Two Oceans Aquarium in partnership with the Department of Basic Education

Marine Sciences

Curriculum Assessment Policy Statement CAPS Gr 10-12

CURRICULUM AND ASSESSMENT POLICY STATEMENT

GRADES 10-12

MARINE SCIENCES

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FOREWORD BY THE MINISTER

Our national curriculum is the culmination of our efforts over a period of seventeen years to transform the curriculum bequeathed to us by apartheid. From the start of democracy we have built our curriculum on the values that inspired our Constitution (Act 108 of 1996). The Preamble to the Constitution states that the aims of the Constitution are to:

- heal the divisions of the past and establish a society based on democratic values, social justice and fundamental human rights;
- improve the quality of life of all citizens and free the potential of each person;
- lay the foundations for a democratic and open society in which government is based on the will of the people and every citizen is equally protected by law; and
- build a united and democratic South Africa able to take its rightful place as a sovereign state in the family of nations.

Education and the curriculum have an important role to play in realizing these aims.

In 1997 we introduced outcomes-based education to overcome the curricular divisions of the past, but the experience of implementation prompted a review in 2000. This led to the first curriculum revision: the Revised National Curriculum Statement Grades R-9 and the National Curriculum Statement Grades 10-12 (2002).

Ongoing implementation challenges resulted in another review in 2009 and we revised the Revised National Curriculum Statement (2002) and the National Curriculum Statement Grades 10-12 to produce this document.

From 2012 the two national Curriculum statements, for Grades R-9 and Grades 10-12 respectively, are combined in a single document and will simply be known as the National Curriculum Statement Grades R-12. The National Curriculum Statement for Grades R-12 builds on the previous curriculum but also updates it and aims to provide clearer specification of what is to be taught and learnt on a term-by-term basis.

The National Curriculum Statement Grades R-12 represents a policy statement for learning and teaching in South African schools and comprises of the following:

a) Curriculum and Assessment Policy statements (CAPs) for all approved subjects listed in this document;

b) *National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R-12*; and

(c) *National Protocol for Assessment Grades R-12.*

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SECTION 1: INTRODUCTION TO THE CURRICULUM AND ASSESSMENT POLICY

INTRODUCTION TO THE CURRICULUM ANDASSESSMENT POLICY STATEMENTS FOR MARINE SCIENCES GRADES 10-12

1.1 Background

The *National Curriculum Statement Grades R-12 (NCS)* stipulates policy on curriculum and assessment in the schooling sector.

To improve implementation, the National Curriculum Statement was amended, with the amendments coming into effect in January 2012. A single comprehensive Curriculum and Assessment Policy document was developed for each subject to replace Subject Statements, Learning Programme Guidelines and Subject Assessment Guidelines in Grades R-12.

1.2 Overview

(a) The *National Curriculum Statement Grades R-12 (January 2012)* represents a policy statement for learning and teaching in South African schools and comprises the following:

(i) Curriculum and Assessment Policy Statements for each approved school subject;

(ii) The policy document, National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R-12; and

(iii) The policy document, National Protocol for Assessment Grades R-12 (January 2012).

(b) The *National Curriculum Statement Grades R-12 (January 2012)* replaces the two current national curricula statements, namely the

(i) Revised National Curriculum Statement Grades R-9, Government Gazette No. 23406 of 31 May 2002, and

(ii) National Curriculum Statement Grades 10-12 Government Gazettes, No. 25545 of 6 October 2003 and No. 27594 of 17 May 2005.

(c) The national curriculum statements contemplated in subparagraphs b(i) and (ii) comprise the following policy documents which will be incrementally repealed by the *National Curriculum Statement Grades R-12 (January 2012)* during the period 2012-2014:

(i) The Learning Area/Subject Statements, Learning Programme Guidelines and Subject Assessment Guidelines for Grades R-9 and Grades 10-12;

(ii) The policy document, National Policy on assessment and qualifications for schools in the General

Education and Training Band, promulgated in Government Notice No. 124 in Government Gazette No. 29626 of 12 February 2007;

(iii) The policy document, the National Senior Certificate: A qualification at Level 4 on the National Qualifications Framework (NQF), promulgated in Government Gazette No.27819 of 20 July 2005;

(iv) The policy document, An addendum to the policy document, the National Senior Certificate: A qualification at Level 4 on the National Qualifications Framework (NQF), regarding learners with special needs, published in Government Gazette, No.29466 of 11 December 2006, is incorporated in the policy document, National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R-12; and

(v) The policy document, An addendum to the policy document, the National Senior Certificate: A qualification at Level 4 on the National Qualifications Framework (NQF), regarding the National Protocol for Assessment (Grades R-12), promulgated in Government Notice No.1267 in Government Gazette No. 29467 of 11 December 2006.

(d) The policy document, *National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R-12*, and the sections on the Curriculum and Assessment Policy as contemplated in Chapters 2, 3 and 4 of this document constitute the norms and standards of the *National Curriculum Statement Grades R-12.* It will therefore, in terms of *section 6A* of the *South African Schools Act, 1996 (Act No. 84 of 1996,)* form the basis for the Minister of Basic Education to determine minimum outcomes and standards, as well as the processes and procedures for the assessment of learner achievement to be applicable to public and independent schools.

1.3 General aims of the South African Curriculum

(a) The *National Curriculum Statement Grades R-12* gives expression to the knowledge, skills and values worth learning in South African schools. This curriculum aims to ensure that children acquire and apply knowledge and skills in ways that are meaningful to their own lives. In this regard, the curriculum promotes knowledge in local contexts, while being sensitive to global imperatives.

(b) The National Curriculum Statement Grades R-12 serves the purposes of:

- equipping learners, irrespective of their socio-economic background, race, gender, physical ability or intellectual ability, with the knowledge, skills and values necessary for self-fulfilment, and meaningful participation in society as citizens of a free country;
- providing access to higher education;
- facilitating the transition of learners from education institutions to the workplace; and
- providing employers with a sufficient profile of a learner’s competences.

(c) The National Curriculum Statement Grades R-12 is based on the following principles:

- social transformation: ensuring that the educational imbalances of the past are redressed, and that equal educational opportunities are provided for all sections of the population;
- active and critical learning: encouraging an active and critical approach to learning, rather than rote and uncritical learning of given truths;

- high knowledge and high skills: the minimum standards of knowledge and skills to be achieved at each grade are specified and set high, achievable standards in all subjects;
- progression: content and context of each grade shows progression from simple to complex;
- human rights, inclusivity, environmental and social justice: infusing the principles and practices of social and environmental justice and human rights as defined in the Constitution of the Republic of South Africa. The National Curriculum Statement Grades R-12 is sensitive to issues of diversity such as poverty, inequality, race, gender, language, age, disability and other factors;
- valuing indigenous knowledge systems: acknowledging the rich history and heritage of this country as important contributors to nurturing the values contained in the Constitution; and
- credibility, quality and efficiency: providing an education that is comparable in quality, breadth and depth to those of other countries.

(d) The National Curriculum Statement Grades R-12 aims to produce learners that are able to:

- identify and solve problems and make decisions using critical and creative thinking;
- work effectively as individuals and with others as members of a team;
- organise and manage themselves and their activities responsibly and effectively;
- collect, analyse, organise and critically evaluate information;
- communicate effectively using visual, symbolic and/or language skills in various modes;
- use science and technology effectively and critically showing responsibility towards the environment and the health of others; and
- demonstrate an understanding of the world as a set of related systems by recognising that problem solving contexts do not exist in isolation.

(e) Inclusivity should become a central part of the organisation, planning and teaching at each school. This can only happen if all teachers have a sound understanding of how to recognise and address barriers to learning, and how to plan for diversity.

The key to managing inclusivity is ensuring that barriers are identified and addressed by all the relevant support structures within the school community, including teachers, District-Based Support Teams, Institutional-Level Support Teams, parents and Special Schools as Resource Centres. To address barriers in the classroom, teachers should use various curriculum differentiation strategies such as those included in the Department of Basic Education's *Guidelines for Inclusive Teaching and Learning* (2010).

1.4 Time allocation

1.4.1 Foundation Phase

(a) The instructional time in the Foundation Phase is as follows:

Subject	Grade R (Hours)	Grades 1-2 (Hours)	Grade 3 (Hours)
Home Language	10	8/7	8/7
First Additional Language		2/3	3/4
Mathematics	7	7	7
Life Skills Beginning Knowledge Creative Arts Physical Education Personal and Social Well-being	**6** (1) (2) (2) (1)	**6** (1) (2) (2) (1)	**7** (2) (2) (2) (1)
Total	**23**	**23**	**25**

(b) Instructional time for Grades R, 1 and 2 is 23 hours and for Grade 3 is 25 hours.

(c) Ten hours are allocated for languages in Grades R-2 and 11 hours in Grade 3. A maximum of 8 hours and a minimum of 7 hours are allocated for Home Language and a minimum of 2 hours and a maximum of 3 hours for Additional Language in Grades 1-2. In Grade 3 a maximum of 8 hours and a minimum of 7 hours are allocated for Home Language and a minimum of 3 hours and a maximum of 4 hours for First Additional Language.

(d) In Life Skills Beginning Knowledge is allocated 1 hour in Grades R-2 and 2 hours as indicated by the hours in brackets for Grade 3.

1.4.2 Intermediate Phase

(a) The instructional time in the Intermediate Phase is as follows:

Subject	Hours
Home Language	6
First Additional Language	5
Mathematics	6
Natural Sciences and Technology	3,5
Social Sciences	3
Life Skills Creative Arts Physical Education Personal and Social Well-being	**4** (1,5) (1) (1,5)
Total	**27,5**

1.4.3 Senior Phase

(a) The instructional time in the Senior Phase is as follows:

Subject	Hours
Home Language	5
First Additional Language	4
Mathematics	4,5
Natural Sciences	3
Social Sciences	3
Technology	2
Economic Management Sciences	2
Life Orientation	2
Creative Arts	2
Total	**27,5**

1.4.4 Grades 10-12

(a) The instructional time in Grades 10-12 is as follows:

Subject	Time Allocation per Week (Hours)
Home Language	**4.5**
First Additional Language	**4.5**
Mathematics	**4.5**
Life Orientation	**2**
A minimum of any three subjects selected from **Group B 1** Annexure B, Tables B1-B8 of the policy document, *National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R-12,* subject to the provisos stipulated in paragraph 28 of the said policy document.	**12 (3x4h)**
Total	**27,5**

The allocated time per week may be utilised only for the minimum required NCS subjects as specified above, and may not be used for any additional subjects added to the list of minimum subjects. Should a learner wish to offer additional subjects, additional time must be allocated for the offering of these subjects.

SECTION 2: INTRODUCTION TO MARINE SCIENCES

2.1 Background

Humans become fascinated with the sea from their very first connection, be that seeing sharks, rays and fish in the kelp forests at an aquarium, or the first salty taste of sea water, and the feeling of cobble stones or the textured sand beneath one's feet. Once introduced to the ocean, people immediately recognise the strong connection to and influence that the ocean has on them. The ocean can be a source of extremes, from gentle calm conditions to threateningly stormy seas.

It can come as a surprise to learn that seventy percent of our planet is covered by water. It is the habitat to countless known and undiscovered species of plants and animals. The sea contains natural resources that are of interest and value to humans, but human activity invariably affects sensitive habitats that are home to thousands of species- places where delicate balances should be maintained.

Earth's weather and climate is also strongly influenced by the sea as moisture and heat energy are transferred from water to bodies of air that then circulate around the world producing weather events which range in extremes from tropical storms to doldrum sea states, where no winds blow. At one point in time all land – and the ancestors of all life as we know it - was submerged by our planet's sea water. The ocean basins contain forceful geological processes which cause the movement of mountains and continents! Powerful forces are present in waves and currents that have given rise to names such as Namibia's Skeleton Coast; and South Africa's Wild Coast and the Cape of Storms.

Humans have many varied bonds with the ocean. Seafood has been a source of sustenance from earliest times – indeed it is thought that the quality proteins that came from eating food from the sea provided a push to human mental development. The ocean has been a means of travelling, exploration and trade since very early times as people discovered how to use ocean currents and trade winds to increase the efficiency of their travel. The impact of the sea on the spiritual life of people who have lived by, from and on the sea made its presence central to their understanding of the world and their own identities. The ocean contributes valuably to the provision of food, mineral resources, transport, trade, tourism, recreation and inspiration. Marine environments are a key element of the South African economy and require effective management. This has been recognised by the implementing of Operation Phakisa to contribute to the South African Blue Economy.

However, humans have also affected the ocean significantly since the start of the Industrial Revolution, with resulting ocean acidification, climate change, coral bleaching, over-harvesting of sea-life such as abalone and fish caught by line off the South African coast, and sometimes excessive or careless mining and transportation of minerals and oil which can cause total destruction of marine environments as was the case with the *Treasure* oil spill off Robben Island in July 2000.

The increase of human population has placed unprecedented pressure on resources above and below sea level. Students of Marine Sciences will become aware of the ocean's influences on humans and humans' influences on the oceans. The Marine Sciences Curriculum is designed to develop a sense of belonging and commitment to the oceanic environment among Marine Sciences students in the FET Phase in order to help develop informed global citizens, who act in accordance with scientifically-substantiated decisions and contribute to the health of our planet's oceans as future scientists, journalists, teachers or specialists informing governmental policies.

Amongst scientists and teachers with a passion for the oceans of the world the idea of 'Ocean Literacy' is being shared as a way of raising all people's consciousness of the impact we are having on the sea and the life above, on and in it. This approach is guided by ideas from around the world (including South Africa) and is facilitated by the National Marine Educators Association of America. Teachers of Marine Sciences agree that all people should understand seven essential principles about the ocean:

1. The earth has one big ocean with many features.
2. The ocean and life in the ocean shape the features of earth.
3. The ocean is a major influence on weather and climate.
4. The ocean made earth habitable.
5. The ocean supports a great diversity of life and ecosystems.
6. The ocean and humans are inextricably interconnected.
7. The ocean is largely unexplored.

A focus of this Marine Sciences course is therefore to nurture citizens, who can communicate about the ocean in a meaningful way and make informed decisions about the ocean and the wise use of its resources.

To become successful in any ocean-related career, students need to be aware of the fragility of our planet, our dependence on the ocean, its beauty and value. Climate change is a threat that needs to be understood and minimised, especially with regard to food security given Africa's increasing human population.

2.2 What is Marine Sciences?

Marine Sciences is an inter-disciplinary subject designed to educate learners with an interest in the ocean, its workings and its impact on the life of the planet and human populations so that they are able to recognise and want to take up the work- and study opportunities associated with the marine environment.

The content within Marine Sciences is woven together to form a multidisciplinary field. It builds connections between the realms of water, sediments, rocks and air, living organisms that inhabit the ocean and human engagements with all of these. It draws attention to ocean ecosystems and their sensitivity to human activity and resource use. Decision makers and the general public need an increased awareness about the complex relationships that affect the ocean. The course will equip learners with a thorough understanding, to think about ways to conserve and sustain the ocean for the future and is informed by four strands,:

1. **Oceanography including Marine Geology, Geography, Chemistry and Physics** that explains
   - the sea floor and sediments together with the structure and origins of coastlines and how these change over time.
   - the chemical composition and properties of sea water, and the effects of pollutants on ocean life.
   - the ways in which the ocean acts as a driver of weather and climate.
   - the waves, tides and currents,
2. **Marine Biology** investigates the classification, fundamental biology, evolutionary processes, marine biodiversity and the adaptation of organisms to their environments.
3. **Ecology** explores ecosystems such as rocky shores, kelp forests and sandy beaches through ecological concepts including nutrient cycles and food chains.
4. **Humans and the Ocean** highlights
   - marine careers,
   - Marine Protected Areas as a model for sustainably managing ocean resources.
   - the harvesting of renewable and use of non-renewable ocean resources
   - the importance of research in understanding the ocean and the effects that human activities and practices have on the ocean and larger global patterns (for example Climate Change and Ocean Acidification).

The issue of sustainability is foregrounded in the teaching of the entire subject.

All four strands are to be taught in each school term. This approach facilitates the possibility of more than one teacher teaching the subject in a school year. For example, the subject lends itself to being taught by a Life Sciences/ Biology teacher who would teach the Marine Biology component and an Oceanography/Geography teacher who would teach the Oceanography, Ecology and Humans & the Ocean content. Each strand increases in complexity over the three FET years which are scaffolded from one tier to another.

The four strands are unpacked in detail in Section 3 where the planning across grades 10 to 12 is shown, with suggested time allocations given per topic. The table below summarises the distribution of hours across the strands and the three Grades.

