the shoreline in water depths of less than 4 metres. A narrow band of seagrass was also found in deeper water (6-7m) nearly 2 km from the shoreline, in an area of gravel. Seagrass was not present in areas of fine-grained soft muds and silts or growing on rock outcrops. The results from the survey suggest that at Sangachal neither type of substratum allows the development of *Z. noltii* root networks.

Figure 3.4 Distribution of seagrass and red algae



General biological and ecological information

Seagrass is an angiosperm (flowering plant) that requires a particular light regime to photosynthesise and grow. The majority of growth takes place in the spring and summer, and established patches can enlarge at 0.5 m per year (C. Maggs pers com.). *Zostera* species form continuous mats, of varying size, which extend marginally by growth of stolons. During periods of low light intensity in the autumn the leaves are shed (Brown, 1990). They are also removed by grazing or wave action during the winter. *Z. noltii* over- winters as a rhizome and shoot fragments, which enable recruitment and re-growth in the spring (Marta et al 1996). Seeds probably do not play a major role in the life history of *Z. noltii*, although they could permit survival during extremely adverse periods (C. Maggs pers com.).

Seagrass plays a diverse range of roles in the maintenance of physical habitats and also biological communities. These include:

- The roots of seagrass bind the sediment, promoting sediment accumulation and stabilisation. This provides protection against wave disturbance which can aid natural coastal defence (Davison & Hughes, 1998; Orth, 1992);
- Leaves of seagrass slow water movement under the canopy and encourage the settlement of fine sediments, detritus and larvae (Orth, 1992).
- Seagrass supports numerous species of algae growing on the leaves as well as diverse benthic fauna in the sediment (Davison & Hughes, 1998; Connor *et al.,*1997b);
- Seagrass provides shelter and refuge from predation for fish and invertebrates.
- Oxygen penetration into the sediment is increased by the transport of oxygen to the roots and rhizomes of seagrass;
- Intertidal seagrass beds in Europe are an important food source for wildfowl. It is possible that submerged beds in the Caspian may also be an important grazing area for migratory and overwintering birds (Burton, 1961;Percival & Evans, 1997);
- Dead seagrass provides a source of organic detritus which is used as a food source for micro-organisms such as bacteria and protozoa (Davison & Hughes, 1998).

Overall, sea grass beds are characterised by high productivity and biodiversity and are considered to be of great ecological and economic importance (Davison & Hughes, 1998; Asmus & Asmus 2000b). The relative importance of the seagrass in the nearshore waters of Sangachal is discussed in Section 3.3.3.

3.3.2 Macroalgae

Presence and distribution

A total of six species of red algae, five species of green algae and one species of yellow-green algae were recorded during the 2001 survey (Table 3.1). The number of algal species recorded was low in comparison to other brackish-water areas such as the northern Baltic, where over 40 species of macroalgae have been recorded (Middelboe *et al.* 1997). The largest red algae in the samples collected was an endemic species *Osmundea caspica*, and the majority of the other red algae were growing epiphytically on it. Species of the genera *Ceramium* and *Polysiphonia* were the most commonly-occurring red algae.

Table 3.1 Algae types identified during the 2001 survey

Red Algae – Rhodophyta:
Callithamnion sp*. cf. corymbosum* *Ceramium sp. cf. tenuicorne* *Osmundea caspica* *Polysiphonia denudata* *Polysiphonia stricta* *Acrochaetium/Audouinella* sp
Green Algae - Chlorophyta:
Chaetomorpha sp. *Cladophora* sp. *Enteromorpha* sp. *Rhizoclonium* sp. *Spongomorpha* sp
Yellow-green Algae - Xanthophyta:
Vaucheria sp

Macroalgae were present on a range of substrates from coarse sand to rock outcrops as well as on living mussels and barnacles and dead shells. Samples of macroalgae were not retrieved in areas composed of fine-grained soft muds and silts. Only a limited number of samples of macroalgae were retrieved from the areas of rock outcrops. This is probably associated with the limitations of the sampling technique rather than the actual distribution of macroalgae. In areas of rock outcrops the grab sampler had a low success rate of retrieving macroalgae samples. Macroalgae (unlike seagrass) was not found in abundance in shallow water areas, but was primarily present in water depths between 4-11m (Figure 3.1). This pattern of distribution is probably strongly influenced by the presence/absence of suitable substrata rather than depth. The types of macroalgae found require solid substrata for attachment, which were largely absent in the shallow water areas. The most distinctive zones of red algae were located more than 1 km from shore, in regions defined as shelly mud, although a limited area of mixed seagrass and macro-algae was identified close to shore in the north of the survey area (Figure 3.1).

