9 Ecology

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9 Ecology

9.1 *Introduction*

This chapter of the Environmental Statement (ES) considers the potential impacts of the Eastside development on ecology (species and processes) including subtidal ecology, intertidal ecology, terrestrial ecology, ornithology, and fish and fisheries. Nature conservation interests with regard to protected areas and species under the EC Habitats Directive are considered in the following chapter (Chapter 10).

The potential for impacts on ecology was identified during consultation with Gibraltar Ornithological and Natural History Society (GONHS) and is identified in the Town Planner's Scoping Opinion (Government of Gibraltar, (GoG) 2005 – see Appendix A) which requires that the ES discusses "*potential impacts of the development on terrestrial and marine ecology and the causal linkages (e.g. physical disturbance, sedimentation, current and water quality changes).*" In particular, the Scoping Opinion indicates that consideration should be given to cave and rocky shoreline habitats, corals, shellfish harvesting and the selection of materials for Eastside's marine structures.

9.2 *Assessment Methodology*

9.2.1 *Data Collection*

Data has been collected through consultations held with various stakeholders (e.g. Government departments and GONHS) and available reports and other references as cited in the text, including the Gibraltar Biodiversity Action Plan (BAP) (GONHS, 2006). The information collected provided a broad description of the terrestrial and marine ecology of Gibraltar, including lists of fauna and flora found in the inter-tidal and sub-tidal habitats on the east and west coasts.

9.2.2 *Subtidal Ecology Survey*

An investigation of the submerged (subtidal) environment was undertaken using underwater video imagery. The survey covered the coastal area along the east side of Gibraltar including:

- Eastside area (video along 1000m long transects in up to 9m water depths supported by quadrats); and
- An offshore area to cover sites that could be used as sources of fill for land reclamation (sonar scans to develop a seabed features / outcrops map supported by video along concentric transects typically between 15m and 22m water depths).

All video footage generated was transferred to DVD format for analysis. The results of the subtidal survey are summarised in Section 9.3.

9.2.3 *Intertidal Ecology Survey*

A survey of the inter-tidal and shoreline marine environment was undertaken to provide a general overview of the inter-tidal and shoreline environment along the east coast of Gibraltar covering the stretch between Eastern Beach and Ammunition Jetty (see Figure 9.1). The general overview of the intertidal environment provided a quantitative assessment of species counts and density, overall diversity and richness.

The survey methodology detailed in Appendix F (Intertidal Survey Report) gave special attention to *Patella ferruginea*; a species of limpet protected under Annexe IV (a) to the EC Habitats Directive and the Nature Protection Ordinance. Any *P. ferruginea* individuals found were measured for size, photographed and a GPS position taken. The survey was carried out in a series of approximately 4-hour windows around times of low water when the limpets are exposed and during calm sea conditions to allow safe access by foot, snorkelling or by boat.

The results of the intertidal survey are included in Appendix F and summarised in Section 9.3.

9.2.4 *Sensitive Receptors*

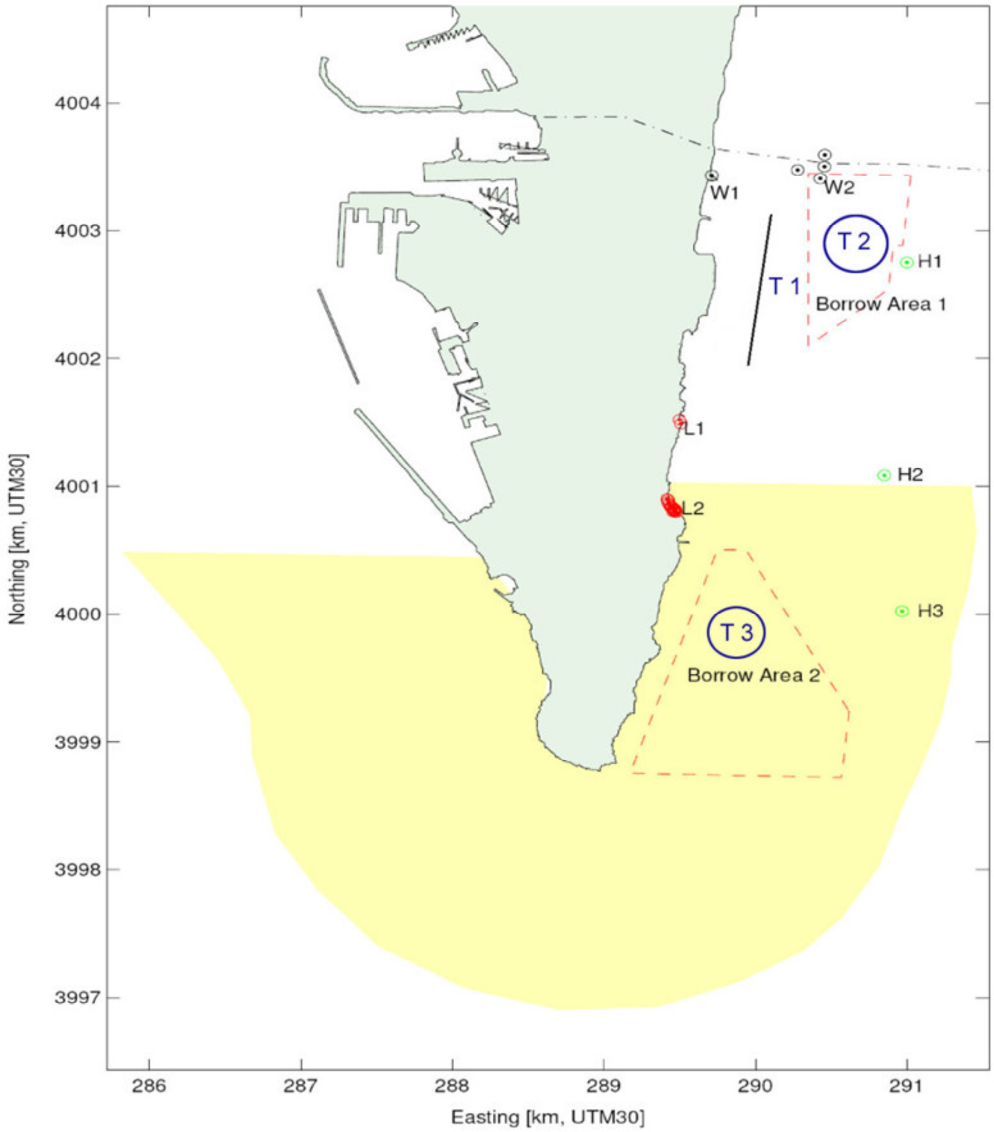
For some impacts, the assessments related to marine issues were made with regard to a number of sensitive receptors (i.e. key habitats and/or species) at locations shown on Figure 9.1 (overleaf). For other impacts, the assessments were made with regard to sensitive receptors identified by the BAP (see Figures 9.2 and 9.3).

9.2.5 *Impact Significance*

In order to classify the significance of predicted impacts, and in an effort to provide a consistent framework for considering and evaluating impacts, the following terminology has been adopted:

- Negligible - the impact is not of concern;
- Minor adverse - the impact is undesirable but of limited concern;
- Moderate adverse - the impact gives rise to some concern but it is likely to be tolerable (depending on its scale and duration);
- Major adverse - the impact gives rise to serious concern; it should be considered as unacceptable unless unavoidable by best practicable means;
- Minor beneficial - the impact is of minor significance but has some environmental benefit;
- Moderate beneficial - the impact provides some gain to the environment; and
- Major beneficial - the impact provides a significant positive gain.

Figure 9.1 Locations of Key Marine Habitats and Species



Key: T1 = 1000 transect at 9m depth; T2 and T3 = Concentration transects at various depths. H 1/H2/H3 = rock habitat, L1/L2 = limpet locations (P. ferruginea), Yellow shaded area = Southern Waters of Gibraltar Marine Nature Area, W1/W2 = wreck locations (see Chapter 15)

9.3 Baseline Conditions

9.3.1 Ecology Overview of Gibraltar

Gibraltar's ecology is well recorded in species lists for birds, reptiles, terrestrial molluscs and plants published and updated by GONHS, largely in its journal Alectoris (Cortes et al. 1980; Cortes 1983; Linares 1993; Menez 1993) and more recently in the Gibraltar BAP (GONHS, 2006).

Despite its limited land and water area, Gibraltar's biodiversity is high and includes some endemic and near-endemic subspecies or varieties. Gibraltar's territory, particularly the Strait of Gibraltar, provides an important migratory route for avian, airborne invertebrate and marine species.

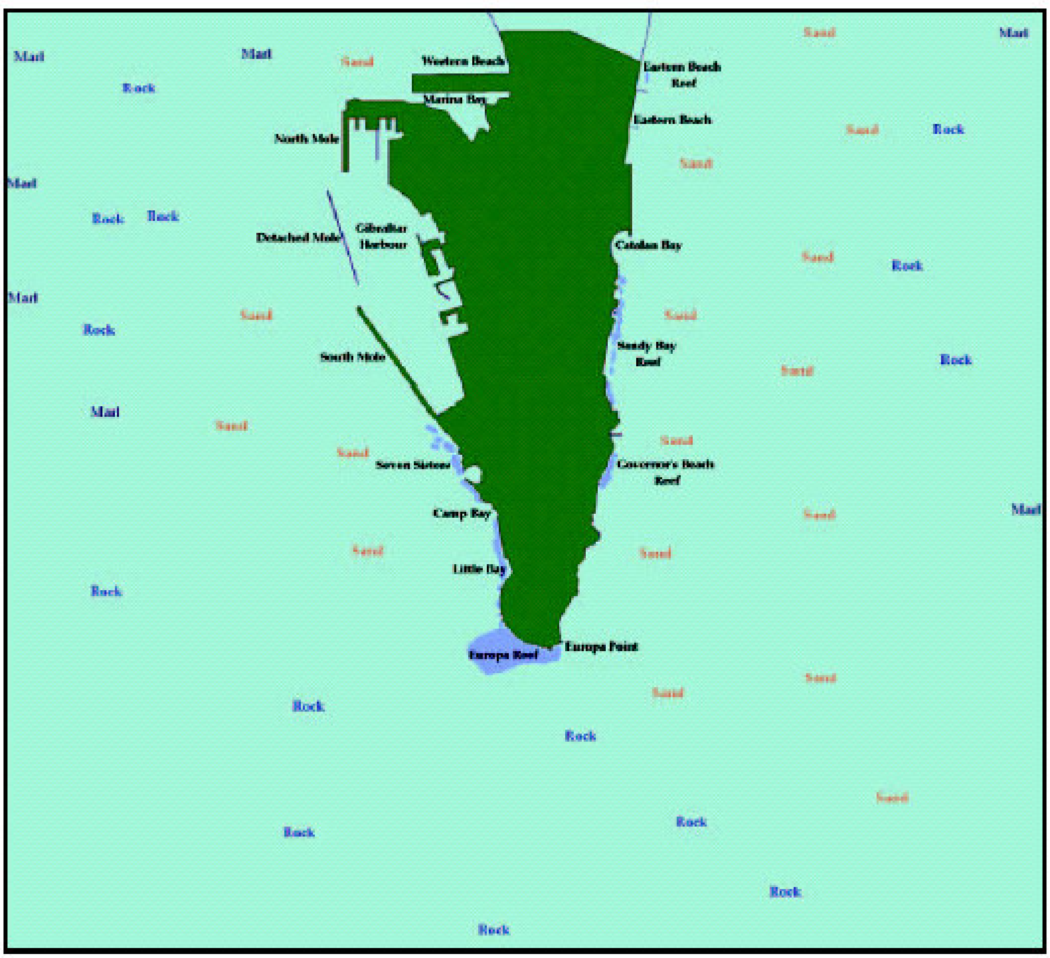
As summarised in the BAP, "*the habitats that make up the territory of Gibraltar can be found within the two main ecosystems. These are the terrestrial and the marine ecosystems, which are sub-divided into some of the representative habitat types found in the Mediterranean region. Some of these areas are delineated by topographical characteristics; others are formed by natural and/or artificial boundaries as in the case of the Upper Rock Nature Reserve, whereas some are bordered by the nature of their underlying geology or the sea bed.*"

The following paragraphs describe the key marine and terrestrial habitat types bordering and potentially affected by Eastside.

