STAWA DEPTH and BREADTH of CONTENT: Teacher Support Documents

Senior Secondary Science WACE 2015 – 2016: Biology - Unit 1

The STAWA Depth & Breadth of Content documents have been developed through the collaboration of teachers working in Department of Education, Catholic Education and Independent Schools.

Purpose

The STAWA Depth & Breadth of Content documents are intended to promote a shared understanding of the course content that improves moderation across schools, regions and systems/sectors.

Caution

The Depth and Breadth points of elaboration are interpretations. The ATAR syllabus content statements are the only parts of these documents that are mandated. Examiners are required to address the mandated statements only.

The STAWA Depth & Breadth of Content documents are a great example of teachers helping teachers for the benefit of all students.

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Leadership in Science Education

BIOLOGY

ATAR Year 11

Unit 1 – Ecosystems and biodiversity

Unit description

The current view of the biosphere as a dynamic system composed of Earth's diverse, interrelated and interacting ecosystems developed from the work of eighteenth and nineteenth century naturalists who collected, classified, measured and mapped the distribution of organisms and environments around the world. In this unit, students investigate and describe a number of diverse ecosystems, exploring the range of biotic and abiotic components to understand the dynamics, diversity and underlying unity of these systems.

Students develop an understanding of the processes involved in the movement of energy and matter in ecosystems. They investigate ecosystem dynamics, including interactions within and between species, and interactions between abiotic and biotic components of ecosystems. They also investigate how measurements of abiotic factors, population numbers and species diversity, and descriptions of species interactions, can form the basis for spatial and temporal comparisons between ecosystems. Students use classification keys to identify organisms, describe the biodiversity in ecosystems, investigate patterns in relationships between organisms, and aid scientific communication.

Through the investigation of appropriate contexts, students explore how international collaboration, evidence from multiple disciplines and the use of ICT and other technologies have contributed to the study and conservation of national, regional and global biodiversity. They investigate how scientific knowledge is used to offer valid explanations and reliable predictions, and the ways in which scientific knowledge interacts with social, economic, cultural and ethical factors.

Fieldwork is an important part of this unit. Fieldwork provides valuable opportunities for students to work together to collect first-hand data and to experience local ecosystem interactions. In order to understand the interconnectedness of organisms, the physical environment and human activity, students analyse and interpret data collected through investigation of a local environment. They will also use sources relating to other Australian, regional and global environments.

Learning outcomes

By the end of this unit, students:

- understand how classification helps to organise, analyse and communicate data about biodiversity
- understand that ecosystem diversity and dynamics can be described and compared with reference to biotic and abiotic components and their interactions

- understand how theories and models have developed based on evidence from multiple disciplines; and the uses and limitations of biological knowledge in a range of contexts
- use science inquiry skills to design, conduct, evaluate and communicate investigations into biodiversity and flows of matter and energy in a range of ecosystems
- evaluate, with reference to empirical evidence, claims about relationships between and within species, diversity of and within ecosystems, and energy and matter flows
- communicate biological understanding using qualitative and quantitative representations in appropriate modes and genres.

Unit 1 content

This unit includes the knowledge, understandings and skills described below.

Science Inquiry Skills

1. identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes
2. design investigations, including the procedure(s) to be followed, the materials required, and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics, including animal ethics
3. conduct investigations, **including using ecosystem surveying techniques (quadrats, line transects and capture-recapture)** safely, competently and methodically for the collection of valid and reliable data
4. represent data in meaningful and useful ways; organise and analyse data to identify trends, patterns and relationships; qualitatively describe sources of measurement error, and uncertainty and limitations in data; and select, synthesise and use evidence to make and justify conclusions
5. interpret a range of scientific and media texts, and evaluate processes, claims and conclusions by considering the quality of available evidence; and use reasoning to construct scientific arguments
6. select, construct and use appropriate representations, **including classification keys, food webs and biomass pyramids,** to communicate conceptual understanding, solve problems and make predictions
7. communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes, including scientific reports

Green: specific content related to Unit 1. The rest of the statements are the same generic ones across the units.