General biological/ecological information

Either light penetration or substratum availability may influence the lower depth limits of the red algae. The upper depth limit of approximately 5m is most likely determined by the substratum availability, as rock outcrops for red algae to fix themselves to were not found in the shallow water areas below 5m. The maximum depth at which red algae were recorded in the present survey was 10-11 m. During the seabed mapping survey high levels of water turbidity were experienced across the whole survey area. As previously mentioned the quality and usefulness of the video footage was compromised by high levels of water turbidity. Therefore it could be assumed that macroalgae are light-limited at depth.

All the red algae recorded were of a filamentous morphology and were predominantly members of the Ceramiales. This is probably due to the sedimentary substratum and high natural turbidity of the water, which would select against morphologies (e.g. foliose, crustose) which are more likely to accumulate silt and hinder photosynthesis. The red algae observed fall into two life history categories:

- Annual or ephemeral species, with one to several life histories being completed during the spring, summer and autumn. These include *Callithamnion* sp., *Ceramium* cf. *tenuicorne*, *Polysiphonia denudata* and *Acrochaetium* sp.;
- Perennial species include *Osmundea caspica* and *Polysiphonia stricta*, perennating as mature thalli; either as entire thalli or holdfasts. Both grow fastest in the spring, occur as large thalli in the summer, and overwinter as perennating bases. The basal parts of both species contain large amounts of storage material, and they can survive reduced light availability or even total darkness for several months.

The perennial nature of *Osmundea* is probably important in determining the structure and persistence of the macro-algal community, since (as noted above) many of the other species were observed to be growing on *Osmundea*.

3.3.3 Summary of seagrass and macroalgae importance

Results from a year long fish monitoring program of the nearshore waters in Sangachal (carried out between July 2000 and June 2001) have shown that shallow water areas support seasonal juvenile fish populations of roach (vobla and kutum), mullet, sprat and kilka. The nearshore region also supports permanent populations of sandsmelt and several species of goby. Several of the fish sampling sites were adjacent to the most extensive areas of seagrass coverage (Figure 3.5). Substantial numbers of small fish (typically 5-10 cm in length) are present in the shallow margins at most times of the year, indicating that the Sangachal area is used as a nursery and foraging site for several species. No information is available on the diurnal behaviour patterns of these local populations, but it is possible that they occasionally or regularly use the adjacent seagrass beds as refuge. If this is the case, then it is also possible that the abundant presence of small fish in shallow waters is directly dependent on the close availability of such a refuge.