9.3.2 *Marine Habitats*

The eastern shoreline of Gibraltar is a combination of sea cliffs, rocky shorelines and beaches. The sea area includes some shore rocky reefs and offshore rocky outcrops, but principally comprises sandy seabed (see Figure 9.2).

Figure 9.2 Locations of Marine Habitats (source: Gibraltar BAP)



The seabed off Gibraltar's east coast predominantly comprises sand with a few scattered low lying rocky outcrops close to the shoreline in shallow water to the south of Catalan Bay and off Sandy Bay and Governor's Beach (see Figure 9.2).

The seabed's ability to support marine fauna and flora has been affected by the activity of Spanish conch rake fishing boats. Despite a prohibition of such activity within Gibraltar's waters, the method of towing conch rakes over the seabed continues and creates troughs of 25cm to 35cm depths, depending on the size of the boat. Conch rake fishing has therefore greatly denuded the seabed of the abundance of bivalves and gastropods that previously colonised the sandy seabed habitat.

There are larger rocky outcrops providing rocky habitat offshore in deep water (30m+) including Weaver's Pinnacle (see H1 on Figure 9.1) and Peter Ives' Pinnacle / El Cortijo (see H2 on Figure 9.1). Peter Ives' Pinnacle attracts fish and is noted to host grouper, spider crabs and conger and moray eels (Smith and Fa, 2004). A third rock area, known as Fred Flintstone's Submarine or El Lomo (see H3 on Figure 9.1) comprises large rocks scattered on the sandy seabed and attracts a wide range of sea-life including grouper, eels, rays and sunfish (Smith and Fa, 2004).

Gibraltar's eastern shore comprises a higher proportion of a natural intertidal area than its western shore. Although there are some sandy beaches along the east coast at Eastern Beach, Catalan Bay and Sandy Bay, they are, according to the BAP, "*frequented by many bathers, especially in summer, and are of little ecological interest as a consequence*." It is the rocky shoreline habitat between these sandy beach areas that is the richest in biodiversity. A detailed description of the intertidal area is provided by the intertidal survey conducted to inform the EIA process (see Appendix F).

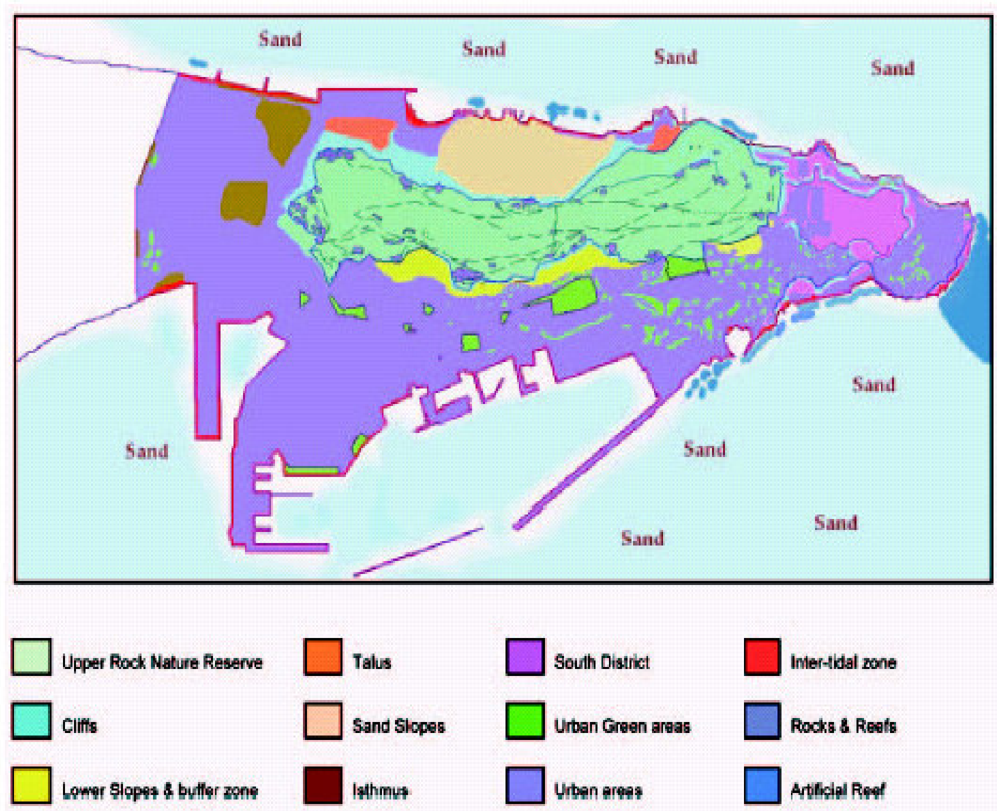
9.3.3 *Caves*

A series of caves are present around Governor's Beach, north of the Ammunition Jetty; their location can be identified by the east-west aligned pier extending from the coast just south of L2 on Figure 9.1. Where they are above the water level, the caves provide an important habitat for Western Mediterranean shags because their ledges provide nesting sites. Some caves are underwater and host sponges, tunicates (e.g. sea squirts) etc., but no plant life. In terms of the caves' current status, the BAP notes that "*the series of caves was most likely compromised by the extraction of sand offshore for the Europort reclamation project. The beach was subsequently lost as a result and the waves now break very close to several of the cave entrances and wash the cave deposits away*." This suggests that previous dredging at the southern borrow area may have adversely affected cave habitat. The BAP also notes that the ongoing archaeological investigations and much of the infrastructure and grid of wires at Gorham's Cave "*constitute a hazard for wintering crag martins and other wildlife, including possibly bats*".

9.3.4 *Terrestrial Habitats*

A number of terrestrial habitats border the Eastside development site, most notably the talus slope and the sand slopes (see Figure 9.3 overleaf).

Figure 9.3 Locations of Terrestrial Habitats (source: Gibraltar BAP)



The talus is identified by the sloping mass of rock debris at the base of the cliff on the east side of the Rock at the base of the vertical cliff that towers up to Rock Gun. According to the BAP the talus habitat "*extends from the eastern end of Devil's Tower Road to Catalan Bay, where the talus slope was quarried for limestone rocks. The formation of the slope is due to the constant deposition of rocky material from the cliffs above. The main deposition took place during the glaciations, with the action of rain water freezing and expanding within fissures and crevices in the rock, fracturing the rocks and breaking them off to fall to the base of the cliff, forming a conglomerate which fused to form breccias. Wind-blown sands off the Mediterranean Basin then covered the talus with a thick mantle, with more rocks later falling from above, to produce the combination of rock and sand where a unique habitat of plants and animals now exists.*"

The nature of the underlying soil and the lack of human disturbance has allowed the talus slope to develop a range of characteristic plant species, including the large yellow restharrow (*Ononis natrix*) and the Gibraltar restharrow (*Ononis natrix* var. *ramosissima*), which grows in abundance here and is endemic to Gibraltar. The other key plants of the talus slope are the Montpellier broom (*Teline monspessulana*), parsley (*Petroselinum crispum*), giant or large-flowered mullein (*Verbascum giganteum*), silver sea stock (*Malcolmia littorea*), erect dorycnium (*Dorycnium rectum*) and Gibraltar candytuft (*Iberis gibraltarica*).

The fauna of the talus habitat is also very varied. Several bird species use the talus habitat as their feeding or breeding grounds, particularly the yellow-legged gull (*Larus michahellis*) (some 60 breeding pairs), kestrel (*Falco tinnunculus*), Barbary partridge (*Alectoris barbara*), little owl (*Athene noctua*), eagle owl (*Bubo bubo*), blue rock thrush (*Monticola solitarius*), black redstart (*Phoenicurus ochruros*) and rock bunting (*Emberiza cia*). The talus also hosts various species of reptiles (snakes, lizards, skinks) and invertebrates (butterflies, beetles, crickets, grasshoppers, ant-lions, lacewings).

The talus slope has deteriorated in the recent past due mainly to the construction of access roads to Catalan Bay, rendering the base unstable, so that sand and soil slippage has occurred regularly until the slope has again achieved a stable angle. In addition, since access to the slope is not restricted to members of the public, excessive walking can be destructive. The BAP notes that Eastside is believed to be the greatest threat to the integrity of the talus slope, particularly if development promotes slope instability and rock falls, as well as additional walking.

The great sand slopes (see Figure 9.3) comprise approximately 45 hectares of the cliff face and extend from the southern end of Catalan Bay to Sandy Bay. The slopes used to form part of the water catchment area, but have since been stabilised and re-seeded with native shrubs and grasses as part of a replanting project undertaken by GONHS. Alien invasive species, particularly the acacia (*Acacia cyclops*), potentially threaten native species due to smothering, and the BAP recognises that action is needed to address this problem.

9.3.5 *Subtidal Ecology Survey*

The following text summarises the findings of the subtidal survey.

The three 1000m long transects undertaken in the subtidal area adjacent to and facing the proposed Eastside development revealed a fairly consistent pattern in terms of seabed morphology, ecology, diversity and abundance. Sand cover accounted for 99% of the seabed throughout the area and exhibited a fairly constant presence of broken shells belonging to different species. Many of the broken shells are thought to result from conch raking. Very few living molluscs were recorded, mainly a few individuals (2-3) belonging to the genus *Sepia spp* and *Octopus spp*. Occasional (2-3 in total) clumps of mussels (*Mytilus spp*) were also recorded.

Fish counts were low to very low throughout the area. Fish shoals recorded were not made up of any significant numbers (<50) and showed no species of ecological or economic importance.

Transects taken in the subtidal areas to the north and south of Eastside area also revealed flat sandy seabed covering up to 99% of the area surveyed. There were no patterns in terms of fish counts and other live receptors including live shells, *Sepia spp* and *Octopus spp*, and of non-living elements such as broken shells.

Transects taken further offshore representing the potential borrow areas again revealed sand cover in excess of 99%. The seabed exhibited several clusters of broken (dead) shells. A few more hermit crabs were recorded compared to the inshore survey areas.

Although rocky outcrops (with diverse and abundant ecological features) are known to be present in deeper waters off east Gibraltar (see above), none was recorded by this subtidal survey.

