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Conceptual Ecological Modelling of Shallow Sublittoral Coarse Sediment Habitats to Inform Indicator Selection

Appendix 1 – 13

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Appendix 1 - List of Species Included in Project Scope

Please see accompanying spreadsheet for full species list and details of how this list was refined.

Alcyonidium diaphanum
Ampelisca spinipes
Anaitides maculata
Balanus crenatus
Bathyporeia pelagica
Branchiostoma lanceolatum
Caulleriella zetlandica
Chaetozone setosa
Dosinia lupinus
Echinocyamus pusillus
Echinus esculentus
Edwardsia timida
Glycera lapidum
Halcampa chrysanthellum
Hesionura elongata
Iphinoe trispinosa
Lanice conchilega
Liocarcinus
Lumbrineris
Magelona mirabilis
Mediomastus fragilis
Microphthalmus similis
Moerella
Neopentadactyla mixta
Nephtys cirrosa
Ophiura albida
Pagurus
Pecten maximus
Pomatoceros triqueter
Protodorvillea kefersteini
Protodrilus
Sabella pavonina
Sabellaria spinulosa
Scoloplos armiger
Sertularia argentea
Spio martinensis
Spiophanes bombyx
Spisula
Timoclea ovata
Travisia forbesii
Urticina felina

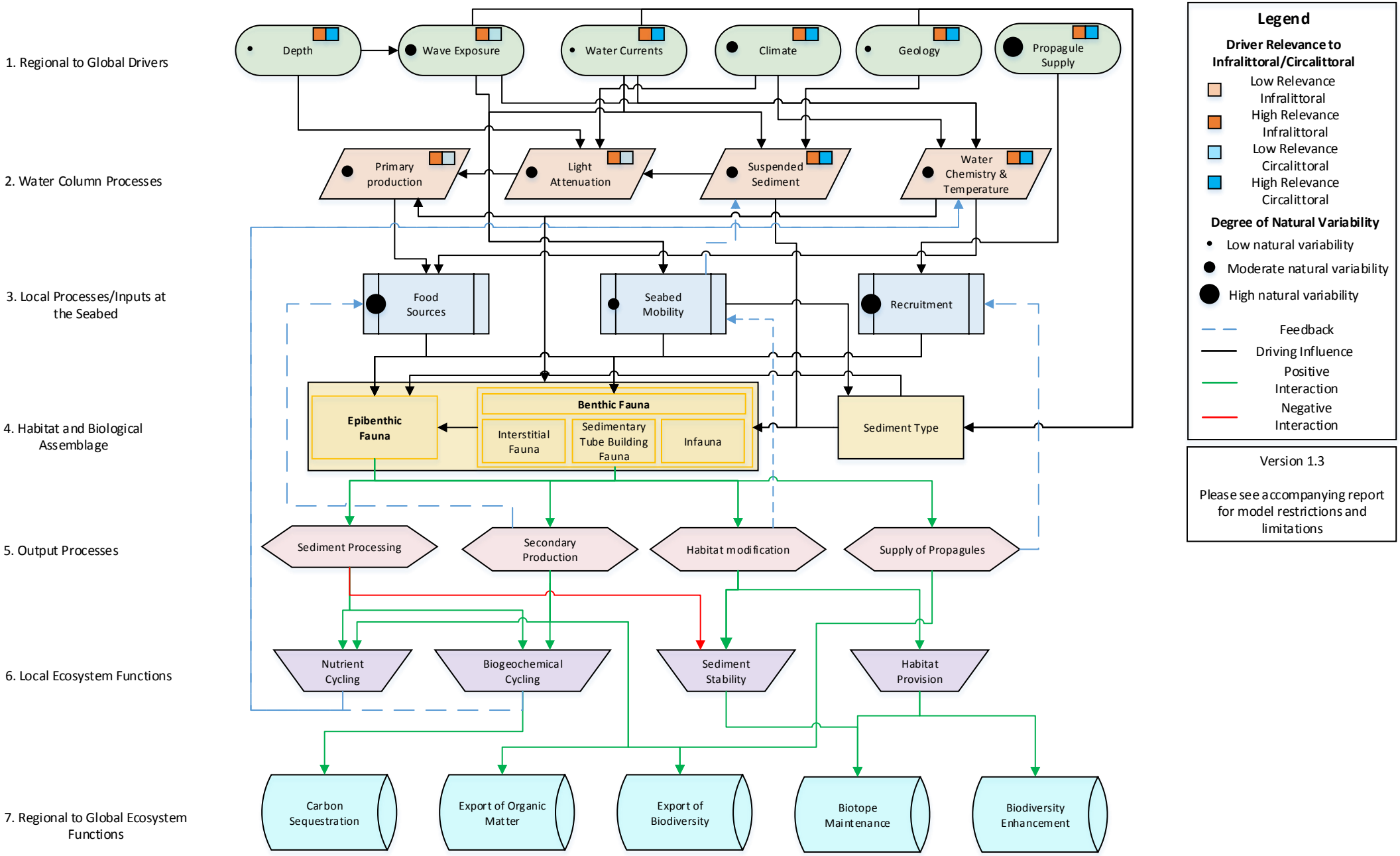
Appendix 2 - List of Keywords Used as Search Terms