Unit 1 Summary

Describing Biodiversity

SU 1, 2, 3, 4: biodiversity and classification

SHE 1: dynamic nature of classification systems

SHE 5: international agreements for protecting biodiversity

SU 5, 6, 7: ecosystems and interrelationships

SIS 3: classification keys, food webs and biomass pyramids,

Ecosystem dynamics

SU 8: energy and matter in ecosystems

SU 9, 10, 11: dynamic populations and keystone species

SHE 3 keystone-species concept in ecology and conservation

SU 12: fire

SU 13: carrying capacity of ecosystems

SU 14: ecological succession

SU 15: impact of human activity on ecosystems

SU 16: conservation strategies

SHE 2: identification and classification of an ecological area as a conservation

SHE 4: Australia's Biodiversity Conservation Strategy 2010–2030

SHE 5: international agreements for protecting biodiversity

SIS 3: using ecosystem surveying techniques (quadrats, line transects and capture-recapture)

SU 17: models of ecosystem interactions

SHE 6: use of contemporary technologies

Unit Content	Elaborations	Possible Activities	Assessment Opportunities
Describing Biodiversity			
1. biodiversity includes the diversity of genes, species and ecosystems; measures of biodiversity rely on classification and are used to make comparisons across spatial and temporal scales	• importance of biodiversity • biodiversity is dependent on size and abiotic and biotic factors present • biodiversity ○ ecosystems - communities interacting with each other and the environment ○ species - variety of organisms in a given location ○ genes - range of alleles in species population gene pool • measuring biodiversity ○ species richness ○ species evenness ○ biodiversity index calculations • classification implications due to variety within species and genera in a given ecosystem • comparisons ○ spatial- geographical location, habitats (terrestrial, aquatic), climatic regions ○ temporal - geological time, pre- and post-industrial or colonisation • biodiversity differs between ecosystems - rainforests, deserts, coral reefs, scrub plains • biodiversity hot spots ○ locations ○ reasons for being declared a hot spot	• Comparisons of ecosystems (Use of pictures and diagrams) • Compare ecosystems for similarities and differences. E.g. Barrier Reef and Maldives • Attenborough • 'Life on Earth' • 'Nature of Australia' ABC shops • You tube videos e.g.. Why biodiversity matters https://www.youtube.com/watch?v=N5ssjM2Fjuc Official video of the International Year of Biodiversity 2010 https://www.youtube.com/watch?v=V1VYmpTikgw&feature=youtu.be&noredirect=1 • Video - Attenborough's Arc Ecology by Inquiry http://www.nwfsc.noaa.gov/education/foreducators/curricula.cfm Biodiversity hotspots http://www.environment.gov.au/topics/biodiversity/biodiversity-conservation/biodiversity-hotspots Hotspots http://www.conservation.org/How/Pages/Hotspots.aspx	
SHE 5: international agreements about biodiversity encourage international cooperation in the protection of unique locations, including ▪ World Heritage sites, for example, Shark Bay, Great Barrier Reef ▪ biodiversity hotspots, for example, south west WA			