Strands	**Weighting by time allocation across grades (Hours)**		
	Grade 10	**Grade 11**	**Grade 12**
Oceanography	**32**	**14**	**30**
Marine Biology	**56**	**56**	**25 **(+6)**
Ecology	**8**	**16**	**5 **(+12)**
Humans and the Ocean	**14**	**16**	**17 ** (+8)**

** Includes the hours taught in Gr11 4th Quarter and included in the Gr12 final Examination.

2.3 The Purpose of studying Marine Sciences

The purpose of studying Marine Sciences is three-fold. The intention is that learners of the subject will acquire and be able to use the following large conceptual abilities. They will be able to:

2.3.1 Apply the scientific method to develop an understanding of Marine Sciences content

All science courses should train learners that unsubstantiated information cannot simply be taken as fact. As learners engage with the Marine Sciences content, so scientific thinking develops alongside the skills that help to formulate the basis for an inquiry or experimentation. Consequently, learners gradually recognise the need to use evidence, evaluate the validity of data and learn to be able to formulate inferences from the information available.

These activities build upon our conceptual understanding in improving our scientific conceptualisation. Teachers should facilitate learners' development of the thinking and reasoning skills which are required to support the formation and the modification of concepts and theories about the natural world.

2.3.2 Develop science process skills

A key purpose of teaching Marine Sciences is to induct learners into using process skills in their investigations as they explore and engage with the ocean and its phenomena. The scientific process includes an incremental development of thoughts and perspectives by:

- **defining a problem** which learners have **observed** in a marine context
- **undertaking further observations**
- **reading** about the topic to better inform themselves in **formulating a hypothesis**
- **investigating** the hypothesis via **experimentation**
- using the **data collected** from the experiments to develop **conclusion/s** and **generalisation/s**
- which **prove or disprove** the hypothesis.

Using Marine Sciences content, teachers must create a supportive environment where the learners themselves exercise their intelligence, creativity and responsibility with increasing confidence. Learners need to develop the ability to analyse and reason but also to use process skills to investigate, reflect on, synthesise findings and communicate their conclusions.

The focus with regard to process skills is on conducting a scientific rather than a casual investigation.

2.3.3 Understand the role of science in society

The study of science is often perceived as being remote from everyday human existence. However, within the study of a subject such as Marine Sciences, learners will soon recognise that the ocean impacts on the lives of humans. The study of Marine Sciences alerts learners to the social, political and economic impacts that decisions regarding the ocean have. In this fashion, learners come to recognise the critical role that Marine Sciences must play in informing us about our engagement with our ocean planet.

The fact that oceans influence humans and humans influence the oceans, is undisputed. Marine Sciences learning, by its nature occurs in a social setting, apart from the historical association with seafood harvesting and the ocean as a transport medium, the relationship between humans and the oceans is inextricably connected. Any study of science should have a purpose and an outcome of developing critical thinking skills about scientific concepts. Marine Sciences should be taught in a way in which learners become aware of the sensitive nature of ocean ecosystems, ocean life and ocean resources, and the need for humans to utilise the oceans in a way that minimises human impacts.

Each of these major purposes presupposes a set of skills, values, and attitudes which are acquired concurrently with content outlined in Section 3. These are more fully described in Section 2.5

2.4 General Aims

The general aims of Marine Sciences are to:

a. Foster a deep interest in and enjoyment of the scientific study of the ocean.
b. Provide opportunities for learners to acquire knowledge, understanding and appreciation of the marine environment.
c. Develop thinking and process skills that form part of natural arouse curiosity and investigations about the natural world, nurture creativity and the use of scientific method.
d. Develop attitudes such as perseverance and objectivity for the meaningful and ethical pursuit of science/knowledge/learning.
e. Communicate effectively in a variety of ways and using different media on matters related to the study of Marine Science.
f. Stimulate interest in and care for the South African and global environment and understand that, used responsibly, science can contribute to meaningful social, economic and political participation.
g. Offer educational opportunities that allow learners to gain sufficient understanding, knowledge and confidence to become responsible citizens who are able to take an informed interest in matters of scientific importance.

This set of aims are translated into the more focused specific aims or outcomes which explain what successful Marine Sciences learners ought to know and be able to demonstrate through performance

2.5 Specific Aims

The four specific aims serve the three 'big picture' purposes for the Marine Sciences. The specific aims describe the ***skills*** that learners can be expected to acquire during their study. These skills are used to engage with the multi-disciplinary content detailed in Section 3.

The specific aims for Marine Sciences are:

2.5.1. Increase learners' understanding of core Marine Sciences knowledge

By the end of the programme, learners will be able to:

a. **Read information critically** considering the possibility of authorial bias in that the author may be presenting an *opinion* about a topic rather than a set of unsubstantiated ideas.

b. **Access information** from a variety of sources such as reference books, textbooks, online articles, You-Tube videos, the opinions of experts, community members and peer views.
c. **Select the most relevant information** for the immediate task(s) and note any significant anomalies
d. **Distinguish** between facts, assertions, assumptions, hypotheses, theories, predictions and inferences in the texts they encounter; recognise in their own study what assumptions they make, when they are drawing inferences.
e. **Summarise information** and show evidence of an accurate synopsis in a variety of formats such as – a written summary that refers to and includes tables, graphs, flow charts and similar graphic representations.
f. **Present** the information in a format that communicates to a wide audience, which could be a written text, a verbal presentation accompanied by slides, a group activity that illustrates the understanding of new content and its relation to prior knowledge and insight. Such processes will rely on the **recall** of information, and the accurate **description** of concepts, processes, mechanisms, principles, theories.
g. **Understand the structure and style** used in scientific reports.
h. **Acknowledge their sources** accurately and reliably.
i. **Understand that plagiarism is deeply dishonest** and will give rise to disciplinary action.

2.5.2. Observe and record meticulously so that investigations lead to reputable scientific conclusions and generalisations

By the end of the programme, learners will be able to:

a. **use the language of science**, its terminology and vocabulary and its discourse.
b. **describe the nature of science** as a reliable way of explaining patterns observed in the natural world.
c. **describe the purpose of science** and develop explanatory theories that account for events in the natural world. This is done through a careful and systematic study of natural phenomena, and being aware that from time to time a revolution in thinking and a paradigm shift is needed
d. **describe the use of a controlled experiment** as a way of collecting rigorous evidence using an experiment and a control; the use of dependent, independent and controlled variables
e. **identify an issue/problem to investigate** and consider possible solutions before selecting a plausible hypothesis to test through an experiment.
f. **Work collaboratively with others** but also on their own.
g. **Explain the importance of data collection** as intrinsic to the scientific method, and undertake their own collection of data.
h. **Explain the importance of recording data accurately**, whether in the forms of measurements, written descriptions, photographs, drawings or diagrams, and undertake the recording of data.
i. **Explain how the analysis of patterns in data allow for inferences** to be made and actively seek for patterns in the data that the learner has collected.
j. Explain the need to **avoid bias and to strive for objectivity** in collecting and interpreting data and how science uses both deductive and inductive reasoning to advance understanding the natural world.
k. **Explain the value of science** in forming ever-deeper understanding of natural phenomena and its role in predicting and/or anticipating future states or events.

2.5.3. Understand the importance of making defensible scientifically-informed decisions to limit human impact on marine ecosystems

By the end of the programme, learners will be able to:

a. Describe instances where poor management decisions may have impacted on an ecosystem
b. Explain the variables that are known to negatively impact upon an ecosystem
c. Suggest strategies which would help remediate the disaster or similar disasters
d. Research a current issue in the marine environment where a decision is in danger of impacting negatively on an ecosystem, analyse the problems that are likely to emerge and present the findings
e. Recommend one or more alternative proposals that would address the issue in a less harmful way.

2.5.4 Understand and appreciate the historical- and present-day discoveries in the Marine Sciences field, and to recognise the connections between indigenous knowledge of the oceans and current scientific explanations;

By the end of the programme, learners will be able to:

f. Understand the history of ocean discoveries from early records to the recent past in which technological development since the early 1900s paved the way from piano wire depth "sounding" to sonar and satellite recording of oceanographic data.
g. Explain how different cultures and their languages organise the understanding of phenomena coherently but differently (eg colour, number, animal classes), and how such categorizations may bring different insights to the study of the natural world
h. Explain the value which such alternative classifications can/do offer the study of science.

2.6 Attitudes and Values

The general aims for the Marine Sciences have alluded to some of the attitudes and values built in to the curriculum. They are:

a. An understanding of science and how it develops over time is invaluable to learners as global citizens.
b. As learners understand the ocean's influence on their lives and human influence on the ocean, they are made aware of interspecies equity
c. Marine Sciences is best learned in enabling learning environments, as oppose to a context that depends upon memorization and recall. Such an educational environment encourages learners to participate actively in the learning process, to identify problems, seek solutions – often with others, to plan and be able to implement plans of action.
d. The learning in Marine Sciences encourages learners to manage their learning process; to value and rely on their own creativity and ability to persevere, and to work ethically.
e. A high value is placed on the ability to communicate what one is learning – in both formal and informal contexts,
f. The subject, Marine Sciences, proceeds on the basis that each person increasingly understands the need for responsible engagement with the ocean (locally and globally) and is willing to act responsibly based on such insight/s.
g. The importance of critical, logical thinking and of self-reflection stems not only from the demands of the subject but also from the fact that these skills are needed for learners to become responsible, thinking citizens.

2.7 Time Allocation

The time allocated to Marine Sciences is 4 hours per week, in Grades 10 to 12. The curriculum has been designed to be completed within the weeks shown in the table below. Gr10 and Gr 11 requires 4 hours in 32 weeks out of 40 weeks in the school year. This leaves 8 weeks for examinations, tests and disruptions due to other school activities. The curriculum for **Grade 12** has been designed to be completed within 27½ weeks; this leaves 12½ weeks for examinations, tests and disruptions due to other school activities. In Grades 10 to 12 the time allocated for teaching the content **includes practical tasks and investigations, which are integral to the teaching and learning process.**

	Weeks of Teaching		
	Grade 10	Grade 11	Grade 12
Teaching content includes practical tasks, field work and investigations, which are integral to the teaching and learning process	32	32	27½
Exams, tests, other school activities	8	8	12½
Total	40	40	40

2.8 Resources

In Section 3, the resources needed for teaching each topic appear in the right-hand column. This information helps guide teachers with planning and preparation. The Marine Sciences teaching and learning resources include both digital and practical equipment.

Marine Sciences has been designed with the use of digital teaching and learning resource materials. The resources will be electronically circulated to schools that offer Marine Sciences by Two Oceans Aquarium on storage drives. A paperless (digital) approach is promoted to reduce the carbon footprint and to facilitate updating material via the Two Oceans Aquarium's website. Equipment will be circulated on loan as part of the "Two Oceans Aquarium Equipment Library". Teachers must refer to Branch G; The Living Shores of Southern Africa 2018. The on line resources explain the specific depth at which the content is to be taught. Continuous professional development teacher workshops will be arranged to enable Marine Sciences teachers to optimally use each resource. This will include "Skype Mentoring" of teachers by the Two Oceans Aquarium.

SECTION 3: CONTENT CONCEPT AND PROGRESSION

NOTE TO TEACHERS

1. The different colours presented in the table of topics have specific reference to the following strands :

Marine Biology
Humans and the Oceans
Oceanography
Ecology

2. When using the teaching plan, pay particular attention to the depth column. It guides the level of detail that needs to be applied to each specific topic. The depth of content will be covered more fully in the resource material which will be provided.
3. To navigate through Section 3 please note
   a. It is firstly divided into Gr 10 then Gr 11 and then Gr12. It is not in the order which would be found in Oceanography or Marine Biology Text books.
   b. Each grade has a fairly equal spread between Oceanography; Marine Ecology and Humans and the Oceans, while Marine Biology is allocated more time than the rest.
   c. The Subject Marine Sciences consists of topics numbered in this section from 1 to 86.
   d. At the top of each topic page is the
      i. Topic Number and name
      ii. The recommended term in which it should be taught
      iii. The number of recommended hours which should be taken to teach the topic.
      iv. The Depth, indicating level of detail.
      v. The Key Content Concepts
      vi. Suggested practicals and investigations and
      vii. Resources, which can be referred to.

3.3. Marine Sciences: Concept and Progression

Marine Sciences: Concept and Progression Gr 10

Topic No	Grade 10 Term 1	Hours
1	Introduction to Marine Sciences	2
2	Scientific Inquiry	6
3	History of Marine Sciences Research and Ocean Discovery	1
4	Life Processes and the Chemistry of Life	5
5	Cell Biology	12
6	Origin of Planet Earth	1
7	Interior of the Earth	2
8	Geological time	1
	Hours Term 1 Gr 10	30
	Grade 10 Term 2	
9	Topography of the Ocean Floor and Ocean Basins	2
10	Plate tectonics	2
11	The Ocean Planet - Physical Properties of Water	8
12	Energy Transmission in Water- Heat	2
13	Energy Transmission in Water- Light and Light Absorption	2
14	Introduction to Evolution and Evolution Mechanisms	4
15	Basic Classification	1
16	Evolutionary trends, Body plans, symmetry and life patterns	5
17	Plankton	1
18	Protists	3
	Hours Term 2 Gr 10	30

	Grade 10 Term 3	
19	Tides	1
20	Salinity	2
21	The Atmosphere	2
22	Air Movement on the Earth's surface	3
23	Chart work– Location Systems and the Shape of Earth	4
24	Ecological concepts introduction and Nutrient Cycling C N P	4
25	Porifera	4
26	Cnidaria- Introduction and Cnidarian classes	6
27	Platyhelminthes	3
	Hours Term 3 Gr 10	29
	Grade 10 Term 4	
28	Other unsegmented worms	2
29	Annelida and Annelid groups	4
30	Arthropoda- Introduction and Marine Arthropod groups	6
31	Human Impacts upon Ocean Biodiversity (HIPPO)	5
	Hours Term 4 Gr 10	17

Marine Sciences: Concept and Progression Gr 11

	Grade 11	
	Grade 11 Term 1	**Hours**
32	**Marine Careers**	**4**
33	**Scientific Inquiry**	**2**
34	**Sediments**	**2**
35	**Harvesting of Marine Resources**	**2**
36	**Important Metabolic Processes**	**8**
37	**Nucleic Acids- DNA and RNA**	**5**
38	**Cell Division**	**5**
	Hours Term 1 Gr 11	**28**
	Grade 11 Term 2	
39	**The Ocean Planet – The Chemistry of Sea Water**	**6**
40	**Energy Transmission through Water- Sound**	**2**
41	**pH**	**2**
42	**Currents**	**2**
43	**Genetics**	**5**
44	**Viruses and Bacteria**	**2**
45	**Cyanobacteria Phytoplankton (Microalgae)**	**3**
46	**Seaweeds (Macroalgae) - Introduction Green and Red**	**7**
	Hours Term 2 Gr 11	**29**

	Grade 11	
	Grade 11 Term 3	**Hours**
47	**Brown Algae- *Chromista***	2
48	**Vascular plants**	2
49	**Mollusca and Mollusc Classes**	**7**
50	**Animals Marine Life cycles Larvae**	1
51	**Bryozoa**	1
52	**Population Dynamics**	4
53	**South African Marine Ecosystems**	2
54	**The Open Ocean**	2
55	**Shores Introduction**	8
	Hours Term 3 Gr 11	**29**
	Grade 11 Term 4	
55	**Rocky Shores continued and Sandy Beaches**	4
56	**Echinoderms and Echinoderm classes**	6
57	**Human Exploitation of Marine Resources and Indigenous Knowledge**	2
58	**Over Fishing and SASSI**	2
59	**Marine Protected Areas**	2
60	**Ecotourism**	4
	Hours Term 4 Gr 11	**18**

Marine Sciences: Concept and Progression Gr 12

	Grade 12	
	Grade 12 Term 1	**Hours**
61	Diving Science Water Gas laws	2
62	Estuaries	3
63	Chordata Urochordata	2
64	Vertebrate Introduction	1
65	Agnatha	1
66	Chondrichthyes	5
67	Osteicthyes	5
68	Terrestrial Vertebrate Classes and Returning to the Sea	2
69	Marine Reptiles	3
70	Marine Birds	3
71	Marine Mammals	3
	Hours Term 1 Gr 12	30
	Grade 12 Term 2	
72	Kelp Forests	2
73	Waves; Energy transfer	4
74	Chemical composition of water	4
75	Ekman Spiral and Eddies	4
76	Scientific Inquiry Gr12 (Prescribed Practical Work)	9
77	SA Shoreline	2
78	Coastal Formations	2
79	Climate Change	2
80	Ocean Acidification	1
	Hours Term 2 Gr 12	30