Corals are more common on the west side of Gibraltar and include species such as the soft coral *Astroides calycularis* and the gorgonians *Eunicella singularis* and *Paramuricea clavata*. No corals were found in the subtidal survey area. However, some corals may be attached to the rocky outcrops further offshore (see Figure 9.1).

9.3.6 *Intertidal Ecology Survey*

The following text summarises the findings of the intertidal survey. More detailed information is presented in Appendix F.

The rocky coastline between the northern end of Eastern Beach and the northern end of Catalan Bay show two main types of rocky coastline, both artificial:

- Well constructed groynes and rock armour (Eastern Beach, north end of Catalan Bay); and
- Loose rubble reclamation (most of the coastline in this sector).

Despite being of relatively recent construction, the groynes and rock armour appear to be colonising well and already show a good degree of space structuration and increasing diversity. There exists a wide variety of intertidal fauna and flora, including periwinkles (*Littorina neritoides, L. punctata*), topshells (*Monodonta turbinata*), mussels (*Mytilus galloprovincialis*), beadlet and snakelocks anemones (*Actinia equina* and *Anemonia sulcata*, respectively), limpets and false limpets (*Patella rustica*, P. *caerula*, P. *uissiponensis*, C. *safiana*, *Siphonaria pectinata*) and barnacles (*Chthamalus stellatus*, *Balanus perforatus*).

The coastline from the northern end of Catalan Bay to the southern end of Sandy Bay comprises loose rubble and rubbish, leading to limestone cliff under the Caleta Hotel and a final stretch of natural coastline to Sandy Bay. The shoreline is very diverse with a rich algal assemblage (mainly composed of *Corallina elongata* and *Ralfsia spp.*) and dense mussel beds (*Mytilus galloprovincialis / edulis*; see Figure 9.4). Apart from the aforementioned species, these assemblages create a high degree of habitat heterogeneity and microclimates, affording shelter to a wide range of organisms.

Figure 9.4 Rich Algal Assemblages and Dense Mussel Beds

The coastline from the south end of Sandy Bay up to the Ammunition Jetty comprises a stretch of natural rocky coastline. Overall, 23 species were recorded in this area; the most common invertebrate recorded belonged to *Mytilus spp.*

The results of the surveys confirm the presence of a number of species in the nearshore and intertidal areas that are listed under the Nature Protection Ordinance, including *Blennius canevae* (all *Blennius spp.* are protected), *Monodonta turbinata* (all *Monodonta spp.* are protected) and *Stramonita haemastoma* (under synonym *Thais haemastoma*). Another protected species, *Murex brandaris*, was not recorded.

In addition, a total of 24 *P. ferruginea* individuals were found along the coastline of the study area, all at the southern end of the study area near Sandy Bay (see Figure 9.1 and Figure 9.5). Two individuals were found outside the study area as reported by Espinosa et al. (2005). This species is protected under Annex IV(a) to the EU Habitats Directive and the Nature Protection Ordinance.

Figure 9.5 Approximate locations of the P. ferruginea individuals

9.3.7 *Cetaceans and turtles*

The BAP reports that cetaceans are prominent in Gibraltar Bay and the Strait with the common dolphin *(Delphinus delphis*) and striped dolphin (*Stenella coerulaeoalba*) having nurseries in these areas. In addition to the aforementioned dolphins, other cetacean species found in the Bay and the Strait include minke whale (*Balaenoptera acutorostrata*), fin whale *(Balaenoptera polysalus*), humpback whale (*Megaptera novaeangliae*), pilot whale (*Globicephala melaena*), Risso's dolphin (*Grampus griseus*), killer whale (*Orcinus orca*), bottle-nosed dolphin (*Tursiops truncates*), sperm whale (*Physeter macrocephalus*), and Cuvier's beaked whale (*Ziphius cavirostris*). Gibraltar's open waters contain various pelagic fish attracted to local plankton with cetaceans (and predatory fish) following these pelagic shoals.

A number of turtle species are sighted occasionally in Gibraltar's waters, namely the loggerhead turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*) and leatherback turtle (*Dermochelys coriacea*).

9.3.8 *Pelagic Fish*

Gibraltar's open waters contain various pelagic fish including various mackerel and tuna species which have migratory routes through the Strait.

9.3.9 *Fisheries*

According to the Gibraltar BAP, fishing for pelagic fish, notably tuna, used to be based on inshore intercept netting methods, but this fishing activity has stopped due to poor catches. Fishing from La Linea stopped in 1997. GONHS has observed Japanese fishing vessels unloading tuna in Gibraltar in 2005, although it is not known whether the fish were caught in Gibraltar's waters. In addition, illegal seine net, gill net and rake fishing by Spanish commercial fishing boats are identified in the BAP to be a main threat to marine habitats and sites.

No fisheries grounds are present at the site of the development and therefore no impacts on fisheries have been assessed. Consultation revealed that GONHS believe that conch raking by Spanish fishermen has already badly impacted the fish ecology and fisheries resource of the seabed. The impoverished ecological condition of the seabed was evident in the video footage taken during the subtidal ecology survey.

It is understood that some shellfish harvesting does take place on an ad-hoc basis by locals for human consumption. There is no documented information to provide more detail about this activity and it is believed that shellfish harvesting does not take place at a commercial level, so no impact assessment is made regarding this activity.

9.3.10 *Terrestrial Ecology*

It is likely that the original vegetation of Gibraltar was woodland which has largely been destroyed over the centuries by tree felling and extensive goat grazing. Since the removal of goats early this century, maquis (mattoral) has become the dominant vegetation type. Cliff communities are also important. There are nearly 500 species of flowering plants, and the existing semi-natural vegetation is dominated by a maquis scrub of olive *(Olea europea)*, pistachio *(Pistacia lentiscus)*, *Osyris quadripartita* (*Santalaceae*) and the buckthorn *(Rhamnus alaternus)*. There are also areas of pseudo-steppe and garigue (a community of low (less than 1m) scattered, often spiny and aromatic shrubs with a herbaceous undergrowth).

A rich flora is found particularly on the inaccessible cliffs and ledges of the eastern slopes and more information is provided in the BAP. The Europa Point foreshore is the only limestone shoreline on the northern shore of the Strait of Gibraltar and its characteristic plants therefore form a unique community, totally different from that found on the Spanish shore across the bay. It is an important site, for instance, for the endemic Gibraltar sea lavender *(Limonium emarginatum)* and other rare plants and land snails (see below).

Gibraltar is renowned for its Barbary macaques (*Macaca sylvanus*), a long-established introduction (Drucker 1978). It has been suggested that the macaque population now exceeds the carrying capacity of the Upper Rock and therefore requires careful management.

Four species of bat are recorded from Gibraltar including the greater mouse-eared bat *(Myotis myotis)*, Schreiber's bent-winged bat *(Miniopterus schreiberi)*, the pipistrelle *(Pipistrellus pipistrellus)* and the free-tailed bat *(Tadarida teniotis)*. All bats and their roost sites are protected under the Nature Protection Ordinance 1991.

The flora of Gibraltar consists of about 600 plant species including several predominantly North African species which have their only European presence on Gibraltar. Examples include Gibraltar candytuft *(Iberis gibraltarica)* and Gibraltar mouse-ear *(Cerastium gibraltaricum)* both of which occur on rocky outcrops. Gibraltar thyme *(Thymus willdenowii)* is very common locally on rocky outcrops and very rarely, if at all, found elsewhere. The Gibraltar campion *(Silene tomentosa)* was thought to be extinct until its re-discovery in 1994 on rocky outcrops (three plants left in the wild). It is currently the subject of a propagation and reintroduction programme by the Gibraltar Botanic Gardens and the Royal Botanic Gardens, Kew. The campion was thought to be endemic to Gibraltar until its recent discovery in north-west Africa (Valdés & Parra 1999). Other endemic plant species and sub-species include:

- Gibraltar sea lavender *(Limonium emarginatum)* occuring on cliffs and rocky shorelines;
- Gibraltar restharrow *(Ononis natrix ramosissima)* found on rocky outcrops; and
- Gibraltar saxifrage *(Saxifraga globulifera gibraltarica)* found on rocky outcrops.

9.3.11 *Ornithology*

Migratory birds fly along the east coast of Spain and Gibraltar, but their habitats are increasingly being reduced. The east coast of Gibraltar, which falls on the main north-south migratory route for flamingos and reed warblers for instance, has no adequate habitat left. Of interest, there is a small (~50) resident population of shags (*Phalacrocorax aristotelis* *desmarestii*) which uses well known caves on the east coast of Gibraltar near Governor's Beach.

Over 300 bird species have been recorded on Gibraltar (GONHS, 1990), although the majority of them are migrants or rare visitors. Some populations of these species utilise the rock as a migratory stopover, but the importance of the rock to each species or population is not known and is under investigation (Finlayson, 1992).

Gibraltar is renowned for its spectacular spring and autumn passage of migrating raptors that take advantage of the narrow sea crossing between Western Europe and North Africa. Up to 190,000 raptors of 15 species may pass over the rock in a single season with numbers dominated by honey buzzards (*Pernis apivorus*) and black kites (*Milvus migrans*). As indicated above, the most important bird species resident on the Rock include the Western Mediterranean shag and Barbary partridge (*Alectoris barbara*) (Gibraltar is the only site on mainland Europe for this species).

In addition to the above, Table 9.1 presents a list of birds that, according to GONHS, includes those species that are known to commonly use the study area.

Table 9.1 Bird Species around Eastern Gibraltar

Bird Species	Common Name
Puffinus mauretanicus	Balearic shearwater
Puffinus yelkouuan	Medditerranean shearwater
Puffinus assimilis	Little shearwater
Morus bassanus	Gannet
Phalacrocorax aristotelis	Western Med Shag
Larus ridibundus	Black headed gull
Larus audouinii	Audouins gull
Larus cachinnans	Yellow legged gull
Larus fuscus	Lesser black backed gull
Sterna sandvicensis	Sandwich tern
Apus melba	Alpine swift
Fratercula artica	Puffin
Alca torda	Razorbill

9.4 Predicted Impacts

9.4.1 *Construction Phase: Impact of Dredging on Marine Ecology Due to Direct Habitat and Species Loss / Disturbance*