<table>
<tr><td colspan="4">▪ international migration routes and areas used for breeding, for example, by birds, whales, turtles, whale sharks
Bird migration
http://www.birdlife.org/datazone/sowb/casestudy/73
Whale migration
http://www.iwcoffice.co.uk/_documents/sci_com/sc62docs/sc-62-sh21.pdf
http://www.maps.com/map.aspx?pid=16004
Turtles
http://www.conserveturtles.org/seaturtleinformation.php?page=behavior</td></tr>
<tr><td>2. biological classification is hierarchical and based on molecular sequences, different levels of similarity of physical features and methods of reproduction</td><td>• Linnaean classification system is hierarchical - Kingdom, Phylum, Class Order, Family Genus and species with groups becoming smaller and with more features in common down the hierarchy
• species is the basic unit of classification
• international conventions are used to write scientific names
• classification is dynamic and the system continues to be modified as more information is collected
• classification is based on
o structure
o modes and methods of reproduction
o patterns of development
o genetic and biochemical characteristics
• five kingdoms are recognised based mainly on cellular differences
• animal phyla and plant divisions have specific features by which they can be recognised</td><td>• Brief understanding of history of classification
• Understand principles of classification
• Explore anomalies such as ‘liger’ and mules
• Cut and stick activities – Older copies of Biozone Year 11
• Study specimens - Describe the characteristics of major phyla. Distinguish the essential features that are used to classify them. (Web of Life student Manual)
• Make and use multilevel dichotomous keys (these should be complex as many students have done this in lower school)
• Zoo Excursion
Classification of kingdoms
http://www.goldiesroom.org/Note%20Packets/02%20Classification/00%20Classification%20Packet--WHOLE.htm</td><td></td></tr>
<tr><td colspan="4">SHE 1: classification systems are based on international conventions and are subject to change through debate and resolution; changes are based on all currently available evidence
Eucalypts but not Eucalyptus
http://anpsa.org.au/APOL2/jun96-5.html
Carcharodon Megalodon: A Classification Dilemma</td></tr>
</table>

http://www.fossils-facts-and-finds.com/carcharodon_megalodon.html Classification: basic concepts, decision trees and model evaluation http://www-users.cs.umn.edu/~kumar/dmbook/ch4.pdf			
3. biological classification systems reflect evolutionary relatedness between groups of organisms	• phylogenetic trees are used to show evolutionary relatedness • the greater the similarity in DNA/protein sequences, the closer the relatedness	• Use of quality images to show the evolution of organisms over time • Examine phylogenetic trees • Teach through multi choice questions where students have to identify which are more/less related on basis of classification and/or characteristics Phylogenetic systematics, a.k.a. evolutionary trees http://evolution.berkeley.edu/evolibrary/article/phylogenetics_01 Phylogeny http://biology.unm.edu/ccouncil/Biology_203/Summaries/Phylogeny.htm Travels in the great tree of life http://archive.peabody.yale.edu/exhibits/treeoflife/phylo.html	
4. most common definitions of species rely on morphological or genetic similarity or the ability to interbreed to produce fertile offspring in natural conditions – but in all cases, exceptions are found	• different definitions of species all have limitations and exceptions • issues arising in classification may be due to ○ ring species ○ clines ○ hybrids ○ cross breeding in unnatural situations ○ collaborations between species (lichens) • spatial and temporal issues impact species definitions	• Discuss ▪ Circumpolar species (Larus gulls) ▪ Domestic dog Classification activities http://www.saps.org.uk/attachments/article/560/SAPS%20Grouping%20&%20classification%20-%20PartE.pdf	
5. ecosystems are diverse, composed of varied habitats, consisting of a range of biotic and abiotic	• ecosystems, environments and habitats are differentiated in terms of scale and abiotic and biotic components • species only exist within their tolerance limits:	• Measure all abiotic/physical factors in a local area using lab equipment and data loggers • Describe the biotic factors present with in an ecosystem (organisms present or inferred	Field work/reports