	Grade 12 Term 3	Hours
81	El Niño	3
82	Aquaculture of Marine Species	4
83	Commercial use of Marine Algae	3
84	Harvesting Ocean Energy	4
85	Biomimicry	3
	Hours Term 3 Gr 12	17

	Grade 12 Term 4	
	Revision and Preparation for the Final Exam	
	Final Examination	

Section 3.1 Grade 10

1. Introduction to Marine Sciences

Term 1		Strand – Humans and the Ocean		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 Hours	**The Depth of this topic is at a level where learners understand the range of careers. This topic ideally suited for a project. An introduction and a cursory summary should inspire learners to be committed to applying themselves in this course.**	1. Marine Sciences is a wide field in which many different specialties focus on a common goal of understanding the ocean. This includes studies in Geology, Geography, Chemistry, Geophysics, Meteorology, Botany, Zoology, Ecology, Conservation Biology, Natural and Environmental Resource Management, and Engineering Sciences. In South Africa, **one must study Maths and Physical Sciences to matriculation level, and complete at least a half course in each of these subjects at university level, in order to** to perform adequately in any of the above fields. 2. **Geological** Oceanography includes the study of the coastline, the structure of the seafloor, the processes in which the ocean basin features developed, and the history of the sediments found. 3. **Physical Oceanography** studies the physics of **water**. This refers to the causes and characteristics of water movement such as currents, waves and tides. 4. **Chemical** Oceanography is the study of the composition of water – which illustrates some of its history, its processes and its interactions. 5. Marine **Meteorology** is the study of heat transfer and water cycles, as well as ocean-atmosphere relationships. 6. **Marine Biology** is the study of the variety of ocean life forms, their evolutionary adaptations, their relationships to one another, and the ecosystems in which they are found. 7. Other specialisations include Physics, the development of Marine Management Policy, Law, Ocean Engineering (related to structures used in the ocean), and Marine Archaeology. 8. Each marine discipline integrates with the others, making Marine Sciences an ideal subject for teaching interdisciplinary skills. 9. The field informs human interactions with the oceans; these interactions range from resource extraction (minerals, oil or gas) to fisheries. Marine Sciences also guides the sustainable use of these resources, the development of marine protected areas, and the non-consumptive use of the ocean. **Introduction to Careers in Marine Sciences** 10. A range of marine careers exist: marine biologist, marine geologist, environmental educator, sedimentologist, marine and coastal engineer, coastal zone manager, marine architect, ship designer, nature conservation professional, aquaculturist, marine-tourism, and fisheries scientist. **Ocean Exploration: Marine Sciences Careers** 11. The exploration of the ocean contributes to the sustainable future economic potential of coastal areas and associated employment opportunities. Such opportunities are related to the extraction of minerals and resources, either living or non-living, from the ocean. 12. Examples should be presented on how the ocean is explored, what equipment is used by South African researchers, and deep sea exploration vehicles used elsewhere – such as submarine research vessels.	Use a structured approach to introduce the equipment used, data received, and how these apply to the scientific method Investigate tertiary institutions that offer Marine Sciences and what subjects are required by each Visit DAF or DEA research institutions such as the various aquariums Equipment and methods used by oceanographers	Videos A range of websites Brochures from Marine Sciences departments at universities

		13. Discuss other equipment and methods used by oceanographers (e.g. CTD, XBT, Argo floats, ocean gliders, marine animal CTD, moorings, and satellite remote sensing). 14. For school projects, simple apparatus should be regularly. This could include a surface sampling bottle, **Van Doorn bottle** (for collecting water samples), **thermometer**, **refractometer, pH meter, Secchi disks, Ekman bottom grab sampler, Quadrats, and tape measures** for transects to measure plants and animals on the shore. Students should be able to use this equipment for science expo poster projects. Practical work can be done at a local Marine Sciences centre such as an Aquarium Education Centre.		

2. Scientific Inquiry

Terms 1		Strand – Humans and the Ocean		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
6 hours	**The Scientific Method should be thoroughly discussed in this grade. Learners must have a thorough understanding of the key concepts and how to apply the scientific method to their own research.**	*This section provides the basis for the students to develop a Marine Sciences project that demonstrates their skills in applying the Marine Sciences curriculum. As scientists-to-be, students need to practise observing, inquiring, investigating, and researching the natural world. It is here that Marine Sciences as a curriculum subject comes into its own. The oceans are filled with beauty, fascinating elements and intriguing occurrences. The Marine Sciences project is the opportunity for a teacher to engender passion for the oceans among Marine Sciences students.* **The Scientific Method** 1. **Conducting an investigation** – one conducts an investigation by collecting evidence from a variety of sources, developing an explanation based on the data, and communicating and defending one's conclusions. 2. **Method** – the scientific method requires questions leading to a hypothesis that can tested by observations, in turn leading to conclusions. 3. A **theory** is proposed on the basis of evidence obtained from research conducted. **Science Process Skills** 1. **Observe** – use all the senses. 2. **Question and hypothesise** – a hypothesis is a tentative explanation about possible causes or dynamics of a phenomenon. 3. **Predict** – scientific predictions are based on observations, measurements, and relationships between observed variables. 4. **Use the right terminology** – all procedures and reporting are vitally dependent on the precise use of terms. 5. **Define variables** – identify and distinguish between variables that are controlled (held constant) and those which are manipulated. a. **Independent (manipulated) variable** – the measurement or condition that is regulated by the person doing the experiment. b. **Dependent (responding) variable** – what you measure and observe in response to changes in the independent variable. c. **Controlled (fixed) variable –** these refer to conditions that must be kept the same (held constant) in order to isolate the result; a controlled variable has the potential to vary but is deliberately restricted. 6. **Perform experiment.** 7. **Record results.** 8. **Analyse results.** 9. **Draw conclusions.** 10. **Produce a research report and poster** – the report should include Introduction, Hypothesis, Method, Results, Discussion, and Conclusion. **Research Skills** 1. Classify – group related objects and ideas together. 2. Quantify – use numbers and measurements related to time, length, width, volume and ratio.	Observation Hypothesis testing Theory and truth Problem statement (initial inquiry) Hypothesis (allows for predictions) Experimental design (materials and procedure) Data collection (observations and measurements) Analysis and interpretation of data or results (inferences) Drawing conclusions (answering the research question or problem) Have we proved or disproved the hypothesis? Extension (further inquiry – pose new questions that are related to the original question and can lead to new investigations)	**A range of equipment can be used for this practical work; for example, transects, Secchi disks, and water sampling equipment**

		3. Communicate results – describe verbally (text) or visually in tables and graphs. 4. Interpret, discuss data and draw conclusions – explain an observation. Please Note that the Scientific Inquiry is a central Purpose (see 2.3) of this curriculum and should influence each of the topics. Although listed as a topic here it should be referred to on an ongoing basis as informing the approach to the curriculum.		

3. History of Marine Sciences Research and Ocean Discovery

Term 1		Strand – Humans and the Ocean		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
1 hour	**A broad overview of understanding of South African Scientists to the Marine Sciences. The history of Marine Science discovery should encourage learners to make a contribution themselves in the future.**	**History of Marine Development of Sciences research techniques a brief overview** 1. The development of Marine Sciences exploration and techniques used to collect samples such as 2. “wax on a weight” to collect sea floor samples. 3. CTD water collection mechanisms. 4. sonar development in the earlier 20th Century 5. Oceanography research. Development of Sediment and Water sampling techniques. 6. Development of Satellite imaging. 7. Sonar and Sea floor mapping 8. Satellite imagery 9. Scuba equipment and submersible craft has made areas of the ocean more accessible for humans **The Development of Marine Biology as a field (A brief overview)** 10. Background and the development of this topic unfolds as the evolution of animals over time	Museums and the Dept. of Environmental Affairs ware house for the SA Agulhas . Talk by scientists at the school to indicate a marine sciences career and show the different equipment to the students	**A range of YouTube clips and resources are available in an Archaeology library and on the internet.** **George Branch ..Living Shores of Southern Africa**

4. Life Processes and Chemistry of life

Term 1		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
1 hour	**The Depth of this topic is at a level where learners understand processes in organisms for survival**	*Revision and introduction:* Define **Biology as the study of living things** Define living things as organisms **fulfilling the criteria for life (life processes);** that is: 1. **M**ovement 2. **R**espiration 3. **S**ensitive to external and internal stimuli 4. **G**rowth 5. **R**eproduction 6. **E**xcretion and other chemical and metabolic processes (and the organism is made up of cellular units governed by nucleic acids). 7. **N**utrition	Classify organisms into living and non-living	Charts Videos Acronym: MRS GREN

The Chemistry of life

Term 1		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	**The Depth of this topic is at a level where learners understand that living organisms depend on their environment (inorganic compounds) and elements from their environment to manufacture organic compounds.**	**Inorganic Compounds –** the main functions of: 1. **Water:** *mention functions in relation to structure* *2.* **Minerals**: Elements taken in as inorganic ions and needed in relatively small quantities, including Ca, Na, P, Mg, K, S and, in even smaller quantities, trace elements including Cu, Zn and Fe. *Mention some functions of these minerals. Stress the uptake of minerals as compounds and not elements. These are often also referred to as* ***nutrients*** *taken up by plants.* *Review briefly why these substances are needed in plants and animals (i.e. build on prior knowledge.) Do not give detail of structure or function – provide only a brief introduction to the molecular make-up of organisms.* **Organic Compounds** 1. **Organic** molecules are made up of C covalently bonded to other elements, almost always with H and, often, also O. Complex organic compounds have chains or rings of C atoms, with other elements bonded to them. (*The definition of organic compounds is not exact and some exceptions exist)* 2. Other elements involved include, but are not limited to, N and P. **3.** Cells are made up of and contain **proteins, carbohydrates, lipids, nucleic acids and vitamins.** 4. **Carbohydrates** – monosaccharides (single sugars such as glucose and fructose); disaccharides (double sugars such as sucrose and maltose); polysaccharides (many sugars, such as starch, cellulose and glycogen). Their functions in living organisms include providing a source of immediate energy; in plants, they also provide storage and structure. 5. **Lipids (fats and oils)** – 1 glycerol and 3 fatty acids. The structural characteristics lead to their functions in living organisms (eg energy storage, structural and temperature insulation). 6. **Proteins** – amino acids (C, H, O and N; some have P, S and Fe). The functions may be **structural, enzymatic, or in some cases hormonal**. Proteins are sensitive to temperature and pH, with a potential for loss of structure and function. *Discuss the role of enzymes in breaking down or synthesising molecules and the influence of temperature and pH on enzyme action.* 7. **Vitamins** – Description and general functions eg. fat soluble (A, D, E and K) or water soluble (vitamins B and C). 8. Mention **nucleic acids** DNA and RNA. *[Detail to follow Cell Biology section.]*	Practical investigations • Test for carbohydrates • Test for lipids • Test for proteins Homework research- The name and function of 2or3 each of water soluble and fat soluble Vitamins	Chemicals for food tests

5. Cell Biology

Term 1		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
12 hours	**Cell biology** **The Depth of this topic is at a level where learners understand** • **the foundational knowledge of the basic unit of life** • **to understand the basics of early evolution and** • **its relationship to various metabolic processes.**	**Molecular Constituents** Cells are mostly made up of proteins, carbohydrates, lipids, nucleic acids and water. Discuss the significance of true and colloidal solutions and suspensions inside cells. *(Briefly revise Grade 9 work on the cell.)* **Cell Structure and Function: The Roles of Organelles** **1. Cell membrane** - Encloses cell contents and enables transport (**fluid mosaic model).** Movement across membranes**- diffusion, osmosis and active transport; also** define **Isotonic, Hypertonic and Hypotonic** and implications in a marine environment. **2. Nucleus**- The control centre for cellular function and heredity. Chromatin material, nuclear membrane, nucleopores, nucleolus. Define **Prokaryotic and Eukaryotic**. **3. Cytoplasm** - storage and circulation of materials. **4. Endoplasmic reticulum** (rough and smooth) - transport systems; **5. Golgi body/ Dictyosome** - assembles secretions. **6. Vacuole**, lysosomes, vesicles - storage, digestion and osmoregulation **7. Ribosomes** - protein synthesis. **8. Mitochondria** - release energy during cell respiration. **9. Plastids**- **Chloroplast, Amyloplast/Leucoplast, Chromoplast-** production and storage of food and pigments. **10. Cell wall** - support structure in "plant" cells only. *Relate structure and location of organelles to their functions. Look at* ***detailed structure only of nucleus, mitochondrion and chloroplast****, so that this work can be referred to when dealing with cell division, respiration and photosynthesis.* ***Scale*** *and measurements at microscopic level should be explained and understood.* Multicellular organisms- Undifferentiated-tissues-organs-systems…	Study plant (onion epithelium) and animal (cheek) cells Use microscopes and stains; student to draw Experiment to demonstrate osmosis: • into hollowed-out potato or raisins • plasmolysis of onion epithelium Hay diffusion activity: find, identify and draw different cell types Use micrographs to study other organelles; establish how to calculate scale Practise calculations	Textbooks Charts Micrographs Microscope Slides Chemicals Electron micrographs (in textbooks) Transparent rulers Light microscopes Hay diffusion ID sheets Potato Onion

6. Origin of Planet Earth

Term 1		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
1 hour	**Origin of the Earth** **The Key Concepts explains the detail of the Origin of Planet Earth topic and gives the overview required to introduce the concepts.**	1. Modern theorists attribute the birth of the planet to a collapse of an interstellar cloud of gas and dust about 4.6 billion years ago. 2. The gas, dust and other matter were set spinning with increased speed, parallel to the axis of spin. In terms of earth's solar system, the sun (which is a star) was at the centre of that spinning 'disk'. 3. Self-sustaining nuclear reactions have kept the sun hot: the outer regions cooled, gasses collided and formed particles, and their gravity pulled other particles towards them. 4. In our solar system, the sun is orbited by eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. (Pluto is no longer described as a planet.) The planets have been divided into two groups, a warm group and a cold group. The four warm inner planets are rich in metals and rocky materials, and the four outer planets are called cold giants and mainly contain ice, ammonia and methane. 5. The early earth consisted of cold matter. This was bombarded by very large and small particles; on impact, a portion of their energy was converted to heat. The inner core temperature increased to 1000˚C. 6. Earth is currently dominated by water, but that has not always been the case. 7. The early earth was too small for an atmosphere to develop. Oxygen gas (O_2) could not accumulate in the atmosphere until more O_2 was produced than was absorbed into rocks and other compounds. 8. On planet earth, the ocean and atmosphere are by-products of heating and cooling processes. 9. Hydrogen (H_2) and oxygen (O_2) entered the earth's atmosphere locked in minerals, from rocks and minerals that bombarded the earth. Water was locked in the minerals in the form of hydrogen gas (H_2) and oxygen gas (O_2). As the earth heated and melted, water formed – initially in the form of vapour but eventually condensing to form the oceans. 10. Nitrogen is believed to have been brought into the earth and its atmosphere as nitrogen-bearing ice in meteorites and comets. 11. From a liquid "soup" organic molecules developed, resulting in the origin of simple chemosynthetic and photosynthetic cells. 12. Photosynthesis produced a greater volume of O_2 that was added to the atmosphere. 13. Later photosynthetic colonies, such as the stromatolites, converted more CO_2 to 0_2. 14. Earth is just the correct distance from the sun (not too hot, not too cold) for water to predominate in its liquid form, enabling life to flourish on the planet.	Discuss: Is Pluto a planet, and why is it not classed as a planet? Mars… was or is there any life on Mars?	Visit planetarium Videos on origin of the earth and plants Wall charts on evolution of earth National Geographic videos on the origin of the earth

7. Interior of the Earth

Term 1		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**Interior of the Earth** **The depth required in the Interior of the Earth is an overview and introduction of content for reproduction in diagrams or a paragraph description of the morphology of the inner structure of planet earth.**	1. The interior of the earth is studied by: a) Analysing the **material that is extruded** from the interior of the earth (eg from volcanoes). b) Recording and observing **shock waves** such as those produced by earthquakes; the refraction and reflection of these waves show that the interior of the earth is layered. The speed of the waves indicates the density and temperature variations of materials. Direction change (due to refraction or reflection) gives valuable information about the materials through which the waves are transmitted. c) Analysing **meteorite material** that has landed on earth. Scientists believe that this material is very similar to that found in inner layers of the earth. d) Studying stones from the earth – for example, olivine and pyroxene are similar to the earth's lithosphere, and the metals iron and nickel are similar to the inner core. 2. The earth's dimensions, density, rotation, gravity and magnetic field are used to determine the interior structures of the earth. 3. The earth is made up of a series of concentric layers: a) The **lithosphere** or crust is the solid outer layer, which reaches a depth of 60 km to 100 km. It is made up of various elements, including silicon, aluminium, calcium, magnesium, potassium and sodium. b) The m**antle is** a semi-fluid or "plastic-like" layer that is 2900 km below the surface and consists of silicate rocks with a high magnesium and iron content. Convection currents exist in this layer, where the intense heat causes molten rock to rise and sink again. This convection is the force behind tectonic plate movement and the force and material observed in a volcanic lava eruption. c) The **earth's core** consists of two parts – the liquid outer layer (2180 km thick) composed mainly of nickel–iron alloy; and the solid inner core with a 1200 km radius, composed mainly of iron and metals that have an affinity to combine with iron (eg nickel). A substantial amount of sulphur is found in the core. The inner core spins at a slightly faster rate than the earth's surface.	Draw a diagram to illustrate the interior of the earth. Label its parts inner core, mantle, and lithosphere	Videos Charts Sample rocks (eg igneous rock and granite)