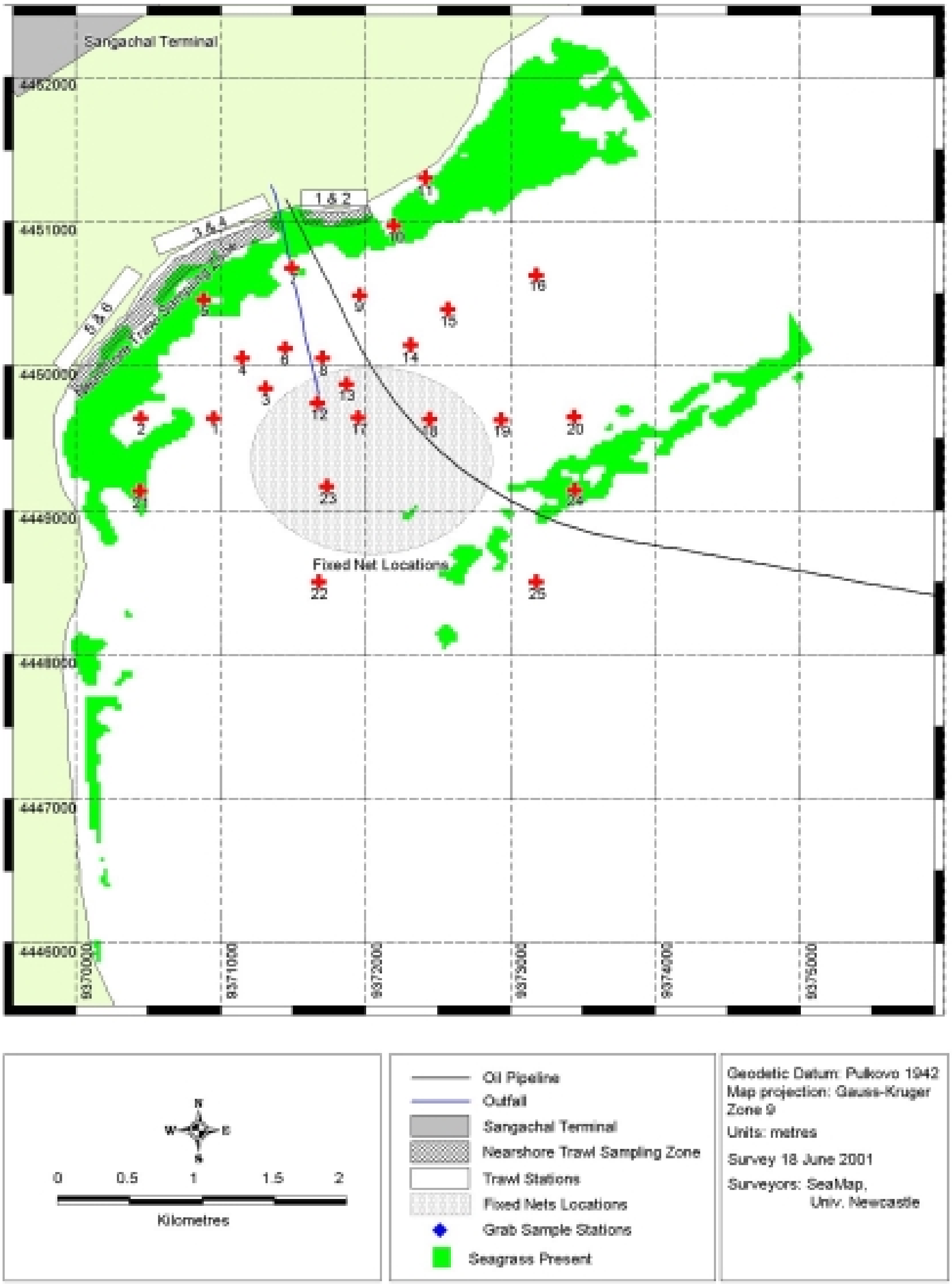
A seabed survey of the Sangachal area was conducted in 2000. Seagrass was observed in grab samples at six stations (10, 13, 15, 19, 21, 22 – Figure 3.5), and five stations coincide with the nearshore seagrass beds delineated in the current seagrass mapping survey (5, 10, 11, 21 and 24). Red algae were not observed in any of the 2000 survey samples; however, this could be a combination of the distribution of station locations, and of the difficulty of obtaining good grab samples from some of the hard substrata with which the red algae are associated. The observations below should be considered as tentative, since:

a) the presence of seagrass in grab samples in 2000 is not firm evidence that the sample was taken within the limits of a seagrass bed (substantial amounts of fresh detached seagrass fronds are regularly encountered in the area);
b) the coincidence of location of 2000 station locations and 2001 seagrass bed location does not mean that seagrass present in 2001 was present at the same locations one year earlier.

The macrobenthic species present in the four 2000 survey stations which coincide with the mapped distribution of seagrass are listed in Table 3.2, which also indicates their relative abundance. As is generally the case for the whole Sangachal bay area, the macrobenthos most closely associated with the seagrass beds is dominated by bivalves (*Abra, Mytilaster, Cerastoderma*). These samples are also dominated by introduced (alien) species (*Nereis, Mytilaster, Abra, Rhithropanopeus, Balanus*) which appear to have replaced the native communities. Apart from *Cerastoderma*, native invertebrates are poorly represented by the occasional presence of one or two oligochaete and polychaete species. The dominant components at the stations summarised in Table 3.2 are dominant across the whole Sangachal area, and it does not therefore appear that the seagrass beds are likely to support entirely distinctive macrobenthic communities. It is also worth noting that many taxa characteristic of native Caspian fauna (especially amphipods and gastropods) were rare or absent in Sangachal samples. However, it is also worth noting that three taxa of native amphipods were present at station 11, and that a range of native fauna (sabellid and ampharetid polychaetes, cumaceans and a gastropod were present at station 5 – both of these stations are close to shore, and presumably close to the inshore limit of the seagrass beds, and it is possible that the presence of seagrass at these locations has assisted in the maintenance of local populations of native invertebrates.