factors, and can be described in terms of their component species, species interactions and the abiotic factors that make up the environment	abiotic and biotic factors impact species survival/presence • conventions for naming ecosystems is based on prominent abiotic or biotic features • ecosystems include aquatic (marine, estuarine, freshwater) and terrestrial (caves, subsoil, soil surface, arboreal - names may differ but there are a huge variety)	(tracks, shells etc.) • Comparison of two areas • Understand the influence of abiotic factors on biotic factors • Describe environment of different named organisms • Use local resources and information, for example Naturaliste Marine Discovery Centre, Perth Hills Centre, Australian Wildlife Conservancy's Karakamia facility etc.	
6. relationships and interactions within a species and between species in ecosystems include predation, competition, symbiosis (mutualism, commensalism and parasitism), collaboration and disease	• relationships between organisms are characterised by those that benefit and those that don't • competition or co-operation within and between species produce specific relationships • predator - prey relationships depend on populations sizes and dynamics to be maintained • micro-organisms causing disease depend on the health of individuals and populations density to survive	• Research different parasites, symbionts and commensals lifecycles • Research infectious diseases • Australian examples of organisms involved in each of the interrelationships David Attenborough videos e.g. • https://www.youtube.com/watch?v=-h8I3cqpgnA • Living Together https://www.youtube.com/watch?v=R8g1BU29WVg	
7. in addition to biotic factors, abiotic factors, including climate and substrate, can be used to describe and classify environments	• substrates ○ aquatic - differ in salinity and water flow/movement ○ soils - particle size, fertility/mineral content and salinity ○ living or dead - as for parasites or decomposers • climate related to temperature range, availability of water	• Describe a local environment to decide what is the most important feature and could it be classified that way	

	○ tropical, temperate, dry/hot, dry/cold, polar ○ micro-climates occur in all environments		
Ecosystem dynamics			
8. the biotic components of an ecosystem transfer and transform energy, originating primarily from the sun, and matter to produce biomass; and interact with abiotic components to facilitate biogeochemical cycling, including carbon and nitrogen cycling; these interactions can be represented using food webs and biomass pyramids	• energy transfers and transformations in ecosystems rely on photosynthesis and respiration • energy flow is represented by food webs and energy pyramids • energy flows through the ecosystem with 10% energy transfer from one trophic level to the next - 90% energy loss at each change in trophic level limiting the length of food chains and the complexity of food webs • transfer and transformation of matter is due to photosynthesis, respiration and growth and can be represented as biomass pyramids • matter cycles within the ecosystem and can be quantified • carbon and nitrogen cycles ○ role of producers, consumers and micro-organisms/decomposers ○ form of the element at different stages in the cycle - biologically active or inactive ○ impact of human activity on the rate of cycling	• Use local ecosystems to describe food webs • Measure biomass production in germinating/growing seeds/plants over time and in differing conditions • Biozone models	
9. species or populations, including those of microorganisms, fill specific ecological niches; the competitive exclusion principle postulates that no two species can occupy the same niche in the same environment for an extended period of time	• species have specific tolerance limits that enable them to occupy a particular niche • the level of competitiveness is related to the closeness of requirements of organisms: the more similar, the more intense the competition and may lead to competitive exclusion	• Biozone activities • Consider examples of species that have outcompeted others e.g. Rainbow lorikeets have outcompeted red capped and ring neck parrots • Reef Game http://game.reefcheckaustralia.org/	

10. the dynamic nature of populations influence population size, density, composition and distribution	• populations can be describes by size, density, composition (age structure, males/females) and distribution • populations can be quantified by calculating: ▪ population density = number /area or volume ▪ changes in population size = (Births +Immigration) – (Deaths +Emigration) • density dependent and density independent factors influence population size and distribution • populations will grow exponentially unless controlled by the abiotic and biotic factors of the ecosystem	• Perform/understand a variety of techniques to count/estimate population sizes. For example quadrats, transects, capture-recapture, Elliot and Sheffield traps, pit traps, mist netting, seine netting, aerial surveys, video surveys to predict abundance and long term trends in population sizes • Calculations/models of population dynamics can be made from species breeding/mortality and migration patterns	
11. keystone species play a critical role in maintaining the structure of the community; the impact of a reduction in numbers or the disappearance of keystone species on an ecosystem is greater than would be expected, based on their relative abundance or total biomass	• keystone species is one whose impacts on its community or ecosystem are large • when keystone species are removed the effect is greater than would be expected from its relative abundance or total biomass • keystone species can be used to monitor changes in the ecosystem • not all ecosystems have isolated keystone species, but may have a combination of species that act in the same way	• 'EcoBeaker' software http://simbio.com/products-college/EcoBeaker	