8. Geological time

Term 1		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
1 hours	**Geological time** **The depth required in the Geological Time topic is for learners to conceptually understand the age of the planet and relate this to evolution and other paleo-references.**	1. Methods used by scientists to estimate the age of earth have included calculating – a) The time required for oceans to accumulate the current **concentrations of salt.** b) The time required for the **earth's rocks to cool.** c) Measuring **radio-active decay of rocks** in the crust (**radiometric** dating). 2. The earth is an active planet and therefore **none of the original rocks exist** for research to be conducted to determine the absolute accurate age of the planet. a) **Radio-active decay** is a method applied to date the age of rock samples that do exist. The oldest known crust sample (from Hudson Bay in North America) is 4.3 billion years old. b) The time taken for half the atoms of an isotope to decay from one element to another element is known as the half-life. The half-life is used by scientists to date materials in a process called **radiometric dating**. c) Using radiometric dating, scientists have studied rocks recovered from the moon; these were dated at 4.2 billion years old. Meteorites that survived entering the earth's atmosphere and were found on the earth's surface have been dated at 4.5 to 4.6 billion years old. 3. Scientists refer to **geological time** when dating materials and when referring to the history of the earth. 4. The principal divisions of geologic time are called eras: a) **Palaeozoic** era – era of ancient life b) **Mesozoic** era – era of intermediate life c) **Cenozoic** era – era of recent life. 5. Eras are subdivided into periods and epochs (these were initially determined by fossil disappearance, and periods have been further refined by radiometric dating).	Develop a timeline in table form See videos illustrating "Toilet Roll" – unrolled down a passage, with humans arriving only in the last square of the roll Compare geological time on a timeline Compare the earth's history to a 24-hour day, in which humans exist only as of 1 minute before midnight	Timeline printed as a wall chart for the back of the classroom

9. Topography of the Ocean Floor and Ocean Basins

Term 2		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	An overview is required with the understanding of the Topography of the Ocean Floor and Ocean Basins to give learners a frame of reference for understanding the sea floor context. Learners must be able to label a diagram of the features found on the ocean bed and have an understanding of the processes which led to their development.	**Topography of the Ocean Floor** 1. Early navigators measured the depth of the ocean to prevent ships running aground. **Ropes weighted** with lead weights were used. Grease or wax was placed on the weight to gather a sample of sediment from the ocean bottom. However, this method was inaccurate because the rope stretched. Later, **thin wire** was used for more accurate readings. Up to 8 hours were needed to winch that wire back before each reading was recorded. 2. This time-intensive method meant that prior to the introduction of sonar, only 7000 depth recordings existed. These were to a maximum depth of 2000 m. 3. From the **mid-1920s**, **echo sounding** revolutionised ocean-depth research. This led to the research of the mid-oceanic ridges, canyons (such as Fish River Canyon), mountain ranges (such as the edges of African Rift Valley) and flat plains (such as Serengeti). 4. **Radar** is a useful instrument for mapping the ocean floor. For accurate readings and measurements, researchers need to be aware of and take into account the variance caused by differences in temperature, salinity, level from tides, currents, and changes in atmospheric pressure. 5. Recently **satellites** have produced **maps of the ocean floor**. 6. Charts show that beneath the ocean surface we find similar shapes to the shapes found on land. 7. *Identify and **label diagrams** showing the following features:* a) Continental margins, continental shelf, a shelf break, a slope, a rise, and a submarine canyon b) Wave-cut terrace c) Continental margins d) Continental rise e) Abyssal plain and abyssal hill f) Seamount, guyot atolls and islands, and island arc g) A barrier reef and a fringing reef h) Fracture zone, rift valley and trench i) Turbidity currents and turbidites. *Students should be able to name the ocean basins, international rifts, ridges, banks and seas.*	Study a profile of the ocean basins between one continent and another, and examine the different features Use a plumb line with press stick on a lead weight to measure water depth, and collect a sediment sample	Fishing line Lead sinker Videos Maps Charts (To illustrate the process)

10. Plate tectonics

Term 2		**Plate Tectonic Strand - Oceanography**		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hour	Continental Drift Plate tectonics is a topic which should be understood at a greater level of understanding than the previous Oceanography topics. Learners should be able to describe and explain the processes and the possible impacts on other strands and fields of Marine Sciences.	In 1915 Alfred Wegener hypothesised the drifting of continents, based on his observations of 1. The geographic fit of the continental plates 2. The matching rock types and geology 3. The matching fossils found on the matching continental margins. **Plate Tectonics** 1. More recently the discovery of the Mid-Ocean Ridge system provided evidence that convection cells exist below the continents, on which the continents "float". This led to the concept of sea floor spreading from the Mid Ocean Ridge as forming the mechanism of plate tectonic movement. 2. *Students should be able to describe the process of continental drift.* 3. Evidence for sea floor spreading includes the match of earthquake zones, to spreading centres and subduction zones. 4. Plates are made up of oceanic lithosphere. On their edges there are ridges, trenches and fault zones. 5. An original supercontinent, Pangea, broke up into Gondwanaland and Laurasia over the millennia, and drifted around the planet. Further fragmentation and drifting resulted in the current continental pattern. 6. Evidence for crustal movements includes: a) Polar reversals b) Polar wandering c) Sea floor spreading d) Epicentres of earthquakes e) Rift zones and f) Volcanic hotspots *Define the following terms:* a) Asthenosphere b) Mid Ocean Ridge c) Subduction zone d) Rift zones e) Divergent plate boundary f) Convergent plate boundary g) Transformative plate boundary h) Hydrothermal vents *i)* Megaplumes and spreading centre	Investigate the ecosystems related to hydrothermal vents. How are they similar to or different from ecosystems on land? Introduce this in GET as it is in the Gr 10 Geography curriculum. However more detail is required than the Gr 10 Geography curriculum Wooden blocks to illustrate the 3 different types of boundaries so that students can sketch the boundary movements	YouTube clips Charts (eg "mountain maker earth shaker") *PBS learning media* Globe Layered plate Wooden blocks

11. The Ocean Planet – Physical Properties of Water

Term 2		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
8 hours	**The depth of study includes water properties chemical composition of water, the changes of state cohesion, surface tension and viscosity as well as the dissolving properties of water. Learners should be able to work with these concepts with ease, applying these concepts to a range of settings and contexts.**	**The "Water Planet"** The water molecule H_2O is made up of two positively charged H atoms and one negatively charged O atom. It has a specific shape because the positively charged sides make it a polar molecule. Hydrogen bonds are formed between the molecules. The structure of the water molecule is the reason for water having its unique properties. 1. Water is the only substance to exist as a solid, a liquid and a gas in its natural state. 2. **Changes from one state** to another require the adding or removal of large quantities of energy. 3. Water has a **high heat capacity**; it is able to release significant quantities of heat with a small change in temperature. (Refer to the Water Cycle) 4. **Latent heat** is the energy absorbed or released by a substance during a change in its physical state (without changing its temperature). Examples are the freezing process from water to ice (**latent heat of fusion**) or the vapourisation process from water to water vapour (**latent heat of vapourisation**). This energy is expressed in the amount of joules or calories required per mass of substance undergoing the change of state. 5. **Specific heat** is the heat required to raise the temperature of the unit mass of a given substance by a given amount, usually one degree. Water has a high heat capacity and requires 4.184 J of heat for 1 g of water to increase 1 °C. (In comparison, copper requires 0.3 J.) 6. The **surface tension** of water is the cohesion between water molecules at the surface. 7. **Viscosity** of a liquid is **the measure of a liquid's resistance to flow**. The internal friction of a moving fluid is the result of its molecular make-up. Syrup at room temperature has a high viscosity as it tends to resist flow, whereas water has a much lower viscosity than syrup. Water's low viscosity is the result of its molecular make-up, which has very little friction when it is in motion. Viscosity is influenced by temperature. 8. Water, like most liquids, is nearly **incompressible** – unlike a diver's wetsuit (neoprene), which is compressed with depth. 9. When a person is diving, the pressure of water increases by 1 atmosphere for every 10 m of depth. This fact is of great importance to scuba divers. 10. **Density** or mass per unit volume: pure water has a density of 1 $^{g}/_{cm^{3}}$ at 4 °C. 11. Sea water has an average salinity of 35 $^{g}/_{cm^{3}}$. 12. The density of water increases with a decrease in temperature; pure water reaches its maximum density at 4 °C. 13. The density of water increases with an increase in salt content. 14. The effect of pressure on density is small. 15. Less dense water floats on more dense water. 16. Water vapour is less dense than air. A mixture of water vapour and air (moist air) is less dense than dry air. *Define the concepts* ***heat capacity, latent heat, latent heat of fusion, latent head of vapourisation, dew point, humidity, and boiling and freezing points for water.***	Change of state and examples Density of water: cold verses warm water Density calculations Viscosity exploration Surface tension exploration	Salt Household liquids of various viscosities Dish-washing liquid Food colourant Warm water Ice

12. Energy Transmission through Water- Heat

Term 2		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hour	**Energy transfer** **Learners should be able to apply these contexts to basic settings.**	1. **Energy** is **transmitted** in water in three ways: **heat, light and sound.** 2. Heat energy is transmitted in three ways: a) Conduction b) Convection c) Radiation. 3. **Conduction** is a molecular process in which heat is applied, causing the molecules to move faster. The rapid movement is passed onto adjacent molecules, which in turn also increase their movement. 4. Water is a less effective conductor than metals are. 5. **Convection** is a density-driven process in which heated fluid moves and carries heat to a new location. Water rises when heated and sinks when cooled. 6. **Radiation** is the direct transmission of electromagnetic waves from the source to an object. Unlike conduction and convection, which require a medium in which to function, radiated heat can move through a vacuum. Oceans are heated by solar radiation that is absorbed by the upper layers of the water. 7. Heat transmission from the ocean surface is inefficient. **Much of the heat** is reflected off the surface; **the rest** heats the surface water. Some of this heat is moves lower down in the water column by conduction The deeper heated water will in turn move upward and float above bands of water colder that it. 8. The atmosphere, by contrast, is heated from below – by the land or sea. Heat is efficiently transferred to the atmosphere by vertical movement of air.	How do various birds adapt to refraction and pressure when diving from air into water?	Videos Charts

13. Energy Transmission through Water- Light and Light Absorption

Term 2		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hour	**Energy transmission** **Light** **Learners should be able to apply these contexts to basic settings.**	**Light Absorption in Water** 1. Sea water transmits the visible portion of the **electromagnetic spectrum**. 2. 60% of light is absorbed within the first metre. 3. 80% is absorbed in the first 10 m. 4. Only 1% of visible light penetrates to 150 m. 5. No light penetrates below 1000 m. 6. Not all wavelengths are transmitted equally. 7. **Short wavelengths** are transmitted to a **greater depth**. 8. The long wave (red) end of the spectrum is lost within the first 10 m. 9. Objects deeper than 10 meters appear dark as they only receive and reflect blue light; red objects appear black. 10. Silt, plants and suspended particles scatter and absorb light in the water column. Their combined effect decreases the amount of light quickly; this decrease of light across a distance is called **attenuation.** **11.** Light attenuation can be observed and measured with the use of a **Secchi disk.** 12. Light is measured by a light meter. **Refraction** 1. When light passes from air to water, its rays are bent or refracted. 2. This refraction occurs because light travels more quickly in air than in water, because of the different densities of the mediums. 3. This effect can be compared to a cylinder rolling at an angle off a hard pavement onto a soft sandy surface. The section on the sandy surface will move more slowly than the section on the solid surface. 4. Because of this “bending” of light waves, items seen through the surface of water are not positioned where they appear to be.	Refraction exploration	Videos Glass Pencil

14. Introduction to Evolution and Evolution Mechanisms

	Term 2	Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**Evolution – Introduction** **This important topic needs to be fully understood as it is the basis upon which the Marine Biology is taught.**	This topic is based on scientific theory using knowledge gained from Geology, fossil records and, more recently, also biochemical research. Those who take exception to this information because of their religious beliefs are encouraged to be able to discuss evolution from a scientific point of view, but can record their reservations. Alternate points of view can be incorporated into classroom discussion, to maintain a transparent approach. **The earth is 4.54 billion years old, and life appeared in the sea 3.7 billion years ago.** This summary is based on various forms of dating using oldest known rocks in the earth's crust as well as rock samples from the moon and meteorites. *(Mention plate tectonics and their implications for rock dating.)* **Definition of evolution:** The change in genetic makeup of populations of organisms, over time, that gives rise to greater variety and complexity. Charles Darwin coined the term "Descent by modification". **Evidence of the process** *(Provide suitable examples and discussion to illustrate these):* **1. Fossil record –** How fossils are formed and types of fossils; comparative dateable strata; increase in complexity and diversity; intermediate forms. **2. Modification by descent –** Homologous limbs and organs of related groups indicate common ancestry and change over time or conditions. **3. Biogeographical –** Continents separated by continental drift show related but distinct species. (Time frames can be applied to these differentiations). **4. Vestigial structures –** for example, leg bones in some whales indicate ancestral organs that have become redundant through evolution in a changed environment. **5. Embryology –** Development of (particularly) vertebrate embryos shows similar early stages, with diversification taking place later on. **6. Biochemistry and Genetics –** These fields can highlight the degree of relatedness among species. Several similarities exist in metabolic pathways and chemistry, indicating common ancestry, whereas the differences indicate points of departure between species. **Alternate points of view** to the theory of evolution**:** *(not for examination purposes)* *Potential conflicts between the scientific view and various cultural or religious interpretations of creation should be discussed. Suggest* ***Theistic evolution*** *as one possible point of view taken by scientists who are also deeply religious*.	**Videos**	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

Evolution – Mechanisms

Term 2		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**The Depth of this topic is at a level where learners understand natural selection on an introductory level and speciation in the introduction of a new species.**	**Natural selection –** Several mechanisms were proposed for the process of evolution. The mechanism introduced by Charles Darwin in *The Origin of Species* (1859) has become accepted as theory and is backed by evidence in nature. *Briefly highlight aspects of Darwin's voyage of discovery.* **Explanation of natural selection:** 1. Extensive **natural genetic variation** occurs among members of a population. 2. **More offspring are born than will** survive to reproductive age. 3. **Changes take place in their environment**, mostly gradual, but sometimes sudden and catastrophic. Different changes require different strengths or adaptations. 4. Individuals with the **best variations** or genetic makeup to survive in the changing environment will **live and compete more effectively, to be able to reproduce**. (Survival of the fittest) 5. The successful breeders **pass on their favourable genes** to their offspring. 6. With time, and other mechanisms, micro-evolution allows for speciation and macro-evolution for greater changes. **Notes:** a) It is because **variation is so important, as a driver of natural selection**, that sexual reproduction takes place. b) Certain catastrophic events in the earth's history caused five mass extinctions, almost wiping life from earth and requiring the evolutionary process to start anew each time. It has been proposed that we are now in a sixth, human-induced, mass extinction event (Anthropocene). **Drivers of Speciation:** A species is defined as a group of natural populations capable of interbreeding to produce viable offspring. (Several other definitions also exist, depending on the organisms being studied). **1. Geographic (allopatric) –** When a group of a species is separated from the main body for long enough, the offshoot group evolves to suit its unique circumstances, to the point that this group can no longer interbreed with the original group. *(Give examples.)* Often isolation is driven by adaptations enabling individuals to avoid competition by moving to a separate habitat or different food source. **2. Reproductive –** This implies some sort of isolation of a group initially leading to a change in breeding habits or structures, thus isolating a reintroduced group until they speciate. For example: different breeding season, courtship, pheromones, pollinators, or copulatory organs, or infertile offspring. *(Marine examples very rare.)* **Punctuated Equilibrium –** concept was introduced by Stephen J Gould in 1972. Adds to natural selection, suggesting times when conditions are stable with very little change in population genetics, interspersed with times of rapid genetic change and speciation following or during a phase of environmental change. Evidence in fossil record backs this theory. *Define and discuss:* **1. Convergent** and **divergent evolution, co-evolution.** **2. Symbiosis** and **endosymbiosis** as further drivers of speciation; macro-evolution	Simulation game to illustrate natural selection Find own examples online YouTube videos	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