The sampling methods used in 2000 will not have been effective for some mobile epibenthic species, or for invertebrates which swim within the seagrass canopy, so it is not possible, from the available data, to provide a definitive characterisation of the communities associated with the seagrass beds. However, the available data indicate that the dominant species are either filter-feeders or omnivores which are also found in abundance in the absence of seagrass, and this would suggest that the macrobenthic community would not be highly sensitive to damage to the seagrass beds.

Figure 3.5 Sampling stations (2000 seabed environmental survey, 2000/2001 fish sampling locations) and distribution of seagrass from 2001 seabed mapping survey



The seagrass beds in the nearshore waters of Sangachal are relatively limited in their spatial coverage, as they are only primarily found occupying a narrow strip of the seabed close to the shoreline. Their role in stabilising and maintaining the environment could be quite significant, but it is currently difficult to establish with a high degree of confidence

Table 3.2 Macrobenthic taxa present (and relative abundance) at Sangachal 2000 survey stations located within areas of seagrass distribution mapped in 2001

Species	Stations				
	11	24	10	5	21
Gammaridae indet.	5				
Niphargoides sp.	3				
Niphargoides carausui	5				
Turricaspia spp				3	
Ampharetidae sp				5	
Manayunkia caspica				5	
Pterocuma pectinata				2	
Nereis diversicolor	5	5	5	5	
Hypania invalida		2	5	5	
Hypania kowalewski				5	5
Balanus improvisus		5	4	3	
Rhithropanopeus		5	2	5	
Mytilaster lineatus	5	5	5		
Tubificidae spp			3		
Cerastoderma lamarcki	3	5	5	5	
Tubificidae sp BPSD38#30	5	5		5	3
Abra ovata	5	5	5	5	2
Isochaetides michaelseni	3	4			

Key to numbering:

2 = 1-10 individuals per m^2
3 = 11-100 individuals per m^2
4= 101-1000 individuals per m^2
5 = 1001-10,000 individuals per m^2

4 Seagrass and algae sensitivity to Phase 1 construction activities

Although current site specific information on the role and ecological importance of seagrass is limited, a preliminary assessment is required of the sensitivity of the plant communities themselves to the construction of pipelines associated with the Phase 1 project and later phases of the Full Field Development project. In order to address the issue of seagrass and algae sensitivity, a number of issues need to be considered:

- Changes to the existing features of the nearshore Sangachal environment need to be identified;
- The potential for, and rates of, recovery of the affected areas;
- The importance of the seagrass and red algae communities or biotopes, in terms of their role in providing a habitat for other species and maintaining biodiversity.

Activities associated with pipeline construction work in the nearshore waters of Sangachal include:

- Trenching/dredging;
- Construction of shoreline jetties;
- Increased vessel traffic.

These activities have the potential to affect the environment in a number of ways:

- Direct temporary losses and permanent alterations in the seabed substrata;
- Increased water turbidity and higher levels of suspended sediment through the resuspension of mobile sediments;
- Smothering caused by the settlement of suspended material;
- Long term changes to sediment movement and associated alterations to seabed substrata;
- Changes to land drainage patterns may also occur as a result of onshore civil engineering work.

Of primary concern to the health and stability of the seagrass and macroalgae populations are changes in the sediment type distribution and increases in turbidity and suspended sediment.