Amphipod
Anemone
Barnacle
Benthic
Benthic Species Interactions
Benthic topography
Bio-deposition
Bioengineer
Biogeochemical process
Bioirrigation
Biological composition
Biological driver
Biotope
Bioturbation
Bivalve
Brittlestar
Bryozoa
Burrowing
Burrowing anemone
Chemical driver
Circalittoral
Climate variation
Coarse sediment
Community
Connectivity
Crustacea
Cumacean
Currents
Deposit feeding
Depth
Dissolved oxygen
Driver
Ecosystem function
Ecosystem process
Ecosystem service
Environmental driver
Environmental position
Epibenthic
Epifauna
Errant polychaete
Feeding
Feeding method
Filter feeding
Food resource
Food web
Functional group
Geology
Gravel
Coarse sand
Growth form
Habitat provision
Habitat stability
Hydrodynamic flow
Hydroids
Infauna
Infralittoral
Interstitial
Light attenuation
Macrofauna
Meiofauna
Microalgae
Microbial activity
Mobile Crustacea
Mobility
Nitrogen flux
Nutrient cycling
Nutrient provision
Organic Carbon
Physical driver
Physiographic
Phytoplankton
Predator-Prey Interactions
Prey
Primary production
Protodrilid
Salinity
Seabed energy
Seabed mobility
Seasonal variability
Secondary production
Sedentary polychaete
Sediment
Sediment stability
Species trait
Spionidae
Sublittoral
Substratum
Subtidal
Suspension feeding
Temperature
Tidal stress
Tidal stream
Trophic level
Tube formation
Turbidity
Urchin
Veneroida
Water composition

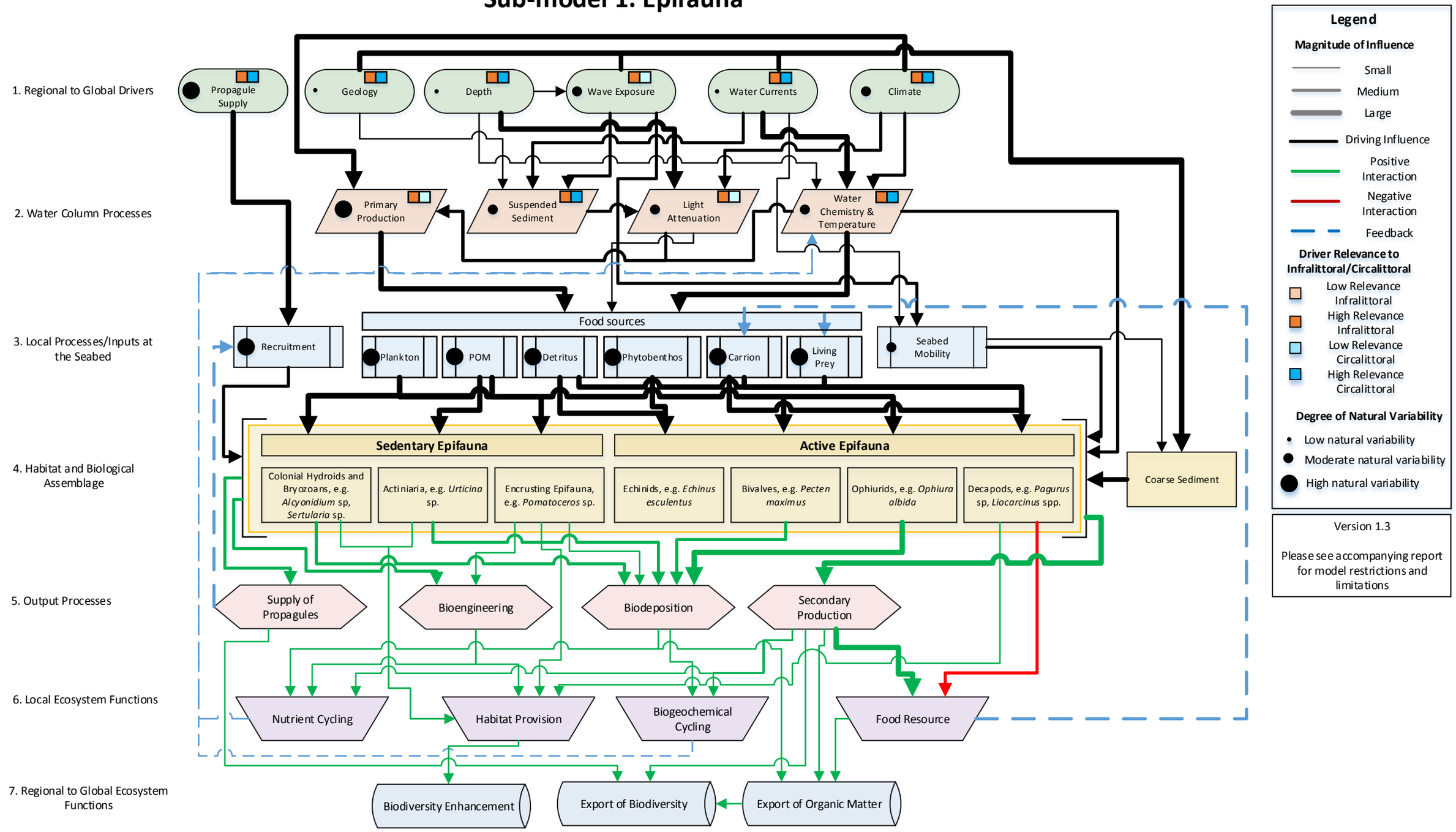
In addition to the search words used above, each of the selected species names (Appendix 1) were also searched for individually.