SHE 3: keystone species theory has informed many conservation strategies. However, there are differing views about the effectiveness of single-species conservation in maintaining complex ecosystem dynamics

The keystone-species concept in ecology and conservation

http://bio.research.ucsc.edu/people/doaklab/publications/1993mills_soule_doak.pdf

The keystone species: the concept and its relevance for conservation management in New Zealand

http://csl.doc.govt.nz/Documents/science-and-technical/SFC203.pdf

Significance of keystone species in conservation strategies

http://www.biotecharticles.com/Biology-Article/Significance-of-Keystone-Species-in-Conservation-Strategies-690.html

12. fire is a dynamic factor in Australian ecosystems and has different effects on biodiversity	• many Australian species are adapted to fire to different extents and frequencies with the intensity and frequency of fires affecting species composition/biodiversity of an area • many species rely on fire for continuation of their life cycle • Australians have used fire in ecosystem management with differing outcomes	• Australian Wildlife Conservancy http://www.australianwildlife.org/News-and-Publications/Wildlife-Matters-Newsletter.aspx • Kings Park Botanic Gardens research on smoke and plant germination http://www.bgpa.wa.gov.au/kings-park/events/kings-park-education • C.S.I.R.O. research • Dept of Parks and Wildlife prescribed burning policy www.dpaw.wa.gov.au/management/fire/prescribed-burning/burn • Hills Discovery Centre, "Fire - A force for life" • Honey Possum and Fire - Research	
13. ecosystems have carrying capacities that limit the number of organisms (within populations) they support, and can be impacted by changes to abiotic and biotic factors, including climatic events	• carrying capacity of an ecosystem is dynamic and depends on abiotic and biotic factors • carrying capacity varies over long term - climate changes, or short term - changes of season, climatic events such as floods or droughts • humans influence carrying capacity by altering the abiotic (water supply, soil nutrient levels) and biotic (supply of food, reduction of predators) factors	• David Attenborough's Natures Great Events, particularly The Great Salmon Run, The Great Feast and the Great Tide • Biozone • Examine the predicted impact of climate change on Australian ecosystems particularly iconic Australian flora and fauna • Catalyst – The Tipping Point http://www.abc.net.au/catalyst/stories/s1647466.htm • ABC TV Show available in ABC shops "Cassowary" narrated by William McInnes • A five step plan to Feed the World - Where do we find enough food to feed 9 billion http://www.nationalgeographic.com/foodfeatures/feeding-9-billion/	
14. ecological succession	• succession occurs due to changes in the abiotic	• Field trip – transect of coastal dunes or granite	Field work and

involves changes in the populations of species present in a habitat; these changes impact the abiotic and biotic interactions in the community, which in turn influence further changes in the species present and their population size	and biotic factors in an area over time • in the series of succession each change produces greater complexity in the ecosystem • pioneer species start the process, in doing so change the conditions making them suitable for other organisms • a stable climax community is the end result • succession can be primary or secondary	outcrop in Darling Ranges • Catalyst Earth on Fire" http://www.abc.net.au/catalyst/stories/4014144.htm	report
15. human activities that can affect biodiversity and can impact on the magnitude, duration and speed of ecosystem change include examples of i. habitat destruction, fragmentation or degradation	• changes in ○ magnitude - how large are the changes ○ duration - how long does it last ○ speed - how long does it take for the changes to occur • changes in ○ abiotic and biotic features that impact tolerance limits ○ changes in carrying capacity impacting on viability of populations ○ migration pathways ○ interruption to life cycles • destruction ○ land clearing ○ changing salinity ○ intense fire • fragmentation ○ road building ○ changing water courses ○ leftover areas from destruction processes • degradation ○ pollution - air soil water ○ change in soils fertility or salinity	• New Scientist April 25 2014 **Aliens versus predators: The toxic toad invasion** • Investigate small mammal extinction and decline due to cat and foxes. • Dryandra conservation • Research 'Operation Western Shield' Birdlife State of Australia's Birds publications http://birdlife.org.au/education-publications/publications/state-of-australias-birds Australian Wildlife Conservancy – "Into Oblivion" http://www.nature.org/ourinitiatives/regions/aust	