15. Basic Classification

Term 2		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
1 hour	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved	The system of **two domains, incorporating seven kingdoms,** is **currently supported.** However, several other suggestions have been proposed. The theory **changes constantly with ongoing research**, especially comparing genetic makeup of single-celled organisms. The current system recognises: Two domains: **Prokarya** and **Eukarya** (some researchers prefer to separate archaea and bacteria, which together form the prokarya domain into two separate domains.) These domains are divided into 7 kingdoms: 1. **Bacteria –**these are very small simple single celled organisms which can display plant-like or animal-like characteristics. **2.** **Archaea –** these organisms are almost identical to bacteria; differences include cell wall chemistry and shape of ribosomes. 3. **Protista –** these are mostly single-cell eukaryotes (can be colonial or multicellular, but never differentiated); they are either animal-like (protozoa) or plant-like (dinoflagellates) or a mixture. 4. **Chromista –** this group includes brown algae and has an endosymbiotic origin. 5. **Fungi –** these organisms have filamentous bodies and use saprophytic feeding. 6. **Plantae –** this includes red and green algae and vascular plants. 7. **Animalia –** these are multicellular eukaryotic heterotrophs. **Linnaean system:** a) Kingdom b) Phylum (animals) / Division (plants) c) Class d) Order e) Family f) Genus g) Species As research continues, there is some movement and subdivision of these groupings. Emphasise **binomial nomenclature**, using **genus and species**, as well as conventions for publishing (capitals, underlining or italics) – for example, *Eubalena australis* (Southern Right whale); <u>Coracinus capensis</u> (Galjoen-our national fish).	Photographs with statistics Choose kingdoms using a key Identify animals to different levels, using animal photos (with statistics) and keys	Slides Photographs Diagrams Charts Video clips

16. Evolutionary trends, body plans, symmetry and life patterns

Term 2		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
5 hours	**The Depth of this topic is at a level where learners understand form and function to survive.**	**Animal section:** This section deals with classification and biology of the major heterotrophic/consumer phyla, highlighting significant marine heterotrophs**. It is important that each phylum is not considered in isolation, but seen as part of an evolutionary continuum.** *Point out similarities and differences and how these differences enable survival in more demanding environments.* ***Cladograms and Phylogenetic trees-*** The relationship between organisms can be shown using a diagram called a **Cladogram**- This groups organisms into groups of organisms having a similar appearance and shows possible relatedness- similar to a family tree. Another approach, called a **Phylogenetic tree**, groups organisms based on similar appearance, internal anatomy, physiology, biochemistry **and genetic makeup** (when available) and indicates their possible relatedness, as well as a **timescale between branches**. *Point out that the concept of evolutionary relatedness is an intensively active research field and that new discoveries continue to change our existing understanding. Show examples of Cladograms and Phylogenetic trees and point out the differences between them.* **A Phylogenetic tree showing the major animal Phyla should be introduced at this stage and be referred to throughout the Zoology phase.**	Study Cladograms and Phylogenetic trees of the 7 Kingdoms and **major Animal Phyla**, to see how they work.	Examples of Cladograms and Phylogenetic trees.
	Marine animals: body plans and symmetry	*Revise:* Single cell, colonies, tissues, organs, systems. *Explain the following concepts and terms:* 1. Tissue layers in distinct arrangements and number (**diploblastic and triploblastic**). *2. Body cavity (**coelom; pseudo-coelom**); acoelomate, pseudo-coelomate and coelomate. Explain these terms with the aid of diagrams.* 3. Body symmetry: **Asymmetrical**, **Radia**l and **Pentaradia**l symmetry, **Bilateral** symmetry, and the implications of each.	Study photos of marine heterotrophs; name and identify them	Pictures Photos of marine heterotrophs Preserved animals or a , Kelp holdfast
	Life Patterns	***An overview of all phyla to be discussed, and to introduce relevant terminology.*** As animals evolve or adapt to new and changing environments, and through the time represented by the fossil record, we see animals becoming more complex and specialised in the way they perform their various life functions in more complex or demanding environments. *Use explanatory diagrams, where relevant. Not too much detail is required in this overview because the details will be covered under the relevant phylum. Definitions should be emphasised and added to the glossary.* 1. **Support – hydrostatic**, **exoskeleton** and **endoskeleton** ($CaCO_3$, cartilage and bone). 2. **Locomotion – sessile** or **sedentary**, wriggling, burrowing, swimming, walking and flying. **3. Nervous coordination –** Simple response, nerve net, **cephalisation**, brain, **segmental ganglia** and spinal cord, sense organs – light, mechanical and chemical (sight, smell, taste, touch/ current and sound).	Use YouTube videos extensively	

		4. **Nutrition-** Source of food, mode of feeding, means to process food: Filter feeder, grazer/browser, scavenger/ detritivore, predator; external/ internal digestion; **phagocytosis**, simple gut, through gut, specialised compartments. 5. **Circulation and internal transport –** Diffusion and body plan, **coelenteron**, blood (with respiratory pigment), **open system** and **haemocoel**, **closed system** and vessels. **6.** **Gaseous exchange (GE) – The ideal GE surface is** thin, moist, broad, well ventilated**,** close to rest of cells or well supplied with blood, and enclosed or protected. **Includes** skin; gills; tracheal system; lungs (bag) with folds/ compartments, **alveoli** and tube networks. **7.** **Excretion and osmoregulation –** *Explain the need for these processes*. Important terms: salt or fresh water, osmosis, diffusion, **Endoplasmic reticulum** (ER), **contractile vacuole**, flame cells, **nephridia**, kidneys, salt glands and **hyperosmotic** blood. 8. **Thermoregulation –** The need for thermoregulation, marine versus land, **ectothermic** (specific enzyme systems, anatomy and behaviour), **endothermic** (metabolic, insulation and behaviour), **counter-current exchange** mechanisms, **homoeothermic** versus **poikilothermic**. 9. **Reproduction –** Asexual or sexual; sex organs (**gametes**); uni- and bi-sexual; external and internal fertilisation; sperm transfer; **ovi-, ovovivi- and vivi-parous**; sex change strategy.		

17. Plankton

Term 2		Strand – Ecology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
1 hour	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved •	1. The term "plankton" refers to **large communities** of **organisms that float on** major ocean currents. 2. These organisms may be **photosynthetic (phytoplankton) or animal-like (zooplankton).** 3. The individual organisms **range in size** from sub-microscopic bacteria through single-celled organisms to multicellular larval animals and substantially larger jellies (which range from 1 mm to 30+ m in size). 4. Their distribution is normally limited to **nutrient rich waters** where the **phytoplankton** can multiply and provide food for the rest of the **planktonic food chain**. 5. Whilst the resident organisms drift with the current, **they can migrate up and down in the water column** on a daily basis. 6. This daily migration normally occurs **in response to light and predation**. Most of the organisms migrate downwards during the day when the surface is brightly illuminated, and upward at night (**diel vertical migration**). 7. Planktonic species have many **adaptations to achieve this migration**, including: a. An ability to **propel themselves**, although weakly, to move up to the surface b. N**eutrally buoyant jelly** as a floatation device c. Storing their food reserves as **buoyant fats and oils** d. Gas-filled **bladders** e. **Long spines or frills** to **increase surface area**, all slowing any downward drift. 8. Several small predators (**fish, krill** and others) will float along with and feed on organisms within the plankton. (These larger components of the planktonic food chain will become food for large filter feeders such as whales). 9. Plankton can be further subdivided into: a. **Holoplankton –** organisms like jellies and **phytoplankton**, which **spend their entire life** cycle in the planktonic community b. **Meroplankton –** the **larval** forms of animals that spend a while in the planktonic community before migrating or **settling out** in their adult form. This includes the larval forms of some echinoderms, crustaceans, worms and many fish species. 10. Communities of **heterotrophic plankton** may exist at **great depth**, living on the bodies of dead plankton or nutrient-rich particles falling from the surface. 11. Planktonic communities are widespread, **generally limited by nutrient availability and sunlight**, although there are other contributing factors. 12. Planktonic organisms play a **significant role** in: a. **Oxygen production** b. Primary and secondary production **driving major food chains**; it has been estimated that photosynthetic plankton represent about 80% of the biomass in the ocean. c. **Nutrient cycling**.	Video clips are fine for this section	Internet YouTube

18. Protists

Term 2		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
3 hours	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved	Many marine animals undergo a larval stage that involves floating as part of the widespread oceanic plankton. These larvae feed on **single-celled** (protists and other) **zooplankton** and **phytoplankton**. **Protista** 1. **Protists are therefore at the base of the biggest food chain on earth**. Also responsible for forming, amongst others, **limestone and fossil fuels**. 2. **Single-celled eukaryotic organisms**, bound by a membrane and containing fluid, organelles and chemicals. (*Brief revision of cell biology.*) *3.* **Many protists** have **$CaCO_3$** as part of their structure. *(Investigate potential effects of ocean acidification.)* **Marine examples** *(Illustrate, using photos or diagrams.)* **Forameniferae** 4. The cell has an **amoeboid** nature, pushing out cytoplasmic threads and tubes to feed. 5. Cells are enclosed by a **shell, referred to as a test, made of calcium carbonate or granules of sand or silt**. Size ranges from **100 micrometres up to a few centimetres**, at which stage they may be **multinucleate** cells. 6. As the cells grow, the test adds on new chambers. The tests can be cylindrical, hollow tubes or intricate coiled structures (like a snail shell). 7. Most live within the **oceanic sediment**, but many are **planktonic**. 8. Of those, **some house symbiotic algae**, but most feed on **phyto- and zooplankton**. **Radiolarians** 9. **Range in size from 30 microns to 2mm** and have a glass-like **silica-rich shell**. 10. Shapes vary **from spherical to cone-like** or multi-sided, with **spine-like extensions to increase surface area** for buoyancy. 11. Most are **planktonic predators or filter feeders**. **12.** Dead cells **sink to the ocean floor** to form thick layers (up to 100 m deep) known as **radiolarian ooze**.	Photographs, slide show or videos Study live examples (aquarium or rock-pool study) Example of a protist ID chart, used to classify protists in plankton samples Collect and identify plankton samples, if possible	Live specimens Fresh plankton sample Microscopes Plankton ID sheets

19. Tides

Term 3		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
1 hour	**Learners should understand the process of tidal variability and be able to apply the concepts the variability of animal distributions in intertidal zonation.**	1. The rise and fall of the sea surface results from the **gravitational attractions of the moon and the sun** acting on the rotating earth. *(Explain using diagrams.)* 2. Generally there are two high tides and two low tides per day. These are called **semi-diurnal tides**. *3. Define: high tide, low tide, tidal range (<u>with extreme examples</u>), tidal datum or <u>mean low tide level,</u> neap tide, and spring high and spring low tides.* 4. Because the moon moves along its orbit as the earth rotates on its axis, a tidal day lasts for 24 hours **and 25 minutes**. 5. Tidal currents are associated with rising and falling of the tide in coastal waters. 6. The time when the tide turns, and the **horizontal movement** is zero, is called **slack water.** 7. Some areas have only one high and one low tide per day, such as the Gulf of Mexico. These are called **diurnal tides**. (*Explain using diagrams.)* 8. Tides influence human commercial and recreational activities.	Tide tables Internet reference to tables Case studies Models of Tide changes are available	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

20. Salinity

Term 3		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**The effect of salt** **Salinity** **Learners should have a basic understanding which when applied should lead to an ability to explain concepts such as Thermohaline circulation.**	1. During the time that the earth was formed, relentless rainfall landed on the earth's rocky surface. 2. Volcanic atmosphere gasses – such as chlorine – were dissolved in the rain water. A high content of CO_2 and sulphur dioxide in the atmosphere created acidic rainfall, and acid rainwater dissolved large amounts of minerals on earth's surface and drained away. Salts accumulated over time. 3. Over millions of years rainwater dissolved salts that drained via rivers into the ocean, where the salts accumulated because of water evaporation. Therefore the sea is salty. 4. Water has been called the **universal solvent** as it has an excellent **ability to dissolve** a wide range of materials because of its polar nature. 5. The salt molecule (Na^+Cl^-) consists of one atom of sodium (Na^+), which has a positive charge, and one atom of chlorine (Cl^-), which has a negative charge. Salts dissolve easily in water because of the polarity of H_2O. In solution, the **molecule dissociates** and sodium ions are surrounded by the negatively charged O end of the water molecule. The chloride ions are surrounded by the positively charged H_2 end of the water molecule. 6. When salts are dissolved in water, the density of water increases because salts have greater density than water. 7. The average density of water at 4˚C is 1.0278 $^{g}/_{cm^3}$. The open ocean has an average salt content of 35 $^{g}/_{kg}$. 8. If two solutions of differing properties come into contact, they will not mix easily because of their differing densities. a. **Haloclines** are separate layers of different salinity. b. **Thermocline** is a layer of rapidly changing temperature. c. **Pycnocline** a layer of rapidly changing density. The pycnocline includes both the halocline (salinity gradient) and the thermocline (temperature gradient). The pycnocline refers to a rapidly changing density with depth, because of rapid changes in temperature and salinity. ***d. Apply these concepts by exploring thermohaline circulation.*** 9. The separate "pockets" of water are commonly seen in estuaries where fresh, salt, warm and cold water mix.	Salt water and fresh water layered experiment Boil off sea water reducing solution to salt crystals	Glass Salt water Fresh water Food colouring Hot plate or Bunsen burner

21. The Atmosphere

Term 3		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**The depth of the content listed in the Key Concepts. Learners should know and be able to apply these concepts to various problems.**	1. Earth is surrounded by two "envelopes" – a fluid one, the **ocean;** and a gaseous one, the **atmosphere**. 2. The sun heats the earth, which radiates some heat to the atmosphere and the ocean. 3. **Oceans and land absorb heat better** than the atmosphere does. Oceans also retain their heat better than land does, where for example heat is lost from some rock types relatively quickly. This difference results from the specific heat capacity (SHC) of water in relation to the SHC of air. 4. SHC of water is what dampens seasonal changes in aquatic and coastal environments. 5. Heat is **transferred from land into the atmosphere,** which **sets air in motion**. 6. The heat transfer produces **surface** winds and **transfer of heat** from one part of the atmosphere to another. 7. Both winds and currents transport heat. 8. The dynamic interaction between atmosphere and ocean **constantly modifies itself**. The atmosphere and ocean are constantly moving, driven by density changes (in the air or water) and gravity. One system drives the other. **Layers and Structure of Atmosphere** 1. Air is composed of a range of gasses (N, O_2, CO_2, Ar, Ne, He, H and O_3). The most common are nitrogen, oxygen, carbon dioxide and water vapour. 2. Air pressure is the force with which air presses towards the earth's centre. 3. The atmosphere's layers are named the troposphere, stratosphere, mesosphere and thermosphere. Most clouds are found in the troposphere. *(Illustrate using diagrams.)* 4. Temperatures in the higher mesosphere and thermosphere decrease with increasing altitude. 5. The earth's climate changes naturally. There are natural and human forces which affect the climate, and recently human causes have sped up the extent to which climate is changing. 6. One of the major factors causing climate change is an increase in greenhouse gases such as CO_2. This increase in the CO_2 layer traps outgoing long-wave radiation, creating a greenhouse effect and global warming. 7. The ozone layer has been substantially depleted during the last century because of the release of chloro-fluorocarbons (CFCs) into the atmosphere. A loss of ozone results in more ultraviolet rays reaching the earth's surface. With the banning of CFC use, this process is slowly being reversed.	Greenhouse gases	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic See NOAA resources

22. Air Movement on Earth's surface

Term 3		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
3 hours	**Wind and air movement** **Learners should understand this content as an overview and as an introduction to South African weather systems as the content could be applied to other strands.**	**Air Movement on Earth's Surface** 1. If the earth did not rotate, air movement would nevertheless occur because of uneven heating of the land surface. 2. The Coriolis Effect (resulting from earth's rotation) has a significant effect on the movement of air within the atmosphere. *3. Use diagrams to illustrate the following:* *a) Hadley's cell, Ferrell's cell and polar cells* *b) Wind bands associated with the cells* *c) Zones of descending air produce doldrums (eg horse latitudes).* 4. Seasonal differences result in the wind bands appearing to migrate north and south as seasons change (*use diagrams to illustrate.)* 5. Explanation of the seven different isobaric systems include 'cut off lows' and the weather related thereto. 6. Basic cloud and fog development with recognition of the various types. 7. Interpretation of the weather systems affecting Southern Africa (synoptic charts and analysis charts) 8. Understanding of the Beaufort wind scale and the Geostrophic wind scale. 9. Storm surges occur when storm-elevated sea surfaces reach the shore, resulting in flooding. **Storms in the oceans (Tropical Revolving Storms or Cyclones;) and Mid Latitude Depressions** 1. Tropical Revolving storms including cyclones, hurricanes, and water spouts contain strong rotating winds that cause damage and affect shipping. 2. Formation: storms such as cyclones or hurricanes occur over warm water in tropical oceans far from jet streams. Mid latitude depressions (MLD) occur at the frontal zone between warm moist tropical maritime air and cold dry polar maritime air. Vortexes occur with fronts in this latitude band. They predominantly are west to east moving with the jet streams. 3. Size: Cyclones are large, up to 1600 km across. MLD's are very large and are often associated with a family of depressions. In the southern ocean the primary is south and east of the secondary (ies) depressions. Warm fronts and cold fronts cover many nautical miles in size. 4. Duration: Cyclones and MLDs can last up to 3 weeks. 5. Wind speed: Cyclones have a lower speed, around 320 km/h. MLDs move faster, more than 480 km/h. 6. Occurrences: Indian Ocean cyclones move from the warm tropical waters towards Mozambique in late summer. 7. They travel south west and recurve at about 22° S latitude and lose energy over colder water or when passing overland. Avoidance is important for ships especially small vessels such as yachts Roughly 10 hurricanes occur in West Atlantic per year (thus not a South African phenomenon). 8. Warning time: Cyclones, MLDs and hurricanes several days.	Coriolis Effect Drawings of different cells and their associated wind bands	Videos

		Orographic Effect 1. As winds move across the ocean, water is absorbed. Mountains along the coast deflect on-shore winds upwards. The air cools, causing condensation, and precipitation occurs on the windward side of the mountain. 2. On the lee side of the mountain, air is dry. This is called a rain shadow. (eg George is wet, Oudtshoorn is dryer, and Prince Albert is the driest. Use diagrams to illustrate.) 3. The Andes Mountains in South America are another example of a range that develops a rain shadow on the lee side of the mountain range – in this case, the Atacama Desert. (Use diagrams to illustrate.)		