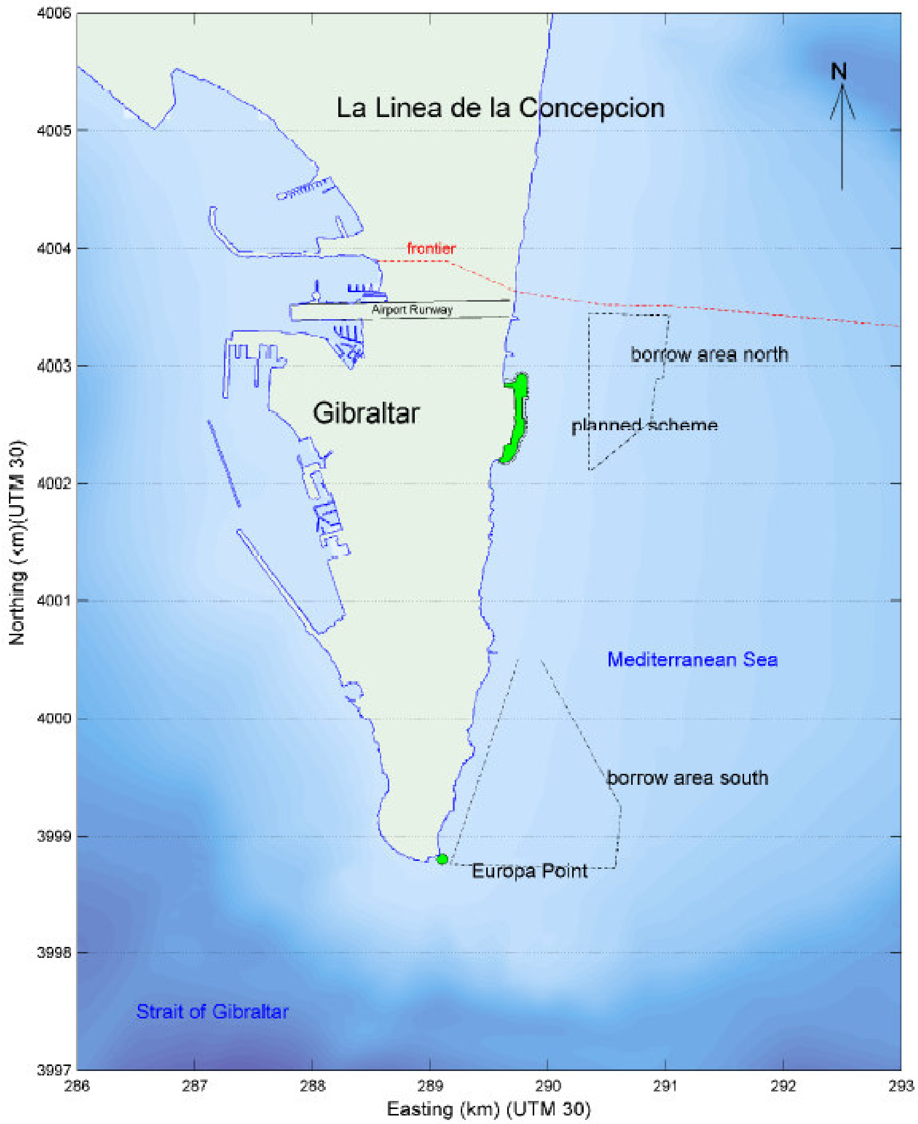
Dredging and some reclamation will be required for Eastside and is predicted to take place around the Eastside site and at the proposed northern and southern borrow areas (see Figure 9.6).

Dredging and reclamation typically cause impacts on the marine environment and its ecological receptors and processes. At Eastside this would include a direct and unavoidable loss and/or disturbance of the benthic habitat and associated species within the footprint of the project itself and at the borrow areas. Reclamation will cause the direct loss of marine habitats and species due to burial whilst dredging will cause the direct loss of marine organisms because the excavation operation of the trailing suction hopper dredger (TSHD) will remove the seabed's sediment and its ecological contents.

The size of the areas affected is indicated in Figure 9.6 and listed below:

- Intertidal shoreline (of rubble tip) = c.900 linear metres;
- Northern borrow area = 65.8ha by 1.52m depth (= 1,000,160 cubic metres); and
- Southern borrow area = 158.7ha by 0.63m depth (= 999,810 cubic metres).

Figure 9.6 Indicative Footprints of the Eastside development and the Borrow Areas



Given the nature of the reclamation for Eastside, it can be assumed that the entire length of the rubble tip (about 850 m) and the associated subtidal and intertidal habitats and species will be lost. The loose rubble provides most of the rocky coastline in this part of Gibraltar between the sandy beach habitat of Eastern Beach and Catalan Bay, but it is a highly unstable environment which is not conducive to the settlement of rocky intertidal organisms.

The proposed reclamation will be protected from wave action by rock and/or concrete armour units along its seaward faces. These materials will provide new rocky substrate within the intertidal and subtidal areas thereby extending the rocky littoral habitat over the existing environmental conditions. Potentially, the reclamation works will result in the creation of more than 900 metres of rocky coastline habitat. Given that rocky intertidal habitat elsewhere provides the most diverse habitat, the additional rock substrate provided by Eastside is predicted to have a minor beneficial impact on subtidal and intertidal ecology.

It should be noted here that the best results in terms of colonisation by new habitats would be obtained by using a rocky limestone revetment as opposed to concrete (i.e. using Accropodes). The chemical and physical characteristics of limestone are known to make it better suited for colonisation by a wide range of marine organisms. A local example indicates, for instance, that the endangered *P. ferruginea* exist on limestone blocks along the western end of the runway and along the north Mole on limestone blocks, but *not* on the adjoining concrete elements. Unfortunately the limited availability of the correct size and weight of limestone rocks, required to construct the revetment, makes their use impractical.

Figure 9.7 Loose Rubble Shore at the Eastside Development

Given the depth of dredging envisaged, it can be assumed that this dredging would cause the complete removal of all sessile or slow moving benthic flora and fauna within the dredged areas. The seabed off Gibraltar's east coast is known to be subject to considerable impacts through conch raking and dredging activities as reflected by recent findings here showing low ecological diversity and abundance (see Section 9.3) with a general lack of larger, slower growing species such as molluscs. In addition, there appear to be poor epibenthic communities present, consistent with regular disturbance caused by conch rake fishing. Given the ongoing losses and disturbances to the already impoverished conditions of the benthic and epibenthic ecology in the area concerned, a minor adverse impact on subtidal ecology is predicted to result from the proposed dredging at the borrow areas.

9.4.2 *Construction Phase: Impact of Dredging on Marine Ecology Due to Sediment Plumes*

As identified in Section 5.4, dredging and associated marine works can cause large-scale releases of sediment into the water column, causing increased concentrations of the total suspended solids (TSS). While some waters naturally contain high TSS concentrations, for the EIA process it has been assumed that the coastal waters off eastern Gibraltar have low TSS concentrations of 1mg/l and that the marine ecology is adapted to these concentrations (see Section 6.4.1). An increase in TSS can have direct and indirect impacts on the marine ecological receptors exposed to higher TSS, for example, by covering/smothering or affecting reproductive processes (e.g. spawning and nursery) and feeding patterns. Of key concern would be impacts on the 24 *P. ferruginea* individuals and the offshore rocky habitats (see Figure 9.1), and the cave habitats around Governor's Beach (located just south of L2 on Figure 9.1).

The impact assessment in the following paragraphs is based on the sensitivities of three species, namely:

- *P ferrguinea* (a protected and rare limpet present along the shoreline);
- *Eunicella verrucosa* (a soft coral representing a colonising coral at the offshore rocky outcrops); and
- *Morchellium argus* (a sea squirt - known to colonise caves – representing a tunicate species in the caves).

The dredging and land reclamation works that are likely to take place for Eastside comprise the following key activities that can generate sediment plumes:

- Dredging trenches for sea defences by a backhoe dredger (BHD) and placing material on the seabed by a split hopper barge (SHB);
- Placement of rock for the sea defences, mainly by a side stone dumping vessel (SSDV); and
- Dredging of sand from the borrow area(s) and placement of sand for land reclamation by trailing suction hopper dredger (TSHD).

It should be noted that the nature and scale (an indicative timeframe for these activities is shown in Figure 6.2 of Chapter 6) of the proposed dredging from the borrow areas using a TSHD is likely to be similar to that undertaken at the southern borrow area for The Island project on the west side of Gibraltar.

Two impact scenarios were used to assess the dredging and reclamation activities during the construction phase of Eastside (identified as sc1 and sc2 in Figure 6.2 in Chapter 6) and these were:

- Dredging and works for the trenches and sea defences (see sc1a and sc1b in Figure 6.2 in Chapter 6 and Figure 7.3a in Appendix D); and
- Dredging and land reclamation works (see sc2 in Figure 6.2 in Chapter 6 and Figure 7.3b in Appendix D).

The two impact scenarios were modelled for spring and neap tide conditions including waves, without wind influences. Scenario sc2a was also modelled with two typical wind conditions (wind direction west-south-west at speed of 10 m/s and wind direction east-north-east at speed of 10 m/s) because this scenario represented the worst case impact since it had the longest duration.

The following paragraphs for this impact assessment report the worst case scenario impacts for each scenario (i.e. sc1a, sc1b, sc2a and sc2b) in terms of:

- The geographic areas over which the assumed baseline TSS concentration (1mg/l) is exceeded for 90%, 50% and 5% of the time during the duration of the works; and
- The TSS concentrations in these areas.

Table 6.4 (reproduced below) refers to the figures from Appendix D representing the worst case scenario model results:

Figure Info / Impact Scenario	sc1a	sc1b	sc2a	sc2b
Layout and sediment plume sources	7.3a	7.3a	7.3b	7.3b
Impact area (% time TSS >1mgl)	7.4c	7.10c	7.15c	7.20c
Impact on TSS (increase TSS in mg/l)	7.6c	7.12c	7.17c	7.22c

Scenario sc1 - the dredging and works for the trenches and sea defences - represents the BHD dredging activities in combination with the SHB construction of the trenches, and includes SSDV activities. This scenario is subdivided into sc1a for the construction of the southern part of the sea defence and sc1b for the construction of the northern part of the sea defence. The following assessment is based on the worst case conditions arising during a spring tidal cycle.

The model predicts that for sc1a:

- TSS concentrations would increase over baseline conditions (assumed to be 1mg/l) for up to 90% of the time over the two-week duration of the works for nearshore (i.e. well within 1km distance offshore) coastal waters from Sandy Bay to the existing groyne along Eastern Beach in front of the airport's runway. The model predicted that the maximum TSS concentrations in the sediment plume at these points would be approximately 16mg/l to 512mg/l, with the highest concentrations immediately around the dredger;
- TSS concentrations would increase over baseline conditions (assumed to be 1mg/l) for up to 50% of the time over the two-week duration of the works for nearshore coastal waters from the pier to the south of Sandy Bay to just over the Spanish border. The model predicted that the maximum TSS concentrations in the sediment plume at these points would be approximately 4mg/l to 8mg/l; and
- TSS concentrations would increase over baseline conditions (assumed to be 1mg/l) for up to 5% of the time over the two-week duration of the works for nearshore coastal waters from Europa Point to a point approximately 0.75km over the Spanish border. The model predicted that the maximum TSS concentrations in the sediment plume at these points would be approximately 1mg/l.

The model predicts that for sc1b the findings are very similar to the results of sc1a but were generally moved 500m northwards. This change to the geographic area of the impact reflects a similar movement of the dredging and marine works under this impact scenario.