Model	Submodel 1: Epifauna										Submodel 2: Sedimentary tube building fauna						Submodel 3: Infauna																									
Major functional group	Sedentary epifauna					Active epifauna					Sedimentary tube building fauna						Predatory infauna				Non-predatory infauna																			
Sub functional group	Colonial hydroids and bryozoans		Actiniaria	Encrusting or tube building epifauna		Decapods		Bivalves	Echinids	Ophiurids	Solitary tube building fauna				Gregarious tube building fauna		Predatory infauna				Burrow-dwelling fauna							Burrowing bivalves				Other burroing fauna									
Species	Alcyonidium diaphanum	Sertularia argentea	Urticina felina	Pomatoceros triqueter	Balanus crenatus	Pagurus	Liocarcinus	Pecten maximus	Echinus esculentus	Ophiura albida	Spio martinensis	Spiophanes bombyx	Lanice conchilega	Sabella pavonina	Ampelisca spinipes	Sabellaria spinulosa	Protodorvillea kefersteini	Anaitides maculata	Glycera lapidum	Nephtys cirrosa	Lumbrineris	Scoloplos armiger	Magelona mirabilis	Chaetozone setosa	Mediomastus fragilis	Travisia forbesii	Neopentadactyla mixta	Moerella	Dosinia lupinus	Timoclea ovata	Spisula	Echinocyamus pusillus	Branchiostoma lanceolatum	Caulleriella zetlandica	Bathyporeia pelagica	Iphinoe trispinosa	Halcampa chrysanthellum	Edwardsia timida
A5.13: Infralittoral coarse sediment																																						
A5.131: Sparse fauna on highly mobile sublittoral shingle (cobbles and pebbles)			■			■	■																															
A5.132: Halcampa chrysanthellum and Edwardsia timida on sublittoral clean stone gravel	■			■										■																						■	■	
A5.133: Moerella spp. with venerid bivalves in infralittoral gravelly sand																			■	■								■	■		■			■				
A5.134: Hesionura elongata and Microphthalmus similis with other interstitial polychaetes in infralittoral mobile coarse sand																									■													
A5.135: Glycera lapidum in impoverished infralittoral mobile gravel and sand											■								■																			
A5.136: Cumaceans and Chaetozone setosa in infralittoral gravelly sand																		■				■		■												■		
A5.137: Dense Lanice conchilega and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand												■	■										■															
A5.14: Circalittoral coarse sediment																																						
A5.141: Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles		■		■	■				■																													
A5.142: Mediomastus fragilis, Lumbrineris spp. and venerid bivalves in circalittoral coarse sand or gravel															■		■		■		■				■					■		■					
A5.143: Protodorvillea kefersteini and other polychaetes in impoverished circalittoral mixed gravelly sand															■	■	■																■				
A5.144: Neopentadactyla mixta in circalittoral shell gravel or coarse sand						■		■		■																	■											
A5.145: Branchiostoma lanceolatum in circalittoral coarse sand with shell gravel																																■					