4.1 Seagrass sensitivity

In Western Europe and North America, there has been a great deal of research focused on *Zostera marina* and disturbance arising from activities such as pipeline laying. It has been found that rhizomes of Zostera elongate at variable rates depending on the environmental conditions. Growth rates with a mean of 0.6 m per annum have been recorded (Hemminga and Duarte, 2000). New beds and new individuals that initially suffer high mortality and can take 5 years to establish and stabilise (C. Maggs pers com.). Destruction of even small areas of large seagrass beds by pipelaying activities could result could result in long-term consequences due to the fragmentation of seagrass beds. As mentioned previously small patches of seagrass experience higher rates of mortality than extensive beds. Changes to the distribution of seagrass may also affect sediment movement and cause further losses of seagrass as the sediment types change to those that do not support seagrass growth.

The majority of growth takes place in the spring and summer, and established patches can enlarge at a rate of 0.5 m per year (C. Maggs pers com.). Thus a trench only 3 metres wide would be expected to take at least 3 years to fill in, growing from both sides. The majority of the re-growth will be through vegetative growth as seeds probably do not play a major role in the life history of *Z. noltii*, although they could permit survival during extremely adverse periods (C. Maggs pers com.). Severe damage caused by Zostera dieback in the 1930s has still not been overcome in the British Isles. In the US particularly, mitigation by transplantation has been attempted, with mixed results (Davison, 1997; Hemminga & Duarte, 2000).

4.2 Macroalgae sensitivity

Losses of macroalgae associated with construction activities through direct substrata alterations and increased turbidity are likely to affect nearshore population dynamics. However, the implications to macroalgae are not as significant in comparison to seagrass as:

- Macroalgae density were found to be lower than that of seagrass;
- Macroalgae are less sensitive to fragmentation in comparison to seagrass;
- Macroalgae plays a less significant role in sediment stabilisation and movement when compared to seagrass.

The sensitivity of macroalgae to temporarily increased water turbidity depends on the factor that sets the lower depth limits (either light penetration or substratum availability). Assuming that lower depths limits are dependent on light penetration then the effects of increased water turbidity would depend on the macroalgae life history:

- Annual or ephemeral species will more readily adapt to periods of increased turbidity than perennial species, as one to several life histories are completed each season. During periods of increased turbidity the distribution of these species will be restricted to shallow water areas with suitable substrata. Rapid reproduction rates would enable them to recolonise deep areas as water turbidity decreased. Increased sedimentation could reduce recruitment as red algae spores cannot settle on silt;
- Perennial species are capable of surviving longer periods of increased turbidity as they contain larger amounts of storage material in comparison to annual or ephemeral species. Short term increases in sedimentation rates would not impact the algae severely, but long term changes could prevent recruitment if surfaces were entirely sediment covered.

5 Summary

The 2001 seabed mapping survey was successful in establishing the current distribution of sediment types, seagrass and macroalgae in Sangachal Bay. Sampling success in areas of hard substrata such as rock outcrops was limited and as a result these areas are underrepresented. This may account for the low number of macroalgae species recorded.

Zostera noltii was the only species of seagrass found in the bay. *Z. noltii* was found inhabiting relatively coarse sediment types with a varying sand and mud content. The densest areas of seagrass were found within a few tens of metres from the shoreline almost across the entire perimeter of the bay in water depths of less than 4 metres. Several species of macroalgae were identified, including six species of red algae. The majority of the macroalgae were found growing on hard substrata such as areas of rock outcrops, mussels, barnacles and dead shell fragments, in water depths of between 5-11 metres.

Recent available scientific literature regarding the distribution of seagrass along the coast of Azerbaijan is limited. Surveys completed in the 1950's and 1960's found seagrass (*Zostera noltii*) to be abundant in the nearshore water between Sangachal and Kizil Agach Bay (E. B. Zaberzinskaya 1968a, 1968b, M. S. Kireeva 1957). Seagrass was found on a mixture of sandy sediment types, within relatively shallow water of less than 4.5 metres. Numerous species of macroalgae were also recorded during these surveys. The highest abundance of macroalgae was found in the vicinity of the Apsheron peninsula growing in areas of rocky outcrops. Dead seagrass and red algae is commonly found washed up across large parts of the shore south of Sangachal especially between Sangachal and Banka, suggesting that seagrass is common in the nearshore waters (W. Boulton pers com 2000).

The current survey provides valuable information on the sediment types and spatial distribution of the seagrass and macroalgae in the nearshore waters of Sangachal. However, additional information is required to enable the potential environment changes caused by pipelaying activities to be put into context of natural variations in seagrass and macroalgae population dynamics.