Scenario sc2 – the dredging and land reclamation works - represents the dredging of sand from one borrow area and the placement of the material at the reclamation site, and includes SSDV activities working on the sea defence. This scenario is subdivided into sc2a for dredging at the northern borrow area (total duration = seven weeks) and sc2b with dredging from the southern borrow area (total duration = seven weeks). The following assessment is based on the worst case conditions arising during a neap tidal cycle:

The model predicts that for sc2a:

- TSS concentrations would increase over baseline conditions (assumed to be 1mg/l) for up to 90% of the time over the seven-week duration of the works for coastal waters (i.e. up to approximately 3km to 4km offshore) from Sandy Bay to a point approximately 0.75km over the Spanish border (see Figure 6.3 in Chapter 6). The model predicted that the maximum TSS concentrations in the sediment plume at these points would be approximately 4mg/l to 8mg/l, with much higher concentrations (512mg/l) immediately around the dredger where it operates in open sea at the northern borrow area and where sediment is placed in the reclamation areas at Eastside (see Figure 6.4 in Chapter 6);

- TSS concentrations would increase over baseline conditions (assumed to be 1mg/l) for up to 50% of the time over the seven-week duration of the works for coastal waters from Governor's Beach to a point slightly less than 1km over the Spanish border. The model predicted that the maximum TSS concentrations in the sediment plume at these points would be approximately 4mg/l to 8mg/l; and
- TSS concentrations would increase over baseline conditions (assumed to be 1mg/l) for up to 5% of the time over the seven-week duration of the works for coastal waters from Europa Point to a point slightly more than 1km over the Spanish border. The model predicted that the maximum TSS concentrations in the sediment plume at these points would be approximately 1mg/l.

When sc2a is modelled with a west-south-west wind direction at 10m/s, the maximum expected plume in excess of 1 mg/l covers a larger water area across the Spanish border (compared to the sc2a situation without wind), including a sea area which extends several kilometres north of the harbour of La Atunara, the reference concentration is exceeded during more than 80% of time while with no-wind conditions, this area crosses the Spanish border by approximately 1km.

The model predicts that for sc2b:

- TSS concentrations would increase over baseline conditions (assumed to be 1mg/l) for up to 90% of the time over the seven-week duration of the works for coastal waters (i.e. up to approximately 3km to 4km offshore) from Europa Advance Battery to a point between the two existing groynes along Eastern Beach. The model predicted that the maximum TSS concentrations in the sediment plume at these points would be approximately 4mg/l to 8mg/l, with much higher concentrations (512mg/l) immediately around the dredger where it operates in open sea at the southern borrow area and where sediment is placed in the reclamation areas at Eastside;
- TSS concentrations would increase over baseline conditions (assumed to be1mg/l) for up to 50% of the time over the seven-week duration of the works for coastal waters from Europa Point to the Spanish border. The model predicted that the maximum TSS concentrations in the sediment plume at these points would be approximately 2mg/l to 8mg/l; and
- TSS concentrations would increase over baseline conditions (assumed to be 1mg/l) for up to 5% of the time over the seven-week duration of the works for coastal waters from west of Europa Point (around Dead Man's Beach) to a point approximately 0.5km over the Spanish border. The model predicted that the maximum TSS concentrations of the sediment plume at these points would be approximately 1mg/l.

The following generic conclusions can be drawn from the modelling results:

- The maximum expected TSS concentrations would be lower during spring tide conditions than during neap tide, however the area of impact is greater during spring tide; and
- Wind influences modelled for sc2 show that the area of the sediment plume can change significantly due to wind effects.

Smaller areas, particularly those areas at and around the dredging and reclamation works, will experience much larger increases above 500mg/l. Increases of this magnitude are to be expected around activities involving large dredging equipment such as a TSHD since it is in the nature of this dredging activity to spill some sediment into the water. The maximum expected TSS concentration affecting the *P. ferruginea* individuals is 16 mg/l which is over baseline conditions and which will be exceeded for >90% of the time. This TSS concentration is predicted to occur as a result of dredging works in the southern borrow area under impact scenario sc2b.

There is no information available for the sensitivity of *P. ferruginea* to increases in suspended sediment. However, the Marine Life Information network for Great Britain and Northern Ireland (MarLIN; see www.marlin.ac.uk) reports the sensitivities of two other limpet species, as shown in Table 9.2.

Table 9.2 Increased Suspended Sediment Sensitivity Assessment Benchmarks for Two Limpet Species (source: www.marlin.ac.uk)

Species	Intolerance	Recoverability	Sensitivity	Evidence / Confidence
P ulyssiponensis	Low	Very high	Very low	Very low
P vulgata	Low	High	Low	Moderate

Of the two limpet species identified in Table 9.2, the China limpet (*P. ulyssiponensis*) more closely resembles *P. ferruginea* and was recorded by the intertidal survey. As a response to increases in suspended sediment, MarLIN reports "*Since* Patella ulyssiponensis *is a grazer on rocky shores, an increase in suspended sediment is unlikely to reduce its ability to find food. Predation rates are unlikely to be affected since its principal underwater predators (crabs and starfish) use senses other than sight to locate prey and birds (such as oystercatchers) prey on limpets when they are exposed by the tide. An increase in suspended sediment may clog the gills of limpets and lead to difficulties in extracting oxygen from the water. Intolerance is assessed as low*." A low intolerance implies that the species population is unlikely to be killed or destroyed by an increase in TSS; however, the viability of a species population will be reduced. The reference situation for MarLIN's assessment is an arbitrary short term, acute change in background suspended sediment concentration such as a change of 100 mg/l for one month.

Given the relatively small increases in TSS concentrations predicted to affect these habitats under the worst case impact scenarios (i.e. a maximum of 32mg/l, disturbance from conch rake fishing and dredging at the southern borrow area), and *P. ferruginea*'s low sensitivity and ability to recover from exposure to suspended sediment, a minor-moderate adverse impact is predicted.

The maximum expected TSS concentration affecting the majority of the area of the offshore rocky habitats is 32mg/l exceeded for 50-60% of the time at Weaver's Pinnacle, 16mg/l exceeded for 30% of the time at Peter Ives' Pinnacle / El Cortijo and 2-4mg/l exceeded for 5% of the time at Fred Flintstone's Submarine / El Lomo. These TSS concentrations are predicted to occur as a result of dredging at the northern borrow area under impact scenario sc2a.

An assessment of the rocky outcrops' sensitivity to increased TSS concentrations can be made by using the pink sea fan (*E verrucosa*) as an example of a soft coral that may be exposed to suspended sediment from dredging. Using information from MarLIN, the sensitivities of this species to increased TSS is known, as shown in Table 9.3.

Table 9.3 Increased Suspended Sediment Sensitivity Assessment Benchmarks for E. verrucosa (source: www.marlin.ac.uk)

Species	Intolerance	Recoverability	Sensitivity	Evidence / Confidence
E verrucosa	Low	Very high	Low	Moderate

As a response to increases in suspended sediment, MarLIN reports that *E verrucosa* "*colonies produce mucus to clear themselves of silt and therefore, although siltation might occur and inhibit feeding for a while, the silt will be removed by water movement or mucus*." The reference situation for MarLIN's assessment is an arbitrary short term, acute change in background suspended sediment concentration such as a change of 100 mg/l for one month. Given the relatively small increases in TSS concentrations predicted to affect these habitats under the worst case impact scenarios (i.e. a maximum of 32mg/l), and *E verrucosa's* low sensitivity and ability to recover quickly from exposure to suspended sediment, a negligible impact is predicted.

The maximum expected TSS concentration affecting the caves is 16mg/l which is over baseline conditions and which will be exceeded for >90% of the time. This TSS concentration is predicted to occur as a result of dredging at the southern borrow area under impact scenario sc2b.

An assessment of the caves' sensitivity to increased TSS concentrations can be made by using the sea squirt (*M argus*) as an example of a cave-colonising tunicate species that may be exposed to suspended sediment from dredging. Using information from MarLIN), the sensitivities of this species to increased TSS is known, as shown in Table 9.4.

Table 9.4 Increased Suspended Sediment Sensitivity Assessment Benchmarks for M argus (source: www.marlin.ac.uk)

Species	Intolerance	Recoverability	Sensitivity	Evidence / Confidence
M argus	Low	High	Low	Moderate

As a response to increases in suspended sediment, MarLIN reports that *M argus* "*colonies produce mucus which is used to remove deposited silt. Colonies live in areas where high suspended sediment levels commonly occur and it is therefore expected that intolerance is low.*" The reference situation for MarLIN's assessment is an arbitrary short term, acute change in background suspended sediment concentration such as a change of 100 mg/l for one month. Given the relatively small increases in TSS concentrations predicted to affect the caves under the worst case impact scenarios (i.e. a maximum of 16mg/l), and *M argus'* low sensitivity and ability to recover quickly from exposure to suspended sediment, a negligible impact is predicted.

9.4.3 *Construction Phase: Impact on Marine Ecology Due to Sediment Disturbance Releasing Contaminants*

Dredging for Eastside has the potential to disturb and release sediment-bound chemical contaminants (e.g. metals) into the overlying water column. This effect could increase contaminant concentrations in coastal waters and increase exposure of marine species to potentially toxic substances.

To assess the potential impact on marine ecology, a sediment-water partitioning approach has been used to predict the concentrations of toxic substances released into the water column due to sediment disturbance, as described in Section 7.4. The predicted concentrations can then be compared to Environmental Quality Standards (EQSs). For this impact assessment, the EQSs for marine ecology are based on the values set under the EC Dangerous Substances Directive (67/548/EEC) (see Section 7.2).

The assessment made in Section 7.4 predicted that sediment disturbance due to the dredging and marine works for Eastside will have no impact on water quality in terms of exceeding the EQSs under the EC Dangerous Substances Directive. The EQS, by definition, is set to protect the most sensitive parts of the ecosystem. Therefore, no impact on marine ecology is predicted.

9.4.4 *Construction Phase: Impact of Dredging on Marine Ecology Due to Sediment Deposition*

As identified in Section 5.4, dredging releases sediment into the water column. The suspended sediment is transported by hydrodynamic conditions and eventually settles back onto the seabed. Depending on the duration, rate and thickness deposition, benthic and epibenthic species sediment deposition can be adversely affected due to the effects of smothering and/or burial. For example, smothering of shellfish species can cause reduced feeding ability, reproductive function and growth, restricted respiratory function and, in extreme cases, mortality. Of key concern would be sediment deposition impacts on the 24 *P. ferruginea* individuals found on the offshore rocky habitats (see Figure 9.1) and the cave habitats around Governor's Beach (located just south of L2 on Figure 9.1).

The impact assessment in the following paragraphs is based on the sensitivities of three species, namely:

- *P ferrguinea*;
- *E verrucosa*; and
- *M argus*.

The dredging and marine works that are likely to take place for Eastside are described in Section 5.4 with an indicative timeframe for the activities shown in Figure 5.8.

Two impact scenarios were used to assess the dredging and reclamation activities during the construction phase of Eastside (identified as sc1 and sc2 in Figure 5.8) and these were:

- Dredging and works for the trenches and sea defences (see sc1a and sc1b in Figure 5.8 and Figure 7.3a in Appendix D); and
- Dredging and land reclamation works (see sc2 in Figure 5.8 and Figure 7.3b in Appendix D).

The two impact scenarios were modelled for spring and neap tide conditions including waves, without wind influences. Scenario sc2a was also modelled with two typical wind conditions (wind direction west-south-west at speed of 10 m/s and wind direction east-north-east at speed of 10 m/s) because this scenario represented the worst case impact since it had the longest duration.

The following paragraphs for this impact assessment report the worst case impacts for each scenario (i.e. sc1a, sc1b, sc2a and sc2b,) in terms of the resulting thickness of deposited sediment after the completion of the considered construction works considered by each scenario.

Table 5.3 (reproduced below) refers to figures reflecting the worst case model results as described in Appendix D.