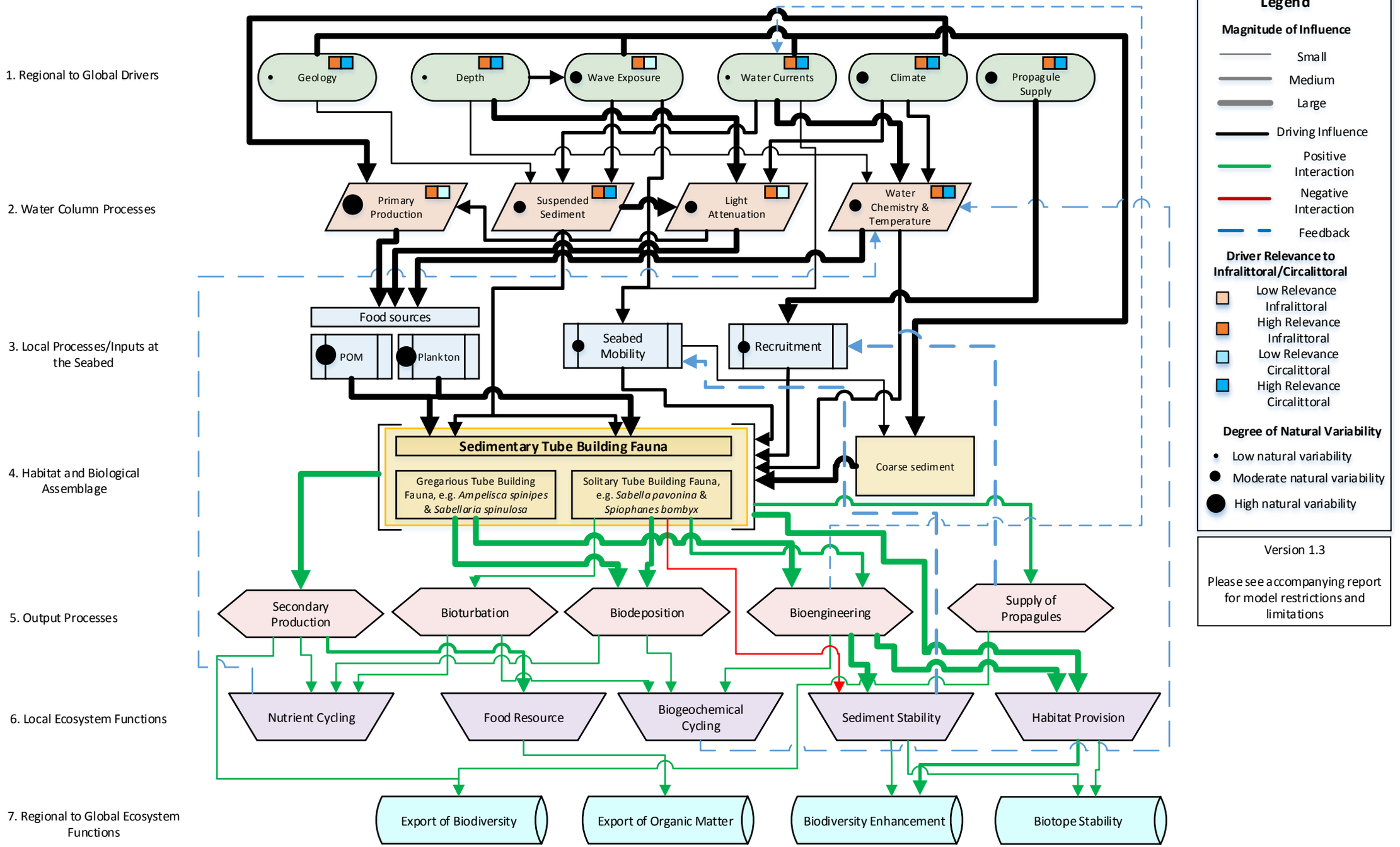
Shallow Sublittoral Coarse Sediments



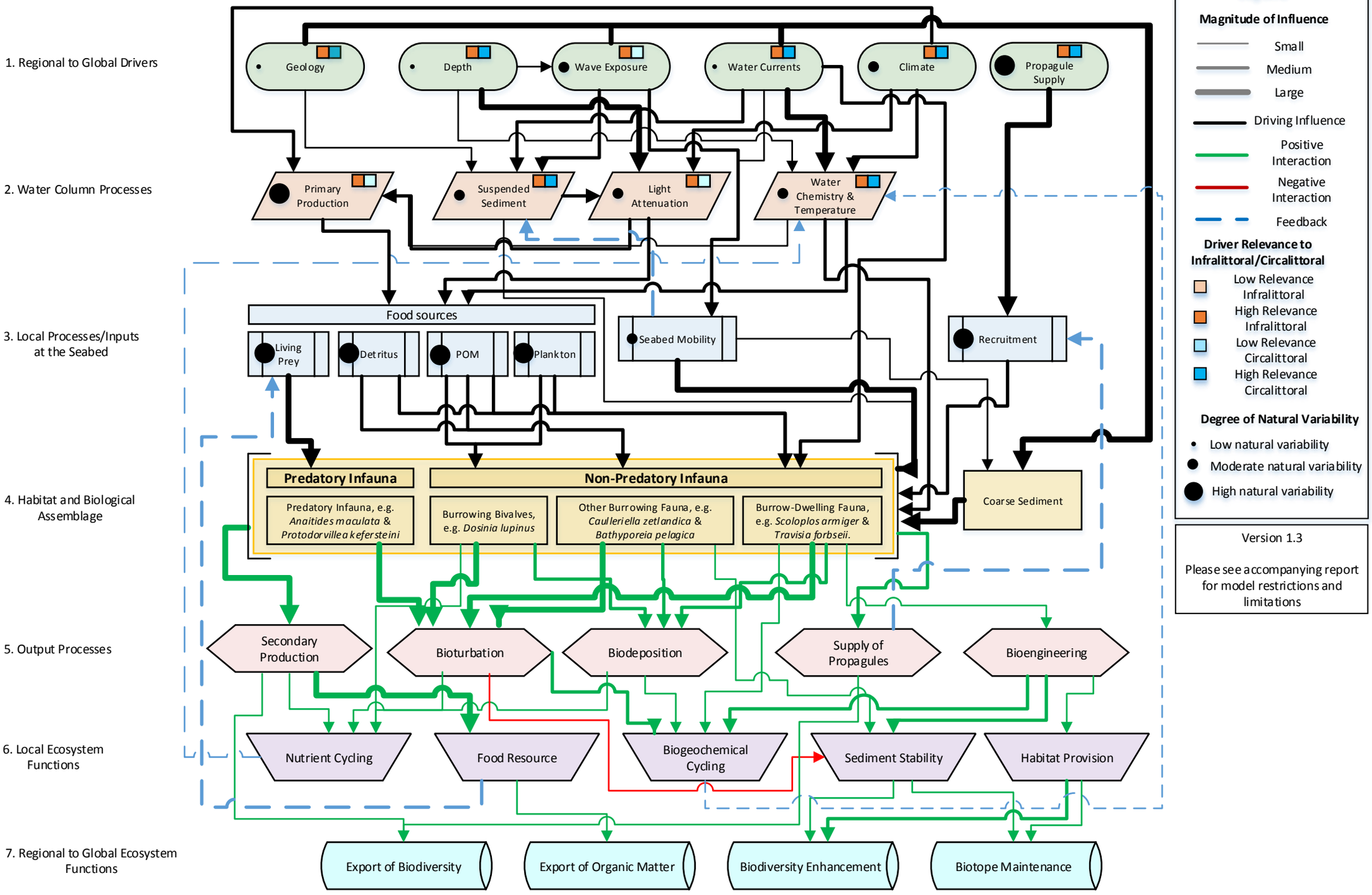