	○ changes in water quality	ralia/explore/ausmammals.pdf	
ii. the introduction of invasive species	• invasive species - plants (weeds) and animals (ferals) • tend to out-compete local species due to high reproduction rates, lower predation and disease rates, high competitiveness for resources • reduce biodiversity of the area	• Investigate small mammal extinction and decline due to cat and foxes • Dryandra conservation • Research ‘Operation Western Shield’	
iii. unsustainable use of natural resources	• natural resources include, air, water, soil, minerals, energy and space • changes to these will change the features of the area beyond the tolerance limits of local organisms and affect survival rates • human use of areas for recreation	• Conservation Commission WA – forest management http://www.conservation.wa.gov.au/management-planning/management-plans/draft-forest-management-plan-2014-2023.aspx	
iv. the impact of pollutants, including biomagnification	• range of pollutants impacting ecosystems • biomagnification - toxicity increases up the trophic levels	• Plastic pollution http://www.abc.net.au/catalyst/stories/3583576.htm Field Work Opportunity • Teach wild Plastic Pollution http://teachwild.org.au Biomagnification • DDT and peregrine falcon eggs - Rachel Carson's landmark book Silent Spring • Mercury – Minamata disease	
v. climate change	• ecosystems may change their range/existence due to changes in climate as a result of human impact • climate change, geologically, is part of the	• Catalyst – The Tipping Point http://www.abc.net.au/catalyst/stories/s1647466.htm • Catalyst – Taking Our Temperature	

	cycle but it is the rate that is faster than previous • climate change alters the interaction of biotic and abiotic factors • the rate of change is too fast for most species to be able to adapt; though some species may benefit	http://www.abc.net.au/catalyst/stories/3633447.htm • World Wildlife Fund http://awsassets.wwf.org.au/downloads/sp029_australian_species_and_climate_change_25mar08.pdf • Australian Institute of Marine Sciences http://www.aims.gov.au/docs/research/climate-change/climate-change.html	
16. conservation strategies used to maintain biodiversity are i. genetic strategies, including gene/seed banks and captive breeding programs	• conservation may occur at the level of: ○ genetic ○ environmental ○ management • modern technology may aid in conservation • Gene and seed banks have been built to preserve biodiversity but there are problems of seed viability with time • captive breeding ○ monitoring of breeding programs to maintain the greatest genetic diversity - zoos swapping breeding stock or use of artificial insemination	Perth Zoo – Captivating Conservation DPaW - Department of Parks and Wildlife when on field trips e.g. Dryandra - Barna Mia Facility Karakamia – Australian Wildlife Conservancy Fisheries WA –Naturaliste Marine Discovery Centre Contact Michael Burke/Carina Lancaster 08 9203 0112 "Environmental strategies, including revegetation and control of introduced species" biosecurity/quarantine procedures -http://www.daff.gov.au/biosecurity/quarantine • Explore political issues to do with siting/funding of gene and seed banks • Investigate exploitation of genetic material from e.g. developing equatorial countries with high biodiversity • Video - The Seed Hunter http://www.seedhunter.com download from http://www.abc.net.au/tv/documentaries/interactive/futuremakers/ep3/	