Figure Info / Impact Scenario	sc1a	sc1b	sc2a	sc2b
Layout and sediment plume sources	7.3a	7.3a	7.3b	7.3b
Sediment deposition (increase in m)	7.8	7.13	7.18	7.23

Scenario sc1 - the dredging and works for the trenches and sea defences - represents the BHD dredging activities in combination with the SHB construction of the trenches, and includes SSDV activities. This scenario is subdivided into sc1a for the construction of the southern part of the sea defence and sc1b for the construction of the northern part of the sea defence. The following assessment is based on the worst case conditions arising during a spring tidal cycle.

The model predicts that for sc1a, the expected maximum thickness of deposited sediment is above 0.1m locally around the trench dredging and the sea defence placement locations at Eastside (see Figure 5.9 in Chapter 5). Elsewhere, deposition is not significant.

The findings for sc1b were very similar to the results of sc1a but were generally moved 500m northwards (see Figure 5.10 in Chapter 5). This change to the location of the impact reflects a similar movement of the trench and sea defence works under this impact scenario.

Scenario sc2 – the dredging and land reclamation works - represents the dredging of sand from one borrow area and the placement of the material at the reclamation site, and includes

SSDV activities working on the sea defence. This scenario is subdivided into sc2a for dredging at the northern borrow area (total duration = seven weeks) and sc2b with dredging from the southern borrow area (total duration = seven weeks). The following assessment is based on the worst case conditions arising during a neap tidal cycle.

The model predicts that for sc2a, the expected maximum thickness of deposited sediment is above 0.1m in and around the northern borrow area. This is due to the relatively high sediment release rates during dredging for six weeks using a THSD (see Figure 5.11 in Chapter 5). In addition, deposited sediment is above 0.1m locally at Eastside due to reclamation works. Elsewhere, deposition is not significant.

Sc2b would have similar effects to sc2a but the maximum thickness of deposited sediment is above 0.1m in and around the southern borrow area (see Figure 5.12 in Chapter 5). This change to the location of the impact reflects a similar dredging operation but at a different borrow area location. In addition, deposited sediment is above 0.1m locally at Eastside due to reclamation works. Elsewhere, deposition is not significant.

When sc2a is modelled with a west-south-west wind direction at 10m/s, the sediment deposition covers a larger water area across the Spanish border (compared to the sc2a situation without wind) because it extends further northward. Similarly, with sc2a modelled with an east-north-east wind direction at 10m/s, the sediment deposition covers a larger water area (compared to the sc2a situation without wind) by extending southward.

The following generic conclusions can be drawn from the modelling:

- The maximum expected sediment deposition thickness is below 0.1m for wide areas in and around THSD dredging works at the northern and southern borrow areas;
- The maximum expected sediment deposition thickness is above 0.1m for local areas at Eastside for trenching and reclamation works;
- The impact (as extent of sediment deposition >0.1m) associated with sc2 is more than the impact associated with sc1 due to the relatively long duration of dredging and the sediment release rates by the TSHD;
- Wind influences modelled for sc2 show that the area affected by sediment deposition increases with wind speed, extending in the direction of the wind.

In terms of impacts on overall coastal geomorphology, the proposed dredging and other works will generally create low levels of sediment deposition (i.e. in terms of millimetres) in the coastal waters off eastern Gibraltar. The modelling results indicate that although the seabed in and around the northern and southern borrows areas can be affected by localised deposition of over 0.1m of sediment, the shoreline is largely unaffected, except at the land reclamation area for Eastside. Increases of this magnitude are to be expected around activities involving large dredging equipment such as a TSHD since it is in the nature of this dredging activity to release sediment.

The maximum expected sediment deposition in the area where most *P. ferruginea* individuals were recorded is ~5mm. This thickness is predicted to occur as a result of dredging at the southern borrow area under impact scenario Sc2b. There is no direct information available for the sensitivity of *P. ferruginea* to increases in suspended sediment. However, based on information from MarLIN, the sensitivities of other limpet species are known, as shown in Table 9.5.

Table 9.5 Smothering Sensitivity Assessment Benchmarks for Two Limpet Species (source: www.marlin.ac.uk)

Species	Intolerance	Recoverability	Sensitivity	Evidence / Confidence
P ulyssiponensis	High	High	Moderate	High
P vulgate	High	High	Moderate	Moderate

Limpet response to smothering is described by MarLIN as follows: "*Smothering of limpets by 5cm of sediment for one month is likely to interfere with locomotion, grazing and respiration. If the sediment is fluid and mobile limpets are unlikely to be able to move through the layer of sediment and will probably die.*" A high intolerance implies that the species population will be killed or destroyed by smothering.

Overall, relatively small thicknesses (~5mm or an order of magnitude less than the known tolerance thresholds) of sediment deposition are predicted to affect *P. ferruginea* even under the worst case impact scenarios. While limpets are highly intolerant of smothering by thicknesses of sediment deposition in the order of 5cm, it is likely that *P. ferruginea* will be able to tolerate the sediment deposition predicted to occur as a result of Eastside. It is also believed that the exposed nature of the rocky intertidal substrate colonised by *P. ferruginea* will prevent deposition when the limpets are above the water level, and will hinder deposition since sediment can be washed away by wave action. Accordingly, a negligible impact is predicted.

The maximum expected sediment deposition affecting the offshore rocky habitats is 10-20mm at Weaver's Pinnacle, 2-5mm at Peter Ives' Pinnacle / El Cortijo and <2mm at Fred Flintstone's Submarine / El Lomo. This sediment deposition is predicted to occur as a result of dredging at the northern borrow area under impact scenario sc2a. Given the relatively small increases in sediment deposition to affect these habitats under the worst case impact scenarios, a negligible impact is predicted since it is expected that marine species would tolerate this degree of smothering.

An assessment of the rocky outcrops' sensitivity to sediment deposition can be made by using the pink sea fan (*E verrucosa*). Using information from MarLIN, the sensitivities of this species to smothering as a result of sediment deposition is known, as shown in Table 9.6.

Table 9.6 Increased Suspended Sediment Sensitivity Assessment Benchmarks for E. verrucosa (source: www.marlin.ac.uk)

Species	Intolerance	Recoverability	Sensitivity	Evidence / Confidence
E verrucosa	Intermediate	Moderate	Moderate	Moderate

As a response to smothering, MarLIN reports that "*Colonies of* Eunicella verrucosa *extend above the substratum and therefore above the smothering. Some small individuals might be killed but the majority of individuals will survive.*" This response is based on smothering to a depth of 5cm above the substratum for one month. Given that the sediment deposition predicted by numerical modelling (i.e. a maximum of 10mm, or 1cm) is much smaller than the reference figure used by MarLIN (i.e. 5cm), a negligible impact is predicted on soft corals at the rocky outcrops. No mitigation measures are recommended and a negligible residual impact is predicted.

The maximum expected sediment deposition where the caves are located is ~5mm. This deposition thickness is predicted to occur as a result of dredging at the southern borrow area under impact scenario sc2b. This low amount of deposition is expected to have a minor adverse impact on the cave archaeology and its contribution to the World Heritage Site.

An assessment of the caves' sensitivity to increased sediment deposition can be made by using the sea squirt (*M argus*). Using information from MarLIN, the sensitivities of this species to smothering by sediment deposition is known, as shown in Table 9.7.

Table 9.7 Increased Suspended Sediment Sensitivity Assessment Benchmarks for M argus (source: www.marlin.ac.uk)

Species	Intolerance	Recoverability	Sensitivity	Evidence / Confidence
M argus	High	High	Moderate	Moderate

As a response to increases in suspended sediment, MarLIN reports that *M argus* "*colonies rely on being able to pump water for respiration and feeding and cannot extend to any great extent to above layer of smothering sediment. Whilst they may survive for a little time in conditions where they are unable to draw water though the siphons, it is expected that they would be killed by smothering that lasts more than a few days.*" This response is based on smothering to a depth of 5cm above the substratum for one month. Given that the sediment deposition predicted by numerical modelling (i.e. a maximum of <~5mm, or <0.5cm) is an order of magnitude smaller than the reference figure of 5cm used by MarLIN, a negligible impact is predicted on sea squirt colonies in the caves.

9.4.5 *Construction Phase: Impact on Marine Ecology Due to Sediment Deposition Re-distributing Contaminants*

Dredging and associated marine works (e.g. reclamation, rock armouring and beach nourishment) can cause large-scale releases of sediment into the water column, causing sediment transport and deposition on the seabed. Sediment deposition can alter the chemical properties of the affected habitats by increasing contamination levels, and can have direct and indirect impacts on the marine ecological receptors exposed to it.

As described in Section 7.3, compared against the sediment quality guidelines applied by the CCME in Canada, the sediment contains contaminants at concentrations that are generally below the threshold effects level (TEL) for ecological effects, with the exception of arsenic which is at concentrations between the TEL and probable effects level (PEL). Therefore, the sediment survey data suggest that the contaminants in the sediment to be disturbed by works for Eastside are sufficiently low such that they are in the minimal effect range where adverse biological effects occur rarely.

Despite the re-distribution of contaminants due to sediment depositions, there will be negligible change to the chemical quality of affected sediments and the magnitude of any change will be such that adverse ecological effects are very unlikely to occur. Therefore, a negligible impact on marine ecology is predicted.

9.4.6 *Construction Phase: Impact on Terrestrial Ecology Due to Construction Disturbance to Talus and Sand Slopes*

The construction works for Eastside have the potential to affect the terrestrial habitats and species of the talus and sand slopes due to air quality and noise.

Based on the air quality assessment made in Section 12.4, it was found that sensitive receptors to air quality impacts would include public open spaces (particularly those of conservation interest or perceived as having high amenity value). For this impact assessment, the talus and sand slope habitats are taken to be a public open space of conservation interest and the findings of the air quality impact assessment in Chapter 12 have been applied. In terms of dust, it was found that the likelihood of significant dust occurring beyond 100 metres from the construction works for Eastside is negligible due to the distance that dust would be transported. Since the lower part of the talus slope, but no part of the sand slopes, will be situated within 100 metres of some of the construction works, a localised and temporary minor adverse impact is predicted on terrestrial ecology if dust were to settle on ecologically important plant species. In terms of pollutants, the contribution of emissions from construction vehicles to local air quality is predicted to be negligible since the predicted increase in emissions of oxides of nitrogen and particulates will not exceed standards for human health. Accordingly, a negligible impact on terrestrial ecology is predicted.

Based on the noise assessment made in Chapter 13, it was found that sensitive (human) receptors to noise impacts would be exposed to significant increases in noise during the construction works if they were within 250 metres of Eastside. Consequently, it is predicted that there could be a significant noise increase at the lower slopes of the talus for noise sensitive species of birds. However, research suggests that birds can habituate to changes to background noise, even sudden noises, and therefore a negligible impact is predicted. For example, "noise tolerance can be demonstrated by the developed tolerance of birds to the loud noises made by bird scarers used to protect crops. Habituation of birds to noise , light and traffic disturbance is reported to be considerable, as birds are rather adaptable and can accommodate regular disturbance events, becoming tolerant to the disturbance over a relatively short period" (see www.ukmarinesac.org.uk).

In summary, the construction of Eastside could have a minor adverse impact on the ecology of the lower part of the talus slope due to dust settling on plants and noise disturbing birds.