Sub-model 1. Epifauna



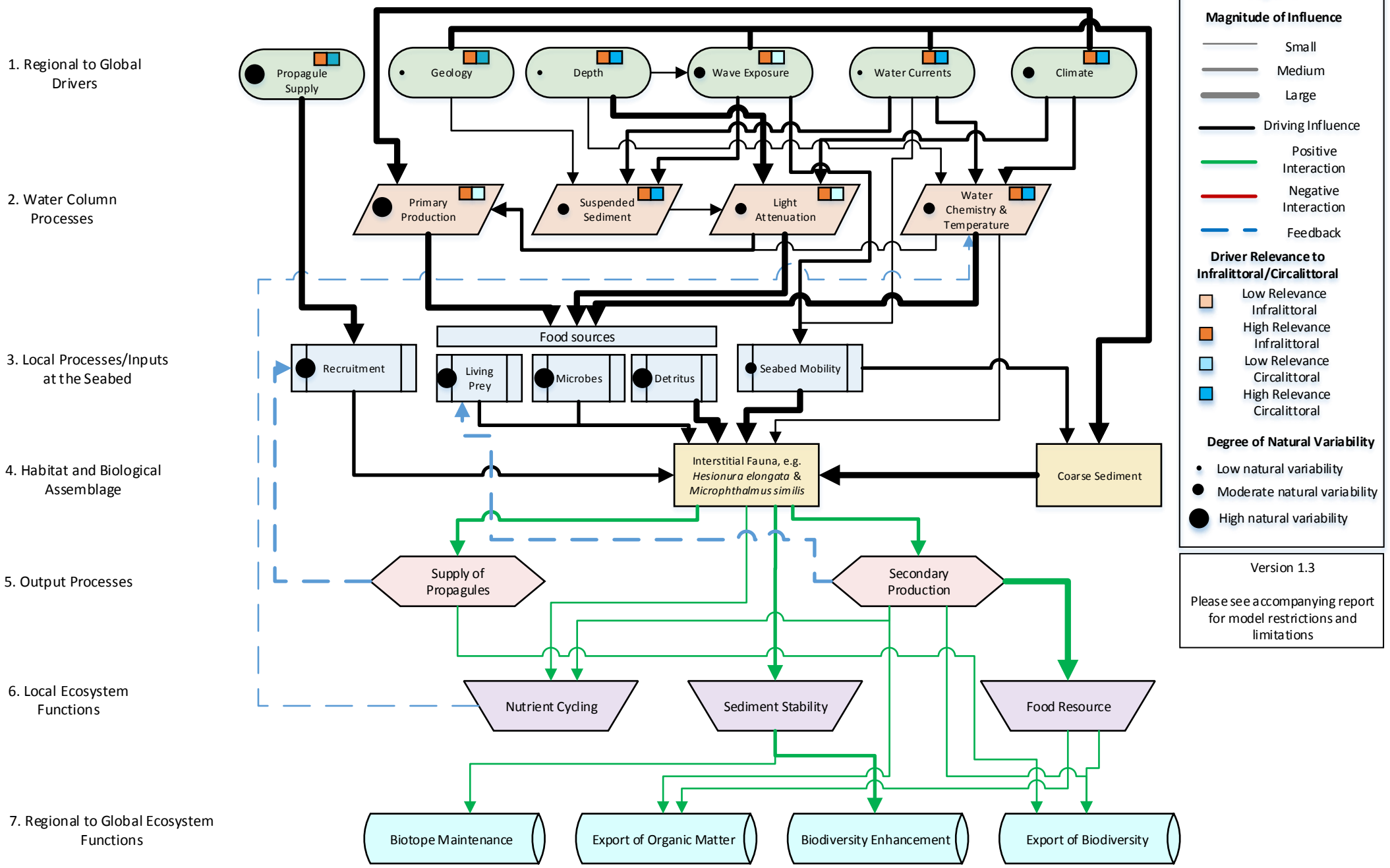
Sub-model 2. Sedimentary Tube Building Fauna