23. Chart work – Location Systems and the Shape of Earth

Term 3		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	**Navigational skills and charts is dealt with on an introductory level.** **It is a topic dealt with in other subjects. The most relevant content is to identify grid references of Marine Sciences studies.**	**The shape of the earth** 1. As the earth cooled after its formation, gravity and rotational forces resulted in it forming into a geoid (almost spherical) shape. 2. The average radius of the earth is 6371 km. 3. There is a slight bulge of 21.3 km at the equator. 4. Most of the **surface land mass** on the planet is found in the **northern hemisphere.** 5. The shape of the earth is relatively smooth, with its highest point **Mt Everest** being **8840 m** above sea level. The deepest ocean trench, the **Mariana Trench,** is **11 000 m** deep. **Location systems** 1. When we study the earth, and the oceans in particular, exact positions on the planet need to be identified. The location system used is lines of **latitude** and **longitude.** a. Lines of latitude are called “parallels” and begin in the centre, at the equator, which is zero degrees latitude (0°). The poles are at 90°, with North Pole at 90° N and South Pole at 90° S. b. Lines of latitude are determined by the angle between the centre of the earth and the equator and an imaginary line to the edge of the earth. c. Lines of longitude (“meridians”) are drawn at right angles to lines of latitude. Zero degrees latitude (0°) is a line drawn from the North to South Poles through **Greenwich Village** near London, UK. This line is called the **Greenwich Meridian,** and the 180° meridian is called the **International Date Line**. This is not a straight line, because it is the line used to divide one day from another. Certain Pacific islands falling under the same country need to fit into the same day. 2. Lines of longitudes are named as the angular change, east or west, from 0°. **Charts and maps** show the planet’s three-dimensional surface as if projected onto a flat surface. The task of a mapmaker or cartographer is to produce a representation onto a flat chart that is most accurate, convenient for use, and the least distorted. 1. Any flat map or chart will be a distorted view of a spherical surface. Charts are drawn by placing an imaginary lamp in the centre of the earth and projecting the image of the globe onto a flat chart surface. Different projections are obtained by different positions of a) the light source inside the globe and b) the chart. 2. Most maps are one of three basic projections: **cylindrical projection, conic projection,** and **tangent plane projection**. The page is either wrapped around the cylinder, in a cone (with the page in contact with the equator), or flat as a tangent plane projection. These projections show land area being disproportionately larger in the upper latitudes. As a result, continents such as Europe, Asia and North America look far larger in area on the chart than Africa, which contains large areas of land at the equator. On the **Peters projection,** Africa appears far larger than Europe and North America. The Peters projection is a computer-generated **projection with land proportionately illustrated** on a map. 3. GIS is used extensively of recent times to record localities at which Marine Sciences research occurs	Graph illustrating proportion of land in northern versus southern hemispheres Interpretation of bathymetry charts Use Skype in the classroom to connect with students at schools in different time zones Use GPS, Google Map and time clocks on cell phones to illustrate how easily time zones and location systems can be applied. Geocache exercises/ games to reinforce concepts.	Bathymetry charts Compass Globe Briefly introduce equipment Thermometer Barometer Hygrometer Anemometer GPS

24. Ecological concepts introduction and Carbon, Nitrogen and Phosphate

Term 3		Strand – Ecology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	**The Depth of this topic is to introduce the components of an ecosystem and understand some of the complex interactions between them. While some concepts will be dealt with separately, it is important for learners to combine them when looking at specific ecosystems.**	**Ecology** **An ecosystem** is defined as a **community of organisms that interact with each other and the particular physical environment in which they live**. **Ecologists** study ecosystems in detail. 1. An ecosystem is linked by a flow of energy and materials through the non-living (**abiotic**) as well as living (**biotic**) sections of the system. 2. The biotic components include organisms from several **trophic levels**: a. **Producers – autotrophs**, mainly phytoplankton and seaweeds. b. **Consumers – heterotrophs** (**herbivores, carnivores, omnivores, detritivores**) that ingest other organisms, using various feeding strategies (eg grazing, browsing, hunting, scavenging and filter feeding). c. **Decomposers – saprophytic** heterotrophs (mainly bacteria and fungi) break down organic compounds after organisms die. This releases nutrients for use again by primary producers. 3. **Feeding relationships** in an ecosystem can be indicated as **food chains or webs**, or graphically as **food pyramids** of **number, biomass or energy**. 4. **Inorganic nutrients** (eg carbon, nitrogen and oxygen) are **cycled** through ecosystems in a **nutrient cycle** (*Detail is provided in sections on nutrient cycle.)* 5. **Energy** is **converted to food** by producers and **passed along the food chain**, with each level **converting some of the energy** to other forms in order **to stay alive**, until eventually the energy (food) is **used up**. Thus we refer to – and can graphically represent – **energy flow** through an ecosystem. 6. Several **interactions occur between organisms** in an ecosystem, including **inter- and intraspecific competition, and predation.** 7. **Symbiotic relationships** also occur **(parasitism, commensalism and mutualism).** *(Unpack these terms and concepts with marine examples – eg parasitic isopods and fish tapeworms, remora and shark, pilot fish and shark, cleaner wrasse, and clown fish and anemone. Discuss **coevolution** as an extension of symbiosis.)* 8. Five South African marine ecosystems are studied: **the open ocean, rocky shores, sandy shores, kelp forests and estuaries.**	Video clips are fine for this section, as a rocky shore habitat will be investigated in detail	Internet YouTube

Nutrient Cycling 1 Carbon

Term 3		Strand – Ecology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
Total of 4 hours For Carbon, N and P	**The Depth of this topic is to introduce the components of an ecosystem and understand some of the complex interactions between them. While some concepts will be dealt with separately, it is important for learners to combine them when looking at specific ecosystems.**	**The Carbon Cycle** The rate at which the oceans absorb CO_2 is controlled by: 1. Water temperature. 2. pH 3. Salinity. 4. The availability of calcium and carbonate ions. 5. Biological processes, such as organic material dropping to the ocean floor 6. Circulation patterns that transfer CO_2 to the deep ocean and back to the surface. 7. The transfer of carbon from CO_2 to organic material occurs by photosynthesis at the sea surface. The CO_2 becomes part of organic matter. When the organic material dies it sinks to the bottom of the ocean; when it decomposes, the CO_2 is released. The increase of CO_2 can potentially increase the acidity of the ocean. 8. This process is referred to as a biological pump. (*Illustrate this cycle with a flow diagram.*)		Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

Nutrient Cycling- 2 Nitrogen

<table>
<tr><td colspan="2">Term 3</td><td>Strand – Ecology</td><td></td><td></td></tr>
<tr><td>Time</td><td>Depth</td><td>Key Concepts</td><td>Investigations</td><td>Resources</td></tr>
<tr><td>Total of 4 hours
For Carbon, N and P</td><td>The Depth of this topic is to introduce the components of an ecosystem and understand some of the complex interactions between them. While some concepts will be dealt with separately, it is important for learners to combine them when looking at specific ecosystems.</td><td>The Nitrogen Cycle

Nitrogen is needed for the formation of amino acids and proteins. Air contains a lot of nitrogen (approx. 78%) but is unreactive and cannot be used directly by plants to make protein. Plants absorb nitrogen only in the form of nitrates, and specific processes are required to convert nitrogen to nitrates.

1. Nitrogen gas enters the ocean at the ocean surface.
2. By nitrogen fixation, dissolved nitrogen gas is taken up by microbes, which convert it into ammonium (NH_4), a more useful form. In this way nitrogen becomes accessible for absorption by organisms and enters the biological cycle.
3. By assimilation, ammonium is consumed by microorganisms and nitrogen becomes incorporated into the cells of living organisms.
4. In some cases, microbes absorb nitrite and nitrate, leading to another form of assimilation. Microbes die and decompose, releasing ammonium and –
a) small particles which contain particulate organic nitrogen (POC)
b) dissolved organic nitrogen (DON)
into the water column.
5. In a two-step process called nitrification, certain microbes convert ammonium into nitrite (NO_2) and then into nitrate (NO_3). And so nitrates are released into the ocean for absorption by photosynthetic organisms.
6. In a process called remineralisation, many organisms consume POC and DON, converting them back into ammonium.
7. To complete the cycle, in a process called denitrification some microbes convert nitrate and nitrites back into nitrogen gas. (Illustrate this cycle with a flow diagram.)</td><td></td><td>[NOAA Education kits]

[CMORE Hawaii fact sheet]</td></tr>
</table>

Nutrient Cycling- 3 Phosphates

Term 3		Nutrient Cycling: Phosphates Strand - Ecology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
Total of 4 hours For Carbon, N and P	**The Depth of this topic is to introduce the components of an ecosystem and understand some of the complex interactions between them. While some concepts will be dealt with separately, it is important for learners to combine them when looking at specific ecosystems.**	**The Phosphate Cycle** Phosphorous is an essential element for life. It is an important part of the **ATP molecule**, which stores and **gives each living cell its energy**. Phosphorus is also found in **DNA and RNA,** which provide all information **for cells and organisms to function and reproduce**. Phosphorus is thus needed for every organism to survive. **The phosphorus cycle** describes the process in which phosphorus travels from submarine and continental surface rocks, through ecosystems to living organisms. 1. Phosphorus does not exist in the environment in its elemental form but rather as **phosphates**. 2. Phosphates are found in rocks. 3. **Weathering** results in phosphorus being released and **washing into soil** and **rivers**. 4. Phosphorus enters the **ocean through run-off** from land, **animal waste** and **decaying animals**. **5.** Phosphorous in soil is **absorbed by land plants** and passed on to **herbivores and carnivores.** 6. Most aquatic producers obtain phosphorus **directly from the water** they live in. 7. Some land animals absorb phosphorus directly from drinking water. 8. Phosphorus is returned to the environment through animal waste and decaying animals. (*Illustrate this cycle with a flow diagram.*)		Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

25. Porifera

	Term 3	Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved	***-Refer to the Phylogenetic tree to place this Phylum in its Evolutionary context.*** **Porifera (sponges)** 1. Mainly **marine**, some freshwater. 2. **Asymmetrical.** 3. A loose collection of partially specialised cells forming a multicellular organism. 4. Very simple **tissue level** of organisation. 5. Outer **dermal** cells for protection. 6. Middle jelly **mesenchyme** layer: a. **Amoeboid** cells to engulf particles. b. **Spicule cells** produce spicules. c. **Spicules** form structural support or a skeleton. **Spicules** are made up of $CaCO_3$, silica or spongin (wiry threads of silk-like material). 7. Spicules make sponges spiky to small grazers and very unpleasant to eat. Colour acts as a warning. 8. Grow continuously. 9. Huge **variety.** 10. Shape and skeletal material are used to classify Porifera. 11. Inner layer of **collar cells**. 12. Sponges are very effective **ecological filters;** they suck water into their pores and collar cells filter out food. 13. **Protection:** Dermis and spicules. 14. **Support:** Mesenchyme with spicules. 15. **No nervous** control. 16. **Nutrition:** Filter-feed using collar cells, which also ensure a constant flow through pores and out. 17. **Transport:** Diffusion to all other cells. 18. **Reproduction: Gametes** form in mesenchyme, eggs are fertilised and then released. **Multicellular larvae** swim for a few days then **settle and crawl** to a favourable **substrate**. Some sponges are **hermaphroditic**. 19. **Asexual** reproduction can happen **by fragmentation or budding.**	Photographs, slide show or videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible OR arrange a lesson or course with nearest aquarium Use one specific locally available example. Incorporate into ecosystem field trips Isolate spicules for study under microscope, by dissolving sponge fragments in nitric or sulphuric acid	Stereo microscope

26. Cnidaria- Introduction and Cnidarian Classes

<table>
<tr><td colspan="2">Term 3</td><td>Strand – Marine Biology</td><td></td><td></td></tr>
<tr><td>Time</td><td>Depth</td><td>Key Concepts</td><td>Investigations</td><td>Resources</td></tr>
<tr><td>3 hours</td><td>The depth of this topic is at a level where pupils appreciate and understand:
Evolutionary trends
The definitive differences between phyla
Specific adaptations, relating to structures to functions
The richness of marine biodiversity and
Why it must be conserved</td><td>-Refer to the Phylogenetic tree to place this Phylum in its Evolutionary context.
Use labelled diagrams to illustrate detail. Use a sandy anemone as an example.
1. “Cnidaria” means “nettles” in Greek.
2. The typical body form is a polyp, but some classes have a life-cycle incorporating a medusa form.
3. Radially symmetrical – ideal for sessile or planktonic existence.
4. Body plan – Diploblastic. Ectoderm, mesoglea and endoderm. Specialised cells within these layers perform all necessary life functions.
5. Hydrostatic support is provided or assisted by:
a. Fluid filled body cavity/gut (Coelenteron)
b. Longitudinal and circular muscles (Musculo epithelial- and digestive cells).
c. Gel mesoglea
6. Nervous coordinationl occurs through a nerve net in the mesoglea (Sensory cells in ecto- and endoderm).
7. Nutrition:
a. Stinging cells (Nematocysts) and other specialised cells capture prey.
b. Mouth (only body opening)and pharynx assist in feeding and maintaining hydrostatic integrity.
c. External and internal digestion due to gland cells and musculo-digestive cells.
d. Internal folds increase the surface area.
e. Digestion products transported to all other cells by diffusion.
8. Gaseous exchange- O_2 diffuses from centre and outside.
9. Reproduction:
a. Can be asexual through fragmentation or budding, or gametes may be formed from clusters of interstitial cells and then released. Resulting larvae are termed planula larvae and they crawl or swim using cilia.
b. Some examples have a complex multi-stage life cycle.</td><td>Photographs, slide show and videos

Observation of as many live species as possible, or arrange lesson or course with nearest aquarium

Use a specific locally available example.