9.4.7 *Operation Phase: Impact on Marine Ecology Due to an Unspecified Conservative Pollutant Discharge from the Eastside Development*

As described in Section 6.4, development at Eastside could adversely affect water quality (and other receptors) due to planned discharges (e.g. surface water and storm water run-off) and accidental spills.

A conservative (in duration) scenario has been assessed to predict the potential risk of an impact associated with the discharge and plume of an unspecified conservative pollutant assumed to have the potential to adversely affect water quality. Therefore, this situation potentially represented a worst-case scenario for a pollution impact. However, it should be noted that a continuous discharge of this nature (e.g. duration) is generally unrealistic.

The set up of the numerical model was similar to the surface and storm water run-off scenario, but in this case the discharge lasted three days (rather than one hour) and the duration of the plume simulation was a complete spring-neap cycle (i.e. 15 days, rather than two days).

Figure 6.1 shows the relative plume concentrations predicted by the model. The maximum expected relative concentrations in the top layer in this three day discharge scenario were significant (above 10%) close to the proposed Eastside development. The plume with a concentration of 1% to 10% reached beyond Eastside over a distance of several kilometres to the north and south. The worst case impact on Catalan Bay is predicted to be about 10 to 20% of the source concentration and the worst case impact on Eastern Beach is predicted to be about 5 to 10% of the source concentration.

No assessment of significance is made for this impact since it is entirely hypothetical. However, it demonstrates that Eastside decreases current velocities directly to its south and north of the proposed development, which means that pollutants can reside for longer periods of time at these locations at Eastern Beach and Catalan Bay.

9.4.8 *Operation Phase: Impact on Terrestrial Ecology Due to Operational Disturbance to Talus and Sand Slopes*

The day-to-day post-construction activities at Eastside have the potential to affect the terrestrial habitats and species of the talus and sand slopes due to air quality and noise.

Based on the air quality assessment made in Section 12.4, it was found that the air quality impacts of Eastside are all due to road traffic generated by it. The assessment showed that no significant air pollution impact is likely to result from Eastside, and so no impact is predicted on the terrestrial ecology of the talus or sand slopes. Accordingly no mitigation measures are recommended and there will be no residual air quality impact on terrestrial ecology.

Based on the noise assessment made in Chapter 13, it was found that road noise would increase by between +0.5dB and +3.7dB magnitude within 300m of the local road network. Consequently, it is predicted that there could be a significant noise increase at the lower slopes of the talus for noise sensitive species of birds. However, since this noise is related to increased road traffic and research suggests that birds quickly habituate to changes to background noise, a negligible impact is predicted. No significant impact is assumed for ecological receptors beyond 300m of the local road network. No mitigation measures are recommended and there will be a negligible impact on terrestrial ecology.

In summary, operation of Eastside is predicted to have no impact due to air pollutants and a negligible impact on the ecology of the lower part of the talus slope due to noise disturbing birds.

9.5 Mitigation Measures

It is anticipated that the mitigation measures described in the following paragraphs will be implemented through a detailed Environmental Management Plan (EMP).

9.5.1 *Construction Phase: Impact of Dredging on Marine Ecology Due to Direct Habitat and Species Loss / Disturbance*

No mitigation measures are recommended, but some degree of natural recovery can be expected depending on the continued effects of ongoing conch rake fishing and dredging.

In addition to natural recovery, it is possible that Eastside will benefit seabed habitats by deterring further conch raking within its vicinity since this illegal activity would be more visible.

9.5.2 *Construction Phase: Impact of Dredging on Marine Ecology Due to Sediment Plumes*

In order to reduce the risk of impact to *P. ferruginea*, it is recommended that consideration is given to either undertaking more dredging from the northern borrow area, or undertaking dredging at the southern borrow area when prevailing currents and/or winds limit the transport of sediment plumes towards the shore.

If any dredging is undertaken at the southern borrow area, it is recommended that monitoring be conducted at sites selected with relevant stakeholders (e.g. GONHS) for dredging induced suspended sediment (as TSS concentrations in mg/l) and sediment deposition (as thickness in mm). In particular, it may be necessary to monitor the known sites of *P ferruginea*. The monitoring will be established as part of an EMP.

As a negligible impact is predicted no mitigation measures are recommended to reduce the risk of an impact on *E verrucosa*.

As a negligible impact is predicted no mitigation measures are recommended to reduce the risk of an impact on *M argus* and the caves.

9.5.3 *Construction Phase: Impact on Marine Ecology Due to Sediment Disturbance Releasing Contaminants*

No mitigation measures are recommended concerning sediment disturbance releasing contaminants.

9.5.4 *Construction Phase: Impact of Dredging on Marine Ecology Due to Sediment Deposition*

No mitigation measures are recommended since negligible impacts are predicted for marine ecology.

9.5.5 *Construction Phase: Impact on Marine Ecology Due to Sediment Deposition Re-distributing Contaminants*
No mitigation measures are recommended for the potential re-distribution of contaminants in sediment.

9.5.6 *Construction Phase: Impact on Terrestrial Ecology Due to Construction Disturbance to Talus and Sand Slopes*
Given the potential dust impact, it is recommended that best practicable means be used to minimise nuisance, including the measures listed in Section 12.5.

Successful implementation should result in a negligible residual impact on the terrestrial ecology of the talus slope.

No specific mitigation measures are recommended for noise disturbance, but the measures identified in Chapter 13 will help to reduce the overall noise associated with construction of Eastside – particularly the noisiest activities.

9.5.7 *Operation Phase: Impact on Marine Ecology Due to an Unspecified Conservative Pollutant Discharge from the Eastside Development*
The impact assessment reinforces the recommended mitigation measures identified with respect to surface and storm water run-off and accidental fuel spills (see Section 6.5).

9.5.8 *Operation Phase: Impact on Terrestrial Ecology Due to Operational Disturbance to Talus and Sand Slopes*
No mitigation measures are recommended concerning noise and air quality effects on the talus slope.

9.6 Residual Impacts

9.6.1 *Construction Phase: Impact of Dredging on Marine Ecology Due to Direct Habitat and Species Loss / Disturbance*
There will be a minor adverse residual impact due to losses and disturbance.

9.6.2 *Construction Phase: Impact of Dredging on Marine Ecology Due to Sediment Plumes*
With the mitigation in place for *P. ferruginea*, the potential for a moderate adverse impact will have been addressed and there will be a short-term minor adverse residual impact only.

A negligible residual impact will remain on *E verrucosa* and the rocky outcrops and on *M argus* and the caves.

9.6.3 *Construction Phase: Impact on Marine Ecology Due to Sediment Disturbance Releasing Contaminants*
There will be no residual impact on marine ecology regarding the potential release of contaminants.

9.6.4 *Construction Phase: Impact of Dredging on Marine Ecology Due to Sediment Deposition*
A negligible residual impact will remain for sediment deposition concerning marine ecology.

9.6.5 *Construction Phase: Impact on Marine Ecology Due to Sediment Deposition Re-distributing Contaminants*
A negligible impact will remain for marine ecology.

9.6.6 *Construction Phase: Impact on Terrestrial Ecology Due to Construction Disturbance to Talus and Sand Slopes*
The mitigation measures identified to reduce dust and noise should reduce these effects to an overall negligible residual impact on terrestrial ecology.

9.6.7 *Operation Phase: Impact on Marine Ecology Due to an Unspecified Conservative Pollutant Discharge from the Eastside Development*
With the recommended measures in place, the potential significance of a residual impact would be reduced to environmentally acceptable levels. Therefore, a hypothetical negligible residual impact is predicted.

9.6.8 *Operation Phase: Impact on Terrestrial Ecology Due to Operational Disturbance to Talus and Sand Slopes*

There will remain an overall negligible residual impact on terrestrial ecology at the talus slope.

9.7 Cumulative Effects

9.7.1 *Cumulative Effect of Dredging on Marine Ecology Due to Direct Habitat and Species Loss / Disturbance*

The cumulative effect of Eastside in combination with other plans or projects (see Section 4.10) has been assessed for marine ecology by using the same approach as described in Section 9.4.

At the time of writing there was no information available on the proposed GoG works at Catalan Bay. It has therefore not been able to assess the potential for in-combination (cumulative) effects associated with works at Catalan Bay.

The Both Worlds project is believed to include land reclamation works at the southern end of Sandy Bay. These works would cause an unavoidable loss of the benthic habitat and species within the footprint of the reclamation area due to burial. The intertidal survey (see Section 9.3 and Appendix F) identifies that the intertidal area at this location is mainly composed of hard sandstone and hosts two *P. ferruginea* individuals found along this stretch of coastline and, although there is evidence that this species does not favour sandstone, it appears that in this case conditions are suitable for its survival.

In essence, the reclamation will replace the existing natural rocky shore habitat and the ecologically impoverished sandy seabed with reclaimed land that is likely to be protected from wave action by rock and/or concrete armour units. These materials will provide new rocky substrate within the intertidal and subtidal areas, and will increase slightly the extent of rocky littoral habitat over the existing environmental conditions, but achieve this by replacing natural habitat with artificial materials.

It should be noted however that the best results in terms of colonisation by new habitats would be obtained by using a rocky limestone revetment as opposed to concrete (i.e. using Accropodes). The chemical and physical characteristics of limestone are known to make it better suited for colonisation by a wide range of marine organisms. A local example indicates, for instance, that the endangered *P. ferruginea* exist on limestone blocks along the western end of the runway and along the north Mole on limestone blocks, but *not* on the adjoining concrete elements.

The loss of the sandy seabed is less of an impact than the loss of the rocky intertidal habitat, particularly if the loss has the potential to compromise the survival of the two *P. ferruginea* individuals found along this part of the coast (see Figure 9.8). Accordingly, a minor adverse cumulative effect on subtidal and intertidal ecology is predicted to result due to the reclamation proposed for the Both Worlds project. Assuming that the two *P. ferruginea* individuals are not impacted, no mitigation measures are recommended and there will be a minor adverse residual cumulative effect associated with the Both Worlds project.

Figure 9.8 Rocky Intertidal Habitat at the south of Sandy Bay and the Both Worlds Project Location

9.7.2 *Cumulative Effect of Dredging on Marine Ecology Due to Habitat and Species Disturbance by Sediment Plumes*

The additional effects of the Both Worlds project are expected to be negligible. The extension is very small, does not envisage dredging and does not create a noticeable change in wave or current behaviour near the dredge and dump locations. No effects of the Both Worlds project are therefore expected on the dispersion of dredge induced sediment plumes.

At the time of writing there was no information available to us on the proposed GoG works at Catalan Bay. We are therefore unable to assess the potential for in-combination (cumulative) effects associated with works at Catalan Bay.

9.7.3 *Cumulative Effect of Dredging on Marine Ecology Due to Habitat and Species Disturbance by Sediment Deposition*

The additional effects of the Both Worlds project are expected to be negligible. The extension is very small, does not envisage dredging and does not create a noticeable change in wave or current behaviour near the dredge and dump locations. No effects of the Both Worlds project are therefore expected on the dispersion of dredge induced sediment and consequent sediment deposition.

At the time of writing there was no information available on the proposed GoG works at Catalan Bay. It is therefore not possible to assess the potential for in-combination (cumulative) effects associated with works at Catalan Bay.