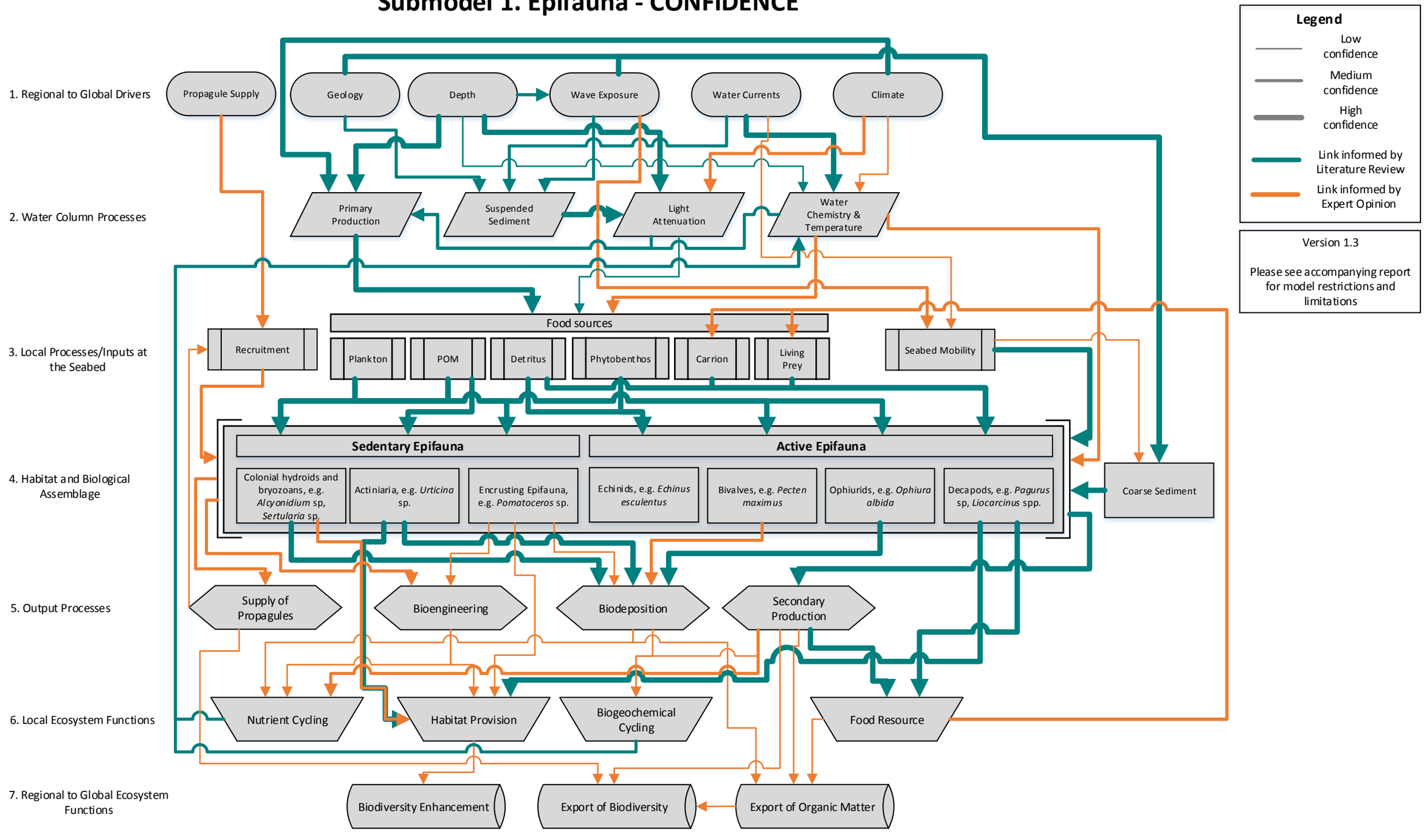
Sub-model 3. Infauna



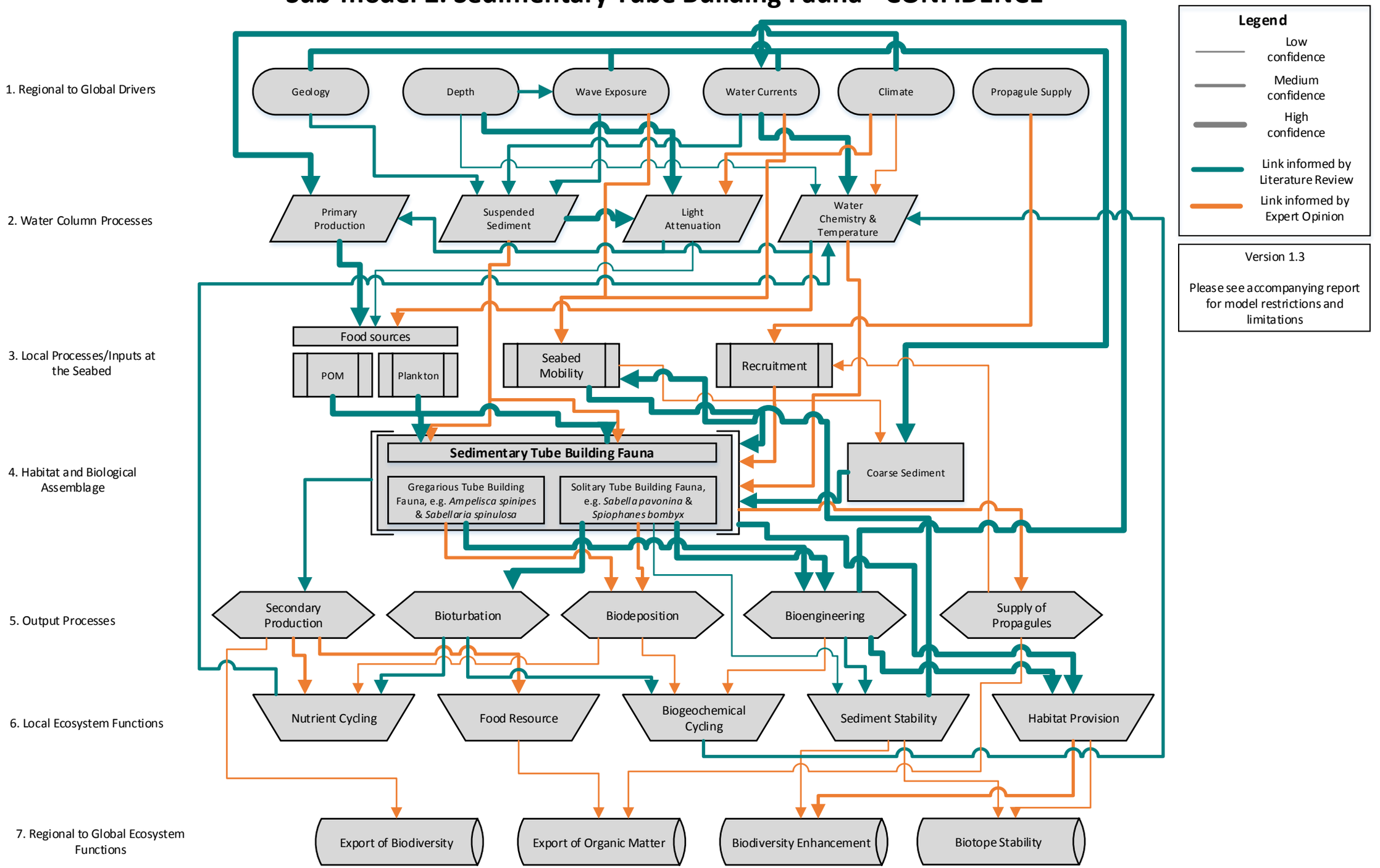
Sub-model 4. Interstitial Fauna



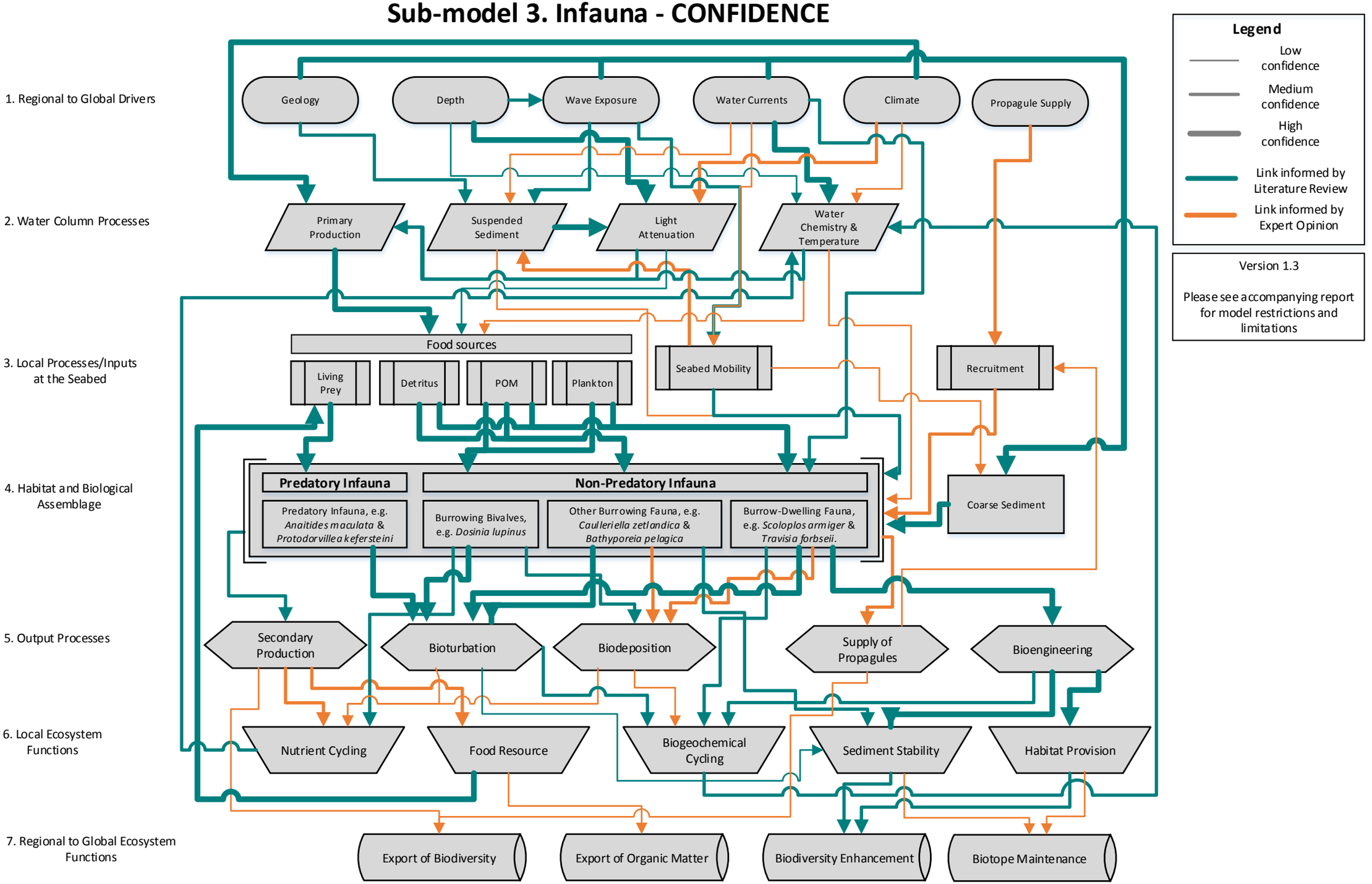
Submodel 1. Epifauna - CONFIDENCE



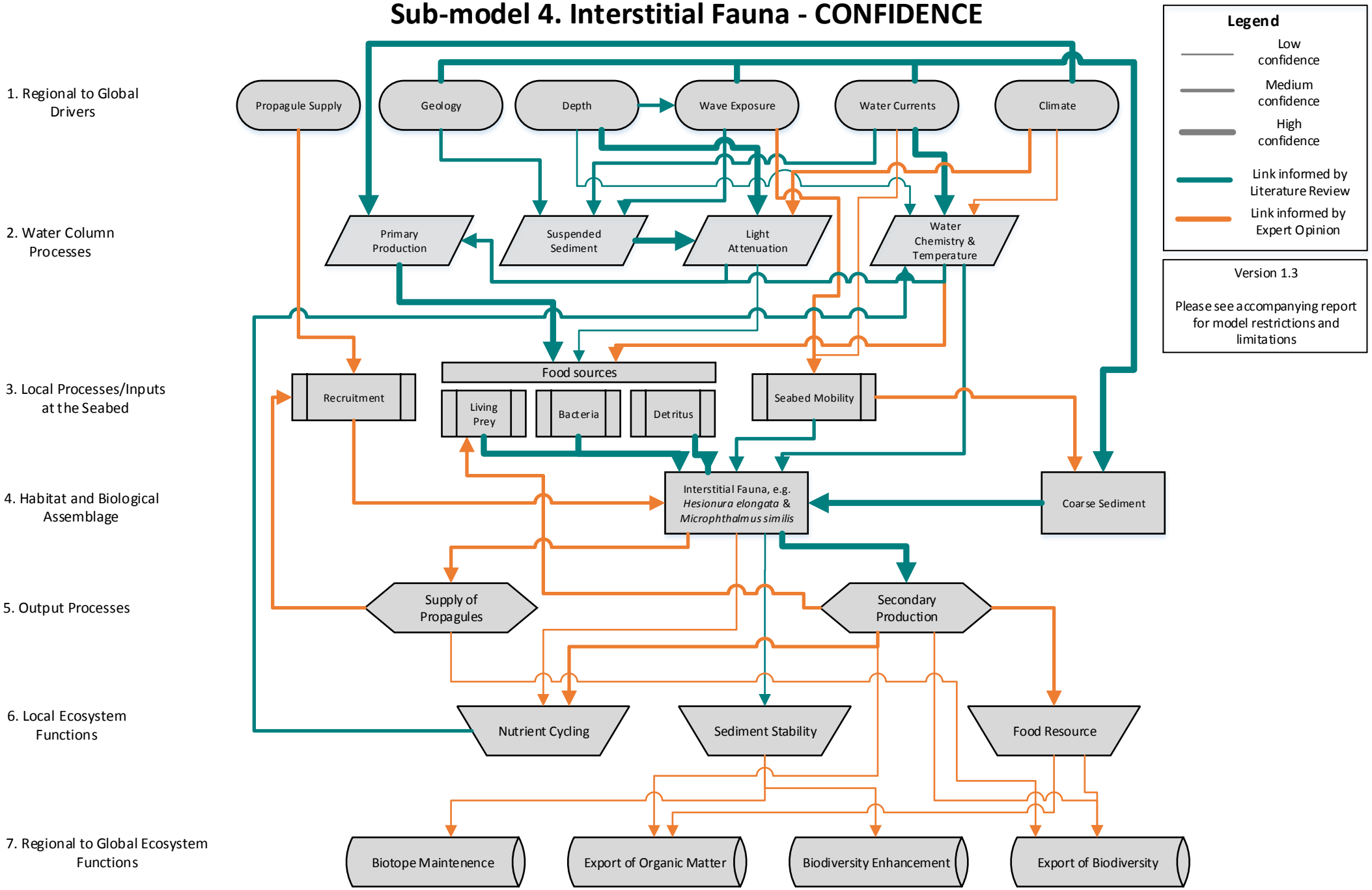
Sub-model 2. Sedimentary Tube Building Fauna - CONFIDENCE



Sub-model 3. Infauna - CONFIDENCE



Sub-model 4. Interstitial Fauna - CONFIDENCE



Appendix 13 - Pressure Descriptions

List of anthropogenic pressures relevant to shallow sublittoral coarse sediment habitats. Pressures and descriptions are taken from the Intercessional Correspondence Group on Cumulative Effects (ICG-C; amended 25th March 2011).