THEME- Increasing surface area. Prepare cardboard cylinders about from an A4 sheet (landscape format). Now have the pupils fold A4 paper sheets to corrugate them and see how many can be fitted around the inside of the cylinder.</td><td>Videos</td></tr>
</table>

Cnidarian classes

Term 3		**Strand – Marine Biology**		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
3 hours	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved	Briefly discuss features and examples of **anemones, colonial anemones, zoanthids, soft coral, hard coral, sea fan, jellies and hydroids.** *(Provide photos or diagrams for each.)* **1. Hydrozoa** a. **Hydroids –** Microscopic polyps growing together from a fern-like or feathery central stalk, some giving rise to a medusa stage known as **hydromedusae**. b. Hydroids include modified **polymorphic** colonies such as **bluebottles**. **2. Scyphozoa and Cubozoa** 1. **Jellies –** Also referred to as jellyfish. 2. Normally have a complex life cycle with polyp and medusa stages. *(Discuss jelly structure and life cycle stages, using diagrams*.) 3. **Anthozoa** • **Anemones –** This is the chosen example, already discussed. • **Colonial anemones –** Single anemones, generally small and growing very close to each other to form extended carpets. • **Zoanthids –** Closely resemble colonial anemones but are joined together by a fleshy membrane, the **coenoenchyme**. Limited to **sub-tropical shorelines**, where they form **broad carpets in the intertidal zone**. Like hard coral they **harbour zooxanthellae**. • **Soft coral –** Several polyps grow from a **central base made up of same two body layers and mesoglea** (eg purple soft coral or sunburst soft coral). • **Hard coral –** Typical in warm tropical oceans. Colonial polyps build $CaCO_3$ cups to live in, where they form large intricate structures. Different corals are classified according to the shape of the structures built. Nutrition is derived from captured zooplankton, mainly **mutualistic zooxanthellae**. • **Sea Fans –** Colonial polyps grow from a stiff central branching protein rod. **Ctenophora –** This **phylum** (common name **comb jellies**) is very similar to Cnidaria. Sizes range from a few millimetres to over a metre. 1. The adult has a thin tissue layer around a **jelly mesogloea**, with a tissue-lined **coelenteron** in the middle. 2. Many have tentacles covered in sticky cells, but there are **no stinging cells** present. 3. Distinct bands of **cilia, used for swimming**, run down the length of the body (hence the name). 4. (*Photos or diagrams, to be able to identify an example.)*	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips	Videos

27. Platyhelminthes

Term 3		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
3 hours	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved	***Refer to the Phylogenetic tree to place this Phylum in its Evolutionary context.*** *(Use labelled diagrams to illustrate detail.)* *1.* **Latin – "Flat worm"**. *Explain significance of flat structure with regard to surface-area-to-volume ratio and transport of gasses.* 2. **Bilateral symmetry**. 3. **Body plan –** Multicellular, **triploblastic** (mesoderm), **acoelomate**. a) Ectoderm specialised to protect and aid in locomotion. b) Endoderm specialised to aid nutrition. c) Mesoderm takes over as the hydrostatic **medium**; also houses organs. 4. Free-living and parasitic examples exist. 5. **Locomotion –** Free living examples are **motile** examples move using **cilia and slime** or **swim**. 6. **Nervous** control – Nerve network, cerebral ganglion or **cephalisation**. Eye spots; also senses touch, current, temperature and chemicals. **7. Nutrition –** Extrudable muscular pharynx sucks food into **branched gut.** 8. **Gaseous exchange** through skin and diffusion. 9. **Excretion –** Inward folds of ectoderm, causing **tubule network** linked to **flame cell** clusters. 10. **Reproduction –** Asexually by **fragmentation or budding**. Sexual: most are **hermaphrodite**, with internal fertilisation. Eggs hatch as miniature **adults** or a **planktonic larval form**. .	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips **NEW THEME- Surface Area to volume ratio** Use two sponge sheets of different widths and cut them into sizes of similar volume. Establish the surface areas of each and put them into shallow trays holding the same volumes of water, for 30s. Then relate surface area to the volume of water absorbed.	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

28. Other Unsegmented Worms

Term 4		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved	*(These phyla need **not** be dealt with **in detail.** Photos and diagrams can be used to ensure students can identify them.)* **Nemerteans** are commonly called **ribbon worms:** 1. Generally found in gravel and sediment in intertidal zones. 2. **Size** varies from a few millimetres to many centimetres long, and exceptions can be several metres long. 3. Tend to be **long, thin and flat** 4. **Have a through gut.** 5. Have a **coelom** modified to form a simple circulatory system. 6. Have a **space** above the foregut, called a **rhynchocoel**, which houses a sticky eversible – and sometimes branched – sticky **proboscis.** 7. The proboscis is used like a net to **capture prey or to filter feed**. 8. Most move like flatworms, with cilia on a layer of mucus. **Nematodes** are commonly called **roundworms:** 1. Very abundant in **marine and estuarine sediments**, also **damp soil** and as **parasites and commensals** in many plants and animals. 2. Size is generally less than 1 mm to a few millimetres long, but exceptions can be several centimetres. 3. Have **tubular bodies** tapering at each end. 4. A pseudocoelom extends the length of the body. 5. **Have a through gut** and feed on **liquids or microscopic animals.** 6. **Movement** is by means of **snake-like wriggling.** **Sipunculids** are commonly known as **peanut worms** as they resemble peanuts in their dormant state. 1. They are found in gravel and sediments and below sedentary organisms, like mussel beds, in intertidal zones. 2. Size is generally 1cm–5cm. 3. They have an eversible **tubular extension (an introvert);** can be extended to ingest food with the mouth at its end. 4. They have a coiled, U-shaped through-gut. 5. The introvert also enables them to move forward by anchoring the extended front and dragging their body along. **Chaetognaths** are commonly called **arrow worms:** 1. Arrow worms are significant predators in planktonic communities, where most of them live. 2. Range in size from about 2mm to 12cm. 3. They have a transparent, tubular, worm-like body with a distinct head and tail. 4. They have a through gut. 5. Around the head are several tooth-like chaetae with which they capture prey. The chaetae can be covered by a flap of skin while they swim. 6. They have lateral and caudal fins; extensions of the epidermis resembling those of bony fish.	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips	Videos

29. Annelida and Annelid Groups

Term 4		Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
4 hours	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved	**Segmented worms** ***-Refer to the Phylogenetic tree to place this Phylum in its Evolutionary context.*** (*Use labelled diagrams to illustrate detail.)* This phylum represents the start of several revolutionary characteristics. 1. There are three major classes; marine examples fall mainly in the class *Polychaetae* – around 4000 species have been identified, both sedentary and free living. 2. **Symmetry –** Bilateral. 3. **Body plan – Triploblastic**, with a **split mesoderm** to make it **coelomate**. 4. The coelom is fluid-filled to provide a **hydrostatic skeleton** and organ space. 5. **Segmentation** a. Allows for coordination of different parts of the body. b. Each segment can be operated independently. 6. The **ectoderm** forms a specialised **glandular** skin (producing mucus) with a protective cuticle. 7. **Locomotion –** Free-living forms move around using a combination of independent segmental contractions and parapodial **bristles**. 8. **Nervous coordination –** a. Compared with the flatworm, segmented worms have more advanced **cephalisation** with better sense organs. b. They also have a larger **cerebral ganglion.** c. A double ventral **nerve cord** links individual **segmental ganglia**. 9. **Nutrition –** a. Front segments are modified for various modes of feeding; broad fan-like surfaces in filter feeders. b. Long sticky threads; wide range of bristle- or tooth-filled jaws in predators to catch and chew prey. c. A through gut with specialised compartments and glands enables effective digestion. 10. **Circulation –** A **closed blood system**, with contractile arteries to ensure effective internal transport. 11. **Gaseous exchange –** Skin, parapodia with segmental gills, extra-oral gills, respiratory pigment. 12. **Excretion –** Most segments have a pair of **protonephridia**, which clean coelomic fluid and blood; excrete waste to outside through **pores.** 13. **Reproduction –** a. Some asexual regeneration of segments or budding can occur. b. Generally unisex, with specialised sex organs or segments dedicated to gamete production. c. Often have **synchronised spawning**. First released gametes produce a scent (**gamone**) stimulating other individuals to spawn. Swarming may also occur. d. Eggs hatch as **Trochophore larvae**, which float as **plankton** before sinking to metamorphose into adults.	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips Observe earthworms or (preferably) Pseudonereis or wonderworm Virtual or YouTube video on dissection	Live worms

Annelid groups

Term 4		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
Part of the time allocation for Annelida Time	**Annelid examples**	Discuss and be able to identify: 1. **Pseudonereis (mussel worm)** or other free-living example; identify parapodia, bristles and jaws. 2. **Tangleworm –** Lives in mucous tubes. Identify feeding threads and gills. 3. **Tube worm or fan worm –** Produces leathery or sandy, calcareous tubes. Feathery outgrowths around the mouth act as filter feeding mechanisms and gills.	Study photographs and, ideally, live examples	Live animals

30. Arthropoda- Introduction and Marine Arthropod Groups

Term 4		Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
6 hours	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved	**Revise life patterns and classification** ***-Refer to the Phylogenetic tree to place this Phylum in its Evolutionary context.*** 1. Although this is by far the **most successful and diverse group of animals**, the basic body plan and definitive features are universal. (*Use labelled diagrams to illustrate detail.)* 2. Symmetry and plan – Most are **bilaterally** symmetrical, all are **triploblastic coelomate**. 3. They have an **exoskeleton:** a. The exoskeleton incorporates **$CaCO_3$ and protein** to provide **protection** and a firm **anchor for muscles,** and it incorporates **levers for mechanical advantage**. b. **Flexible protein membranes** at joints enable movement of the many modified appendages. c. All must **moult** in order to grow. 4. While external segmentation is obvious, this aids flexibility but is not internal, so there is no repetition of segmental organs. Marine examples have **cephalothorax or carapace** and segmented **abdomen**. 5. **Appendages are modified** for sensing (antennae), finding food (pincers or claws), feeding (mouth parts), walking (legs) and swimming, to mention a few. The success of the insects is mainly ascribed to wings. 6. **Nervous** coordination: a. Arthropods have **cephalisation** and a brain leading to a **double ventral** nerve cord. b. They have complex eyes and sensory appendages. 7. **Nutrition:** a. Mouth parts cut and sort food. b. A compartmentalised **through gut**, performing **external digestion**, deals with the wide range of food collected. c. Large digestive gland takes in food particles to further digest them. 8. **Circulation –** a. Blood system is **open**, with **haemocoels** joined by vessels and a dorsal heart. b. Internal organs are bathed in blood (which is similar to sea water). c. **Haemoglobin or haemocyanin** may be present. 9. **Gaseous exchange –** generally through gills in a chamber of the carapace. 10. **Excretion – Green glands** in crustaceans, and **malpighian tubules** and rectal pads in insects. 11. **Reproduction:** a. Marine arthropods lay eggs, which may have been fertilised internally or externally or could even be parthenogenetic. b. Eggs hatch as **Nauplius larvae**, which then go through various **developmental stages** as **meroplankton**. c. Specific life cycles can vary from this general description.	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

Marine Arthropod Groups

Term 4		Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
Time is included in the Arthropoda intro and groups.	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved	*Diagrams and photos are needed, but only for students to be able to identify each class or group.* **Pycnogonids (sea spiders):** 1. Head with pincers and a feeding proboscis. 2. Reduced abdomen. 3. Eight legs and a slender body. 4. Digestive and reproductive organs extend into legs. **Crustaceans:** 1. Include barnacles, isopods and amphipods, shrimps, prawns, lobsters and crabs. 2. Apart from the barnacle, all have a fairly similar body plan and structure. 3. **Barnacle:** a) Exhibits a mollusc-like structure but starts out as a “shrimp”. b) The shell-like plates are produced as an outgrowth of exoskeleton. c) The legs (**cirri**) are used to filter feed. 4. **Lobsters (isopods, amphipods and shrimps):** a) Vary in structure and shape as well as appendages, but have very similar internal anatomy. b) Very close to the generic features mentioned in the introduction. 5. **Crabs:** a) Also very similar to the generic anatomy. b) Have a typically broad flat carapace and a small segmented abdomen folded underneath. 6. The **fossil record** shows that some **crustaceans moved onto land along with proto-arachnids**, giving rise to **myriapods** (millipedes and centipedes), **arachnids** (spiders and scorpions) and **insects** (the most “successful” animals on the planet), amongst other lesser-known groups. Very few of these land-living classes have ventured back to sea with any real success.	Investigation of a comparison between the different animals Obtain and euthanase invasive harbour crabs for dissection	Charts Video clips Slides Diagrams to show symmetry

31. Human Impacts upon Ocean Biodiversity (HIPPO)

Term 4		Strand – Humans and the Oceans		
Time			**Investigations**	**Resources**
An hour HIPPO Intro And an hour for each sub-topic Total 5 hrs	**Human threats to biodiversity** **The Human Impacts topic is one which learners should be able to understand and apply multidisciplinary skills to illustrate the integrated nature of ecology and human engagement. It is here where interspecies equity should contextualise human "light" footprints on planet earth.**	Biodiversity as defined by the International Union for Conservation of Nature is the variability among living organisms; including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. Biodiversity includes species, genetic and ecosystem diversity. There are many threats to biodiversity. The most significant human threats to biodiversity can be remembered by using the acronym **HIPPO: H**abitat Loss, **I**nvasive Species, **P**ollution, (Human) **P**opulation growth and **O**verharvesting. Essential to an ocean economy is a sustainable approach to the management of the coastlines, the ocean and all that it contains. To accomplish this sustainability, the **biodiversity** of all habitats must be protected.	**Visit an Eco-park or SAN Parks facility to discover the elements of HIPPO**	**https://www.e-education.psu.edu/geog30/node/394**

HIPPO-Habitat Destruction

Term 4		Strand – Humans and the Oceans		
Time			**Investigations**	**Resources**
1 hour For HIPPO and Habitat Destruction	**HIPPO Habitat Destruction Human threats to biodiversity The Human Impacts topic is one which learners should be able to understand and apply multidisciplinary skills to illustrate the integrated nature of ecology and human engagement. It is here where interspecies equity should contextualise human "light" footprints on planet earth.**	The section on ecosystems section illustrates some marine habitats. Studies have been shown that these **ecosystems are interrelated, sensitive and exceptionally complex**. No ecosystem habitat exists in isolation, without inputs and outputs that are connected to other marine habitats and ecosystems. Hence the concept of "One Ocean" – and that all elements are interrelated. The first letter of the HIPPO acronym (see previous section) refers to human destruction of **habitats. Habitat destruction** has impacted upon biodiversity and is a primary cause **endangering** the survival of many species. 1. The high level of **endemism** along the South African coastline makes marine organisms particularly vulnerable, as many species are **not found anywhere else** on the planet. 2. **Protecting habitats** is critical for sustaining biodiversity. Many species of invertebrates and vertebrates found in the coastal zone are particularly sensitive to human disturbance. 3. Migratory species are sensitive to habitat destruction because they occupy more than one habitat and move along a **migratory pathway** between habitats. **All these areas** require protection for such species to survive. Should one of the "pathway" habitats be damaged, it could cause **adverse effects** on **the other ecosystems; subsequent** habitats in turn affect others, and **domino effects** could result. The following activities destroy marine habitats: 1. **Fishing trawler vessels** that catch **bottom-dwelling fish** have **destroyed large areas of sea bed**. Bottom trawling is by far the most damaging form of fishing. Some trawling paths result in more damage than others (eg trawling over coral reefs has been compared to chopping down forests with the aim of catching a few squirrels). 2. The **prawn fishery** is associated with substantial damage to habitats. Prawn farming commonly occurs in estuaries in which mangroves are found. Clearing these habitats to farm prawns severely endangers unique and limited mangrove ecosystems, and in turn affects natural fish breeding grounds. 3. **Anchors** that are not fixed to the sea bed but are allowed to drag along the sea bottom damage marine habitats. Coral reefs in particular are sensitive to anchor damage. 4. Disruption of the sea floor by **trawling or dredging** lifts **sediment from the sea bed into the water column**. This increased sediment load blocks light, clogs gills of animals, and blocks the feeding structures of many organisms. This impedes their functionality and increases their stress. Some dredged sediments from the sea floor are **toxic and affect animals** in the water column. Increased sediment affects the food supply, shelter and breeding grounds of marine organisms. 5. **Human construction** upstream of the coastal zone **in wetlands or estuaries** affects coastal habitats, such as estuaries and their associated wetlands, and beaches. 6. Construction of buildings, harbour walls and marinas is notorious for **destroying coastal zone habitats, beach areas and wetlands.**		.https://www.reference.com/science/habitat-destruction-c2a7d89894498e78?qo=cdpArticles#

HIPPO-Invasive species

<table>
<tr><td colspan="2">Term 4</td><td>Strand – Humans and the Oceans</td><td></td><td></td></tr>
<tr><td>Time</td><td></td><td></td><td>Investigations</td><td>Resources</td></tr>
<tr><td>1 hour</td><td>HIPPO
Invasive sp
Human threats to biodiversity
The Human Impacts topic is one which learners should be able to understand and apply multidisciplinary skills to illustrate the integrated nature of ecology and human engagement. It is here where interspecies equity should contextualise human “light” footprints on planet earth.</td><td>The second letter of the HIPPO acronym refers to the introduction of invasive alien animals and plants into an area by human activity.
1. Some introduced organisms have not adapted to the local conditions, which means they do not survive and die off.
2. For other species, conditions are perfect to live, grow and reproduce within the new habitat. Being away from their natural and historic range of distribution enables these species to thrive.
3. In this new habitat the introduced alien organisms do not have the natural controls that balance reproduction in their original habitat. This is because their natural predators, parasites or diseases are absent in the new habitat.
4. Organisms moving into an area can affect resident species in many ways. Introduced species compete for food and prey upon or parasitize local species; they can hybridize with local species or carry in unfamiliar diseases to which local species have no immunity; and they can disturb local symbiotic interactions to such an extent that one or (normally) both symbionts become extinct.
5. Introduced alien species can disrupt local ecosystems to such an extent that they are termed aggressively invasive, and may eventually cause the total extinction of entire endemic communities.