		• Kings Park Activities • Perth Zoo • Dryandra Barna Mia • Kanyana Wildlife Centre • Australian Wildlife Conservancy	
ii. environmental strategies, including revegetation and control of introduced species	• local and national programs have been developed to rehabilitate degraded areas and reduce the impact of introduced species • use of designated paths and walkways to reduce impact of human use	• Research programs related to revegetation and control of introduced species - Greening of Australia http://www.greeningaustralia.org.au/ - Ribbon of Green - Ribbons of Blue - Men of the Trees - The Agriculture Protection Board (APB)	
iii. management strategies, including protected areas and restricted commercial and recreational access	• declaration of national parks and state reserves based on designated features worthy of preservation • restricted access to areas and resources • use of licences and seasonal access to resources - eg fishing	• Naturaliste Marine Discovery Centre, Hillarys; see Fisheries WA. Contact Michael Burke/Carina Lancaster 08 9203 0112	

SHE 2: identification and classification of an ecological area as a conservation reserve also requires consideration of the commercial and recreational uses of the area, as well as Indigenous Peoples' usage rights

National Parks in Australia
http://australia.gov.au/about-australia/australian-story/national-parks
National Parks Council of Australia
http://www.npac.org.au/
SHE 4: Australia's Biodiversity Conservation Strategy 2010–2030 presents a long-term view of the future and the actions that need to be implemented to conserve biodiversity
http://www.environment.gov.au/resource/australias-biodiversity-conservation-strategy-0
SHE 5: international agreements about biodiversity encourage international cooperation in the protection of unique locations including:

- World Heritage sites, for example Shark Bay, Great Barrier Reef

• biodiversity hotspots, for example, south west WA • international migration routes and areas used for breeding, for example, by birds, whales, turtles and whale sharks			
17. models of ecosystem interactions (food webs, successional models) can be used to predict the impact of change and are based on interpretation of and extrapolation from sample data (data derived from ecosystem surveying techniques); the reliability of the model is determined by the representativeness of the sampling	• food webs can be used to demonstrate the impact of changes in components • influence of amount and type of data collected on modelling and therefore decision-making		
SHE 6: contemporary technologies, including satellite sensing and remote monitoring enable improved monitoring of habitat and species population change over time Environmental Monitoring New Technologies for Monitoring: Status and Prospects http://www.environ.ie/en/Environment/NorthSouthUnit/PublicationsDocuments/FileDownLoad,1226,en.pdf Smart Environment Monitoring & Analysis Technologies (SEMAT) http://eresearch.jcu.edu.au/projects/semat Environmental Sensing and Monitoring Technologies: Global Markets http://www.marketwatch.com/story/environmental-sensing-and-monitoring-technologies-global-markets-2014-05-07			
Science Inquiry Skills *other descriptors in the list are the same as the generic list in the introduction to the course*			
1.		Ecological sampling methods	

conduct investigations, **including using ecosystem surveying techniques (quadrats, line transects and capture-recapture**) safely, competently and methodically for the collection of valid and reliable data		http://www.countrysideinfo.co.uk/howto.htm Ecological sampling - pdf of ppt http://www.azrivers.org/AZRiversTeachersGuide/plants/Pepe_Ecological_Sampling_ho.pdf Ecological sampling http://www.wsfcs.k12.nc.us/cms/lib/NC01001395/Centricity/Domain/1016/Ecological_Sampling.ppt Aquatic sampling techniques http://www.ctenvirothon.org/studyguides/aquatic_pdfs/2013/Aquatic%20Sampling%20Workshop%20Powerpoint.pdf Invertebrate collection manual http://australianmuseum.net.au/Uploads/Documents/9382/The%20Invertebrate%20Collection%20Manual.pdf	
3. select, construct and use appropriate representations, including classification keys, food webs and biomass pyramids, to communicate conceptual understanding, solve problems and make predictions		Types of identification keys http://www.keytonature.eu/wiki/Types_of_identification_keys Taxonomic classification and phylogenetic trees http://www.mhhe.com/biosci/pae/zoology/cladogram/index.mhtml Energy and Biomass Pyramids http://www.cfep.uci.edu/cspi/docs/lessons_secondary/energy%20biomass%20pyramids.pdf Food and energy: types of pyramids http://scienceaid.co.uk/biology/ecology/food.html Biomass pyramids www2.nido.cl/~doehlke/pyramids.ppt	