Pressure theme	Pressure	Description	Benchmark (Tillin *et al*. 2010)
Physical damage (Reversible Change)	Habitat structure changes - surface abrasion	The disturbance of sediments where there is limited or no loss of substrate from the system. This pressure is associated with activities such as anchoring, taking of sediment/geological cores, cone penetration tests, cable burial (ploughing or jetting), propeller wash from vessels, certain fishing activities, e.g. scallop dredging, beam trawling. Agitation dredging, where sediments are deliberately disturbed by and by gravity and hydraulic dredging where sediments are deliberately disturbed and moved by currents could also be associated with this pressure type. Compression of sediments, e.g. from the legs of a jack-up barge could also fit into this pressure type. Abrasion relates to the damage of the sea bed surface layers (typically up to 50cm depth). Activities associated with abrasion can cover relatively large spatial areas and include: fishing with towed demersal trawls (fish and shellfish); bio-prospecting such as harvesting of biogenic features such as maerl beds where, after extraction, conditions for recolonisation remain suitable or relatively localised activities including: seaweed harvesting, recreation, potting, aquaculture. Change from gravel to silt substrate would adversely affect herring spawning grounds.	Damage to seabed surface features
Physical damage (Reversible Change)	Habitat structure changes - sub-surface abrasion		Sub seabed-surface structural damage
Physical damage (Reversible Change)	Habitat structure changes - removal of substratum (extraction)	Unlike the 'physical change' pressure type where there is a permanent change in sea bed type (e.g. sand to gravel, sediment to a hard artificial substrate) the 'habitat structure change' pressure type relates to temporary and/or reversible change, e.g. from marine mineral extraction where a proportion of seabed sands or gravels are removed but a residual layer of seabed is similar to the pre-dredge structure and as such biological communities could re-colonise; navigation dredging to maintain channels where the silts or sands removed are replaced by non-anthropogenic mechanisms so the sediment typology is not changed.	Extraction of sediment to 30cm
Biological pressures	Removal of non-target species	By-catch associated with all fishing activities. The physical effects of fishing gear on sea bed communities are addressed by the 'abrasion' pressure type so this addresses the direct removal of individuals associated with fishing/ harvesting. Ecological consequences include food web dependencies, population dynamics of fish, marine mammals, turtles and sea birds (including survival threats in extreme cases, e.g. Harbour Porpoise in Central and Eastern Baltic).	Removal of features through pursuit of a target fishery at a commercial scale
	Removal of target species	The commercial exploitation of fish and shellfish stocks, including smaller scale harvesting, angling and scientific sampling. The physical effects of fishing gear on sea bed communities are addressed by the 'abrasion' pressure type, so this addresses the direct removal / harvesting of biota. Ecological consequences include the sustainability of stocks, impacting energy flows through food webs and the size and age composition within fish stocks.	Removal of target species that are features of conservation importance or sub-features of habitats of conservation importance at a commercial scale.

Physical damage (Reversible Change)	Siltation rate changes, including smothering (depth of vertical sediment overburden)	When the natural rates of siltation are altered (increased or decreased). Siltation (or sedimentation) is the settling out of silt/sediments suspended in the water column. Activities associated with this pressure type include mariculture, land claim, navigation dredging, disposal at sea, marine mineral extraction, cable and pipeline laying and various construction activities. It can result in short-lived sediment concentration gradients and the accumulation of sediments on the sea floor. This accumulation of sediments is synonymous with 'light smothering', which relates to the depth of vertical overburden. 'Light smothering' relates to the deposition of layers of sediment on the seabed. It is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea bed. For 'light smothering' most benthic biota may be able to adapt, i.e. vertically migrate through the deposited sediment. 'Heavy smothering' also relates to the deposition of layers of sediment on the seabed but is associated with activities such as sea disposal of dredged materials where sediments are deliberately deposited on the sea bed. This accumulation of sediments relates to the depth of vertical overburden where the sediment type of the existing and deposited sediment has similar physical characteristics because, although most species of marine biota are unable to adapt, e.g. sessile organisms unable to make their way to the surface, a similar biota could, with time, re-establish.	up to 30cm of fine material added to the seabed in a single event
Physical loss (Permanent Change)	Physical change (to another seabed type)	The permanent change of one marine habitat type to another marine habitat type, through the change in substratum, including to artificial (e.g. concrete). This therefore involves the permanent loss of one marine habitat type but has an equal creation of a different marine habitat type. Associated activities include the installation of infrastructure (e.g. surface of platforms or wind farm foundations, marinas, coastal defences, pipelines and cables), the placement of scour protection where soft sediment habitats are replaced by hard/coarse substrate habitats, removal of coarse substrate (marine mineral extraction) in those instances where surficial finer sediments are lost, capital dredging where the residual sedimentary habitat differs structurally from the pre-dredge state, creation of artificial reefs, mariculture i.e. mussel beds. Protection of pipes and cables using rock dumping and mattressing techniques. Placement of cuttings piles from oil and gas activities could fit this pressure type, however, there may be an additional pressures, e.g. 'pollution and other chemical changes' theme. This pressure excludes navigation dredging where the depth of sediment is changes locally but the sediment typology is not changed.	Permanent loss of existing saline habitat
Pollution and other chemical changes	Organic enrichment	Resulting from the degraded remains of dead biota and microbiota (land and sea); faecal matter from marine animals; flocculated colloidal organic matter and the degraded remains of: sewage material, domestic wastes, industrial wastes etc. Organic matter can enter marine waters from sewage discharges, aquaculture or terrestrial/agricultural runoff. Black carbon comes from the products of incomplete combustion (PIC) of fossil fuels and vegetation. Organic enrichment may lead to eutrophication (see also nutrient enrichment). Adverse environmental effects include deoxygenation, algal blooms, changes in community structure of benthos and macrophytes.	A deposit of 100gC/m^2/yr