Options available to address these existing data gaps include:

- The collection of baseline photon irradiance data prior to and during pipeline installation work. This will provide results on the existing levels of turbidity and the actual affects of construction activities. In-situ measurements could be collected using fixed moorings;
- Use of sediment traps that are retrieved on a regular basis prior to and during pipeline installation work. This will provide information on sediment mobility and rates of sediment deposition;
- Repeat surveys using similar methodologies with improved sampling techniques in areas of hard substrata. Repeat surveys will provide information on overall changes

in sediment type distribution, seagrass and red algae coverage and density on an annual or seasonal basis;

- Targeted seabed sampling of the benthic communities in areas where seagrass is present. This information could be used to provide detailed information on the biological communities that live in areas covered by seagrass.

Ideally a combination including all of the above would provide detailed information on the changes to seagrass and red algae distribution as well as vital supporting information on the influential environmental factors.

6 References

Brown, R.A., (1990). Strangford Lough. The widlife of an Irish sea lough. The Institute of Irish Studies, Queens University of Belfast.

Burton, P.J.K., (1961). The brent goose and its winter food supply in Essex. Wildfowl, 12, 104-112. Percival, S.M. & Evans, P.R., (1997). Brent geese (*Branta bernicla*) and *Zostera*; factors affecting the exploitation of a seasonally declining food resource. Ibis, 139, 121-128.

Chivers, R.C., Emerson, N. and Burnus D.R. (1990). New acoustic processing for underway surveying. The Hydrographic Journal 56, 9-17.

Connor, D.W., Dalkin, M.J., Hill, T.O., Holt, R.H.F. & Sanderson, W.G., (1997b). Marine biotope classification for Britain and Ireland. Vol.1. Littoral biotopes. Joint Nature Conservation Committee, Peterborough, JNCC Report no.299, Version 97.06.

Davison, D.M. (1997). The genus Zostera in the UK: a literature review, identifying key conservation, management and monitoring requirements. Environment and Heritage Sevice, Belfast.; Hemminga, M.A. & Duarte, C.M. (2000). Seagrass Ecology. Cambridge University Press, Cambridge.

Davidson, D.M. & Hughes, D.J., (1998). Zostera Biotopes: An overview of dynamics and sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science, (UK Marine SACs Project), Vol.1.;

Davidson, D.M. & Hughes, D.J., (1998). Zostera Biotopes: An overview of dynamics and sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science, (UK Marine SACs Project), Vol.1.;

Hemminga, M.A. & Duarte, C.M. (2000). Seagrass Ecology. Cambridge University Press, Cambridge.

Marta, N., Cebrian, J., Enriquez, S. & Duarte, C.M., (1996). Growth patterns of western Mediterranean seagrasses: species specific responses to seasonal forcing. Marine Ecology Progress Series, 133, 203-215.

Middelboe, A.L., Sand-Jensen, K. & Brodersen, K. (1997). Patterns of macroalgal distribution in the Kattegat-Baltic region. Phycologia 36: 208-219.

Orth, R.J.,(1992). A perspective on plant-animal interactions in seagrass: physical and biological determinations influencing plant and animal abundance. In Plant-Animal Interactions in the Marine Benthos, Systematics Association Special Volume no 46, (ed. D.M.John, S.J. Hawkins, & Price, J.H.), pp. 147-164. Oxford: Clarendon Press.

Zaberzinskaya, E.B., (1968a). New species of red algae in the Caspian. New of classification of unicellular. L: Nauyka, Leningrad.; Zaberzinskaya, E.B., (1968b). Flora of macrophyte algae of the Caspian Sea. Report. Dissertation – Baku.; Kireeva, M.S., Schchapova,T.F., Species distribution and biomass of algae and seagrass in the Caspian sea. Institute of Oceonology, AS of USSR, v.XXIII, (1957)

Disclaimer

This report has been prepared at the request of URS, by ERT for the sole use of BP. As such the report represents the investigations, findings and conclusions of “Sangachal seabed mapping survey”

The report in no way represents the views, assumptions or opinions of URS. No other warranty, expressed or implied, is made as to the professional advice included in, or contents of, this report. URS is not responsible for any liability arising out of, or in connection with, any reliance on or use of the advice or information provided.