9.7.4 *Cumulative Effect on Terrestrial Ecology Due to Operational Disturbance to Talus and Sand Slopes*

The cumulative effect of Eastside in combination with other plans or projects (see Section 4.10) has been assessed for terrestrial ecology by using the same approach as described in Section 9.4 since the day-to-day post-construction activities at Eastside, in combination with the Both Worlds project could have the potential to affect the terrestrial habitats and species of the talus and sand slopes due to air quality and noise.

Based on the air quality assessment (Chapter 12), it was found that the cumulative effects were of the same significance as the impact of Eastside alone, and therefore no significant air pollution is likely to occur, and so no cumulative effect is predicted on the terrestrial ecology of the talus or sand slopes. Accordingly, no mitigation measures are recommended and there will be no residual cumulative effect on terrestrial ecology.

Based on the noise assessment made in Chapter 13, it was found that the cumulative effects were of the same significance as the impact of Eastside alone, and therefore it is predicted that there could be a significant noise increase at the lower slopes of the talus for noise sensitive species of birds. However, since this noise is related to increased road traffic and research suggests that birds quickly habituate to changes to background noise, a negligible cumulative effect is predicted. No significant cumulative effect is assumed for ecological receptors beyond 300m of the local road network. No mitigation measures are recommended and there will be a negligible cumulative effects on terrestrial ecology.

In summary, the operation of Eastside in combination with other known or proposed projects is predicted to have no cumulative effect due to air pollutants and a negligible cumulative effect on the ecology of the lower part of the talus slope due to noise disturbing birds. No mitigation measures are recommended and there will remain an overall negligible residual cumulative effect on terrestrial ecology.

At the time of writing there was no information available to us on the proposed GoG works to the beaches at Catalan Bay. We are therefore unable to assess the potential for in-combination (cumulative) effects associated with beach works at Catalan Bay.

9.8 Transboundary Effects

9.8.1 *Transboundary Effect of Dredging on Marine Ecology Due to Direct Habitat and Species Loss / Disturbance*

The transboundary effect of Eastside has been assessed for marine ecology by using the same approach as described in Section 9.4. Since there will be no direct habitat loss from Spanish waters associated with Eastside, there will be no transboundary effect. No mitigation measures are recommended and there will be no residual transboundary effect.

9.8.2 *Transboundary Effect of Dredging on Marine Ecology – Habitat and Species Disturbance by Sediment Plumes*

The transboundary effect of Eastside has been assessed for marine ecology by using the same approach as described in Section 9.4.

The impact assessment in the following paragraphs is based on the sensitivities of three species, namely:

- *Patella ferrguinea* ;
- *Eunicella verrucosa*; and
- *Morchellium argus*

The following paragraphs for this impact assessment report the transboundary effects of sediment plumes generated during construction of Eastside for a range of worst case impact scenarios (i.e. sc1a, sc1b, sc2a, sc2b), as described in Section 6.4, Figures 6.3 and 6.4, and cross-referenced to various figures in Appendix D (see Table 6.4 in Chapter 6) in terms of:

- The geographic areas over which the assumed baseline TSS concentration (1mg/l) is exceeded for 90%, 50% and 5% of the time during the duration of the works; and
- The TSS concentrations in these areas.

In general, the transboundary effects are more intense during spring tide conditions than during neap tide, i.e. the affected transboundary area is larger during spring tide conditions and the maximum expected concentration in Spanish waters is higher for all scenarios.

For impact Scenario 1, most transboundary effects are expected during Scenario 1b. Just across the border, the reference concentration is exceeded during more than 80% of the time (during neap tide), while the frequency decreases to 5% at about 1.5 km north of the boundary (during spring tide). The maximum expected concentrations of TSS in Spanish waters are 4-8 mg/l.

For Scenario 1, negligible sedimentation is expected across the Spanish border.

Impact Scenario 2a (northern borrow area) produces the most adverse impacts across the Spanish border. During both spring and neap tide, the reference concentration is exceeded during more than 90% of time in the Spanish territory. The maximum concentrations of TSS are expected to be in the order of 64 – 128 mg/l. The affected area in terms of excess concentrations above 1 mg/l extends 5 km northward from the border (spring conditions).

The expected sedimentation just after Scenario 2a can be up to 100 mm just across the border at water depths around 15 m.

For Scenario 2b, the transboundary effects are considered to be less than for 2a.

To reduce the magnitude and scale of transboundary effects associated with dredging and reclamation, the following mitigation measures should be considered and implemented in a practicable and cost-effective manner as part of the contract awarded for the marine works for Eastside.

To reduce sediment suspension from the TSHD (CIRIA, 2000):

- Optimise trailing velocity, suction head and pump discharge with respect to one another to reduce sediment losses around the draghead;
- Try to reduce water intake by the suction head to increase sediment density and reduce need for overflowing;
- Apply return flow method if the TSHD has this facility to increase sediment density and reduce overflowing; and
- Avoid unnecessary overflowing through operational method.

To reduce sediment plumes from the northern borrow area:

- Undertake dredging in the southern borrow area to avoid the dispersion of a significant sediment plume into Spanish waters; and/or
- Undertake dredging from the northern borrow area as far south as possible to reduce the dispersion of a significant sediment plume into Spanish waters.

Even with the suggested measures for the TSHD in place, it is unlikely that the residual transboundary effects will be reduced significantly since modern dredging equipment tends to work very efficiently, for example, in terms of the accuracy of the draghead, increasing the density of the sediment pumped into the hopper and avoiding unnecessary overflowing. However, with the suggested measures relating to dredging at the borrow areas, the residual transboundary effect associated with sediment plumes from dredging at the northern borrow area could be reduced to a minor adverse or negligible transboundary effect.

Regarding *P. ferruginea*, it is believed that there are no individuals present along the Spanish coast directly north of the east side of Gibraltar. This is because the Spanish coast comprises largely sandy beaches and therefore does not provide suitable habitat for limpet colonisation. Accordingly, there is predicted to be no transboundary effect on *P. ferruginea* as a result of increases in TSS concentrations in Spanish waters. No mitigation measures are recommended and no residual transboundary effect is predicted.

Regarding corals (using *E verrucosa*) at rocky outcrops, it is unknown whether there are any such habitats and species in Spanish waters. However, this transboundary effect assessment assumes that there are similar rock outcrop habitats to Weaver's Pinnacle etc. at similar distances offshore in Spanish waters. Accordingly, a similar level of impact is predicted. So, given the relatively small increases in TSS concentrations predicted to affect these habitats under the worst case impact scenarios (i.e. a maximum of 32mg/l), and *E verrucosa*'s low sensitivity and ability to recover quickly from exposure to suspended sediment, a negligible transboundary effect is predicted. No mitigation measures are recommended and a negligible residual transboundary effect is predicted.

Regarding cave habitats, it is believed that there are no caves present along the Spanish coast directly north of the east side of Gibraltar. This is because the Spanish coast comprises largely sandy beaches and therefore does not provide suitable geological structure for the formation of caves. Accordingly, no transboundary effects are predicted on cave habitats as a result of increases in TSS concentrations in Spanish waters. No mitigation measures are recommended and no residual transboundary effect is predicted.

9.8.3 *Transboundary Effect of Dredging on Marine Ecology Due to Habitat and Species Disturbance by Sediment Deposition*

The transboundary effect of Eastside has been assessed for marine ecology by using the same approach as described in Section 9.4.

The impact assessment in the following paragraphs is based on the sensitivities of three species, namely:

- *Patella ferrguinea*;
- *Eunicella verrucosa*; and
- *Morchellium argus*.

For impact scenario 1 (see Section 6.4), negligible sediment deposition is predicted in Spanish waters under sc1a and sc1b.

For impact scenario 2 (see Section 6.4), the greatest transboundary effect is expected during sc2a with dredging at the northern borrow area creating sediment deposition of 0.1m in water depths of 15m just across the border. The transboundary effects are less for sc2b.

Regarding *P. ferruginea*, it is believed that there are no individuals present along the Spanish coast directly north of the east side of Gibraltar. This is because the Spanish coast largely comprises sandy beaches and therefore does not provide suitable habitat for limpet colonisation. Accordingly, there is predicted to be no transboundary effect on *P. ferruginea* as a result of increases in TSS concentrations in Spanish waters. No mitigation measures are recommended and no residual transboundary effect is predicted.

Regarding, corals (using *E verrucosa*) at rocky outcrops, it is unknown whether there are any such habitats and species in Spanish waters. However, this transboundary effect assessment assumes that there are similar rock outcrop habitats to Weaver's Pinnacle etc. at similar distances offshore in Spanish waters. Accordingly, a similar level of impact is predicted. So, given the relatively small increases in sediment deposition predicted to affect these habitats under the worst case impact scenarios (i.e. a maximum of 10mm at Weaver's Pinnacle), and *E verrucosa*'s low sensitivity and ability to recover quickly from exposure to suspended sediment, a negligible transboundary effect is predicted. No mitigation measures are recommended and a negligible residual transboundary effect is predicted.

Regarding cave habitats, it is believed that there are no caves present along the Spanish coast directly north of the east side of Gibraltar. This is because the Spanish coast comprises largely sandy beaches and therefore does not provide suitable geological structure for the formation of caves. Accordingly, there is predicted to be no transboundary effect on cave habitats as a result of sediment deposition in Spanish waters. No mitigation measures are recommended and no residual transboundary effect is predicted.

9.9 *Uncertainty*

The results of the modelling studies are valid given the applied assumptions and conditions, including coral and tunicate indicator species to predict impact on rocky outcrop and cave habitats respectively. It should be noted, however, that when there is a significant change in these assumptions, the results may change. For example, the results of the sediment plume modelling may change with different dredging methods, different dredging locations and/or different sediment particle size distribution. In cases of relatively small differences (e.g. in the proportion of fine grained particles in the sediment), then linear scaling of the model results is possible. Uncertainty has been addressed by using the best available data to inform the modelling.

9.10 *Summary*

This chapter has assessed the potential impacts, cumulative effects and transboundary effects of Eastside on ecological habitats (at the level of both species and processes). Assessments for nature conservation are considered separately (see Chapter 10). A number of potential impacts were identified and assessed.

A key impact is associated with direct loss and/or disturbance of habitats and species during land reclamation and dredging works. Losses of artificial rocky shoreline habitat at the rubble tip will be offset by the construction which will provide new habitat (see 9.7.1 above). Losses of sandy seabed habitat due to dredging will be subject to some natural recovery, but are largely unavoidable.

The impact of dredging induced sediment plumes on marine habitats and species was assessed for *P ferrguinea* (a protected and rare limpet species present along the shoreline), *E verrucosa* (a soft coral species representing a colonising species at the offshore rocky outcrops) and *M argus* (a sea squirt species - known to colonise caves – representing a tunicate species in the caves). Numerical modelling predicted that only *P ferrguinea* would be affected by potentially significant TSS concentrations and mitigation measures are recommended to reduce this risk.

A similar assessment was conducted for impacts associated with the deposition of sediment plumes. Negligible impacts were predicted on marine species and habitats.

The disturbance of contaminants in sediments due to dredging and marine works was assessed to not cause any significant adverse affects on marine ecology.

It was found that dust settlement may adversely affect the terrestrial ecology (flora) of the lower slopes of the talus habitat, and mitigation measures to control dust have been recommended.