Many marine invasive species are transported across the ocean as “hitchhikers” on hulls of vessels or in ship ballast water. Some have become attached to and been transported by means of scuba gear, packaging, consignments of live animals or bait, exotic food, and as parasites on living host organisms. Some have been introduced by the mariculture industry. These non-indigenous species threaten the abundance and diversity of indigenous species and the stability of their habitats.

Examples of alien invasive species that are known to have invaded South African waters are the European shore crab and the Mediterranean mussel.</td><td></td><td>Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

Refer to SANPARKS and DEA material</td></tr>
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HIPPO-Human Population Increase

Term 4		Strand – Humans and the Oceans		
Time			**Investigations**	**Resources**
1 hour	**HIPPO** **Human Population increase** **Human threats to biodiversity** **The Human Impacts topic is one which learners should be able to understand and apply multidisciplinary skills to illustrate the integrated nature of ecology and human engagement. It is here where interspecies equity should contextualise human "light" footprints on planet earth.**	The third letter of the HIPPO acronym refers to human **population** increase. 1. During the **20th century**, the **global human population quadrupled** from about 1.5 billion to 6 billion people. 2. The world population reached 7.5 billion in 2016, and is currently growing at around 1.13% per year. 3. Populations already clustered in villages and cities along coasts multiplied even more rapidly than the general population, partly due to migration from inland. Today, 60% of the world's population lives within 200 km of a coast and this percentage continues to rise. 4. Coastal regions are thus undergoing environmental decline, and the problem is particularly acute in developing countries. 5. The reasons for this environmental decline are numerous and complex. 6. The high concentration of people in coastal regions has also produced many economic benefits, including improved transportation links, industrial and urban development, revenue from tourism, and food production. 7. Conversely, the combined effects of booming population growth and **economic and technological development are threatening the ecosystems that provide these economic benefits.**		Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

HIPPO-Pollution

	Term 4	**Strand – Humans and the Oceans**		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
1 hour	**The human impacts topic is one which learners should be able to understand and apply multidisciplinary skills to illustrate the integrated nature of ecology and human engagement. It is here where interspecies equity should contextualise human "light" footprints on planet earth.**	The fourth letter of the HIPPO acronym refers to **pollution**. Pollutants, apart from being unsightly and disturbing in pristine environments, affect living organisms in the following ways. 1. **Litter**: a. Animals and birds may mistake **plastic items for food and ingest them.** Larger items can cut or block the digestive tract, causing the death of the animal. Little is known about the effect of micro-plastics, which may result in increased levels of toxins in the body. Because plastics biodegrade exceptionally slowly, this problematic situation will continue **for thousands of years**. b. **Entanglement** of animals; polluting items can choke or strangle animals and birds, leading to severe problems and death. 2. **Oil**: a. Oil floats on the water surface and causes animals to suffocate and their body functions to fail. b. Some birds lose their ability to insulate themselves when covered by oil. Some cannot fly when oiled. **3.** Many **dissolved materials and substances in suspension drain into the ocean:** a. These run into the ocean from industrial areas, via water courses (all drains **do** lead to the ocean). b. They include microbial contaminants, sewage effluent (treated and untreated), industrial waste, heavy metals, fertilisers from agricultural activities, sediments and many other substances. 4. **Agricultural activity**: a) Increases soil runoff and erosion, thus resulting in increased sediment load and turbidity of the water column. b) Increased sediment loads in the water column clog animal gills and affect the functionality of organisms. 5. **Pesticides and toxic chemicals**: a) These substances affect reproductive capacity in some animals, as the toxins build up in fatty tissue. b) Many beaches off the coast have been condemned for swimming as the water quality is of a standard that is likely to damage the health of the bathing public. The impact on animals in such areas will be dire. 6. **Nitrates and phosphate nutrients:** a) From agricultural areas and mariculture facilities, fertilizers or animal waste end up in rivers and flow into the ocean, where they change the water chemistry and affect animals in the area. b) These substances cause eutrophication (algal blooms deplete dissolved oxygen and severely affect ecosystems). c) Some scientists have argued that this disruption could be the cause of rock lobster "walk outs" at Elands Bay on the West Coast. d) There are records of fish which have absorbed dissolved minerals such as mercury. 4. **Thermal pollution:** a. Heat pollution occurs when **warm water (**used as a coolant in industry or electricity production) is **returned to a colder sea**. b. This changes the immediate coastal habitat, resulting in a change in the local biodiversity.		Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

		5. **Noise pollution**: a. **Sonar** from ships (including seismic research surveyor vessels, naval activities and thousands of other vessels on the seas) negatively affect marine animals that use echolocation (such as the natural navigation abilities of migratory animals). The full impact of sonar pollution is not yet known.		

HIPPO-Over Exploitation

Term 4		Strand – Humans and the Oceans		
Time			**Investigations**	**Resources**
1 hours	**HIPPO** **Over Exploitation** **Human threats to biodiversity** **The Human Impacts topic is one which learners should be able to understand and apply multidisciplinary skills to illustrate the integrated nature of ecology and human engagement. It is here where interspecies equity should contextualise the necessity of a "light" human footprint.**	The fifth letter of the HIPPO acronym refers to **over-exploitation**. **Ocean produce is the primary source of dietary protein** for over 2 billion people on our planet, which means that 1 in every 7 people on earth relies on seafood to survive. However, **80% of all fish stocks** have been **exploited to their biological limits** and beyond. **1.** Mechanised fishing and technology – such as sonar, radar and large-scale fishing methods – have resulted in the near-fatal reduction of natural populations. **2. Individual species are becoming threatened or are near-extinct**. 3. Most large fish species found in the ocean have been exploited, resulting in harvesters and fishermen fishing **down the food chain** as they target smaller species. 4. An understanding of over-exploitation of marine resources requires insight into the **fine balance** between **sustainable maintenance and extraction of natural marine resources** on the one hand, and on the other, **the ecosystems** in which they are found. 5. In addition, there is a need to understand sustainable practices when utilising technologically advanced equipment to extract resources. In the past century, the volumes of extracted living and non-living resources has **reached unprecedented high levels**. 6. Marine scientists need to research and find the balance between extraction operations and the impact of those operations on the surrounding habitats and ecosystems. 7. Certain **resource supplies have been depleted**; others will take hundreds of years to recover. 8. In South Africa, marine resource use includes the extraction of **petroleum oil, gas and phosphate** as well as **harvesting of seafood** by trawling and long-line fishing. 9. Key to the **future ocean economy** is the **protection of resources** in our established **marine protected areas,** and the development of our **mariculture industry**.		Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

Section 3.2 Grade 11

32. Marine Careers

Term 1		Strand – Humans and the Ocean		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	**Careers 2: Research on careers for marine scientists** **Learners should understand the fields available as career opportunities. This topic should inform learners in terms of the career options open to them; where they could study further and at what level they need to perform at school level to be eligible for furthering their studies in Marine Sciences.**	Marine Sciences leads to a wide range of **career fields** such as Zoology, Oceanography, Geology, Coastal Processes, Geophysics, Biogeochemistry, Eco-System Dynamics, Ocean Modelling, Forecasting and many more. Students can move into the following **specialisations**: a) Biological oceanographer b) Fisheries scientist c) Marine specialist – journalist or videographer d) Teacher or facilitator at a school, aquarium, museum or science centre e) Vet or part of a collections team at an aquarium f) Technical development of equipment for the collection of ocean data g) Physical oceanographer h) Chemical oceanographer and marine geochemist i) Marine and ocean engineer j) Marine archaeologist k) Marine policy developer l) Environmental lawyer Marine scientists are employed by universities, government departments and units or companies that consult to the government. While all roles require good general expertise and scientific abilities, specialisation in one particular area is usually required for progression in the profession. Examples of specialties are Coastal Management, Fisheries Biology, Mathematical Modelling, Ecosystem Dynamics, and Chemical Risk Assessment. *Students should be made aware that Marine Sciences is a growing career option in South Africa and new career options are likely to develop in the field. In addition, they should be entrepreneurial in their thinking, as this will enable them to be self-employed as consultants or to develop a company that does not depend on government salaries, funding or grants.*	**Should be introduced in Gr 11 for students to timeously make applications** Students should select a Marine Sciences career and prepare an oral presentation including: 1. What skills are required? 2. What are the responsibilities? 3. Who employs such a person? 4. What are the daily tasks of this job? 5. What are the opportunities for self-employment.	www marinecareers.net Research the SANCOR website http://www.marinecareers.net/ https://unh.az1.qualtrics.com/jfe/form/SV_cN0PqaWhaV5JoEZ

33. Scientific Inquiry

Term 1		Strand – Humans and the Ocean		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**The Scientific Method** **In this grade Teachers and learners need to deal with variables and apply the Scientific Method in a way that a thorough working knowledge of the variables, control and uncontrolled variables is achieved.**	*This section provides the basis for the students to develop a Marine Sciences project that demonstrates their skills in applying the Marine Sciences curriculum. As scientists-to-be, students need to practise observing, inquiring, investigating, and researching the natural world. It is here that Marine Sciences as a curriculum subject comes into its own. The oceans are filled with beauty, fascinating elements and intriguing occurrences. The Marine Sciences project is the opportunity for a teacher to engender passion for the oceans among Marine Sciences students.* **The Scientific Method** **The Scientific Method** 1. **Conducting an investigation** – one conducts an investigation by collecting evidence from a variety of sources, developing an explanation based on the data, and communicating and defending one's conclusions. 2. **Method** – the scientific method requires questions leading to a hypothesis that can tested by observations, in turn leading to conclusions. 3. A **theory** is proposed on the basis of evidence obtained from research conducted. **Science Process Skills** 1. **Observe** – use all the senses. 2. **Question and** h**ypothesise** – a hypothesis is a tentative explanation about possible causes or dynamics of a phenomenon. 3. **Predict** – scientific predictions are based on observations, measurements, and relationships between observed variables. 4. **Use the right terminology** – all procedures and reporting are vitally dependent on the precise use of terms. 5. **Define variables** – identify and distinguish between variables that are controlled (held constant) and those which are manipulated. a. **Independent (manipulated) variable** – the measurement or condition that is regulated by the person doing the experiment. b. **Dependent (responding) variable** – what you measure and observe in response to changes in the independent variable. c. **Controlled (fixed) variable** – these refer to conditions that must be kept the same (held constant) in order to isolate the result; a controlled variable has the potential to vary but is deliberately restricted. 6. **Perform experiment.** 7. **Record results.** 8. **Analyse results.** 9. **Draw conclusions.** 10. **Produce a research report and poster** – the report should include Introduction, Hypothesis, Method, Results, Discussion, and Conclusion. **Research Skills** 5. Classify – group related objects and ideas together. 6. Quantify – use numbers and measurements related to time, length, width, volume and ratio.	Observation Hypothesis testing Theory and truth Problem statement (initial inquiry) Hypothesis (allows for predictions) Experimental design (materials and procedure) Data collection (observations and measurements) Analysis and interpretation of data or results (inferences) Drawing conclusions (answering the research question or problem) Have we proved or disproved the hypothesis? Extension (further inquiry – pose new questions that are related to the original question and can lead to new investigations)	**A range of equipment can be used for this practical work; for example, transects, Secchi disks, and water sampling equipment**

		7. Communicate results – describe verbally (text) or visually in tables and graphs. 8. Interpret, discuss data and draw conclusions – explain an observation. Please Note that the Scientific Inquiry is a central Purpose (see 2.3) of this curriculum and should influence each of the topics. Although listed as a topic here it should be referred to on an ongoing basis as informing the approach to the curriculum.		

34. Sediments

Term 1		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**Sediments is an important area of Oceanographic study and should be learnt with the view to apply the content to practicals and project work.**	1. Sediment is material such as sand and stone that is suspended in liquid and normally settles out. Sediments are classified by **origin** and the **situation** where it is discovered. The continent margins and ocean basins are constantly supplied with sediment materials. 2. Types of sediment **origins** include: a) **Lithogenous** sediments from rock b) **Biogenous** sediments from living organisms c) **Hydrogenous** sediments precipitating out of sea water d) **Cosmogenous** sediments from outside the earth's atmosphere. 3. Patterns of sediment **situation** include: a) **Terrigenous** sediments, found near their source on the coastline b) **Neritic** or coastal sediments, which come from land and the coast, and are found under shallow waters towards the edge of the continental shelf c) **Pelagic** sediments are found at depths. 4. **Finer** sediments are deposited offshore away from currents and waves, in places such as quiet bays or estuaries. Coarse sediments are concentrated close to their source in turbulent waters. 5. An accumulation of sediment on the continental margin can slide down to the ocean depths, resulting in a **turbidity current** – which consists of saturated sediment and forms a continental rise. 6. **Sediment cores** are sampled from the ocean floor. These illustrate that sediments form distinct layers which vary in colour, thickness and shape as well as type and grain-size of particles. The layers show a great deal about the age and origin of the sample and the conditions experienced prior to deposition (eg climate and biological content). 7. Sediment particle sizes are described in a classification system. These range from boulders of more than 256 mm to silt and clay of less than 0.0039 mm. In decreasing order the classification is boulders, cobbles, pebbles, granules, very coarse sand, coarse sand, medium sand, fine sand, very fine sand, mud, and finally silt and clay. 8. Geological oceanographers study the sea bottom using piston corers, dredges, grab samplers and acoustic profiling. 9. Many countries mine sand and gravel for the construction industry from the ocean floor. Off Scotland's coast, coal is mined from the ocean bed. Off the South African coast, heavy sands are mined along the Richards Bay coast. Off the north-west coast of Kleinzee and southern Namibia, diamonds are mined; these diamonds were washed down from Kimberlite cores on the subcontinent as alluvial sediment. 10. Oil and gas have been discovered beneath the ocean floor from Angola to the Southern Cape.	Refer to the **turbidity current** that severed the telephone line between London and New York Use **Secchi disk** to record the turbidity or transparency of the water column Refer to the impact sediments have on ecosystems in oceans (such as temperature change, clogging of animals' gaseous exchange organs, effects on plants' capacity to photosynthesise) Create a turbidity current model with sediment Obtain a sediment sample and analyse the grain size	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

35. Harvesting of Marine Resources

Term 1		Strand – Humans and the Oceans		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**Harvests from the sea** **This topic lends itself to higher level thinking and applications of the content used in discussions and debates. Students select should understand what content learnt in sections such as marine geology Sedimentology, water quality and Marine Biology can be applied to discussions.**	This subject gives background information on ocean resources, where they are found, and what impacts their extraction has on the ocean. Research should be conducted on extracting resources from the ocean and how best to manage such extraction in a sustainable way. 1. The ocean is the most used transportation medium on the planet, and is a sought-after recreation medium. 2. The ocean contains the earth's most valuable natural resources. Harvesting of living and non-living resources from the ocean includes: **a. Living Resources** I. Fish: trawling and line fishing. II. Shellfish. III. Seaweeds. **b. Marine sediment mining** I. Drilling for fossil fuels such as crude oil and gas; 30% of oil used by humans is pumped from deposits in continental shelves off coastlines. Antarctica is the only continent where oil is not extracted. II. Phosphate – to be used as fertiliser. III. Table salt. IV. Sands and gravels. V. Deep sea minerals including copper, iron, manganese, nickel and cobalt. **c. Desalination** I. Desalination is the removal of salt from sea water to create water suitable for human consumption by applying reverse osmosis though high-pressure membranes. II. Challenges in applying desalination include leaching of minerals by pure distilled water, the impact of increasing salinity, and high energy consumption. 3. Seafood is the most commonly harvested ocean resource; approximately 90 billion tons of seafood are harvested each year. With a human population of over 7 billion people, 30% of all fish stocks have collapsed, and it is likely that *all* fish stocks will have collapsed by 2050 unless preventative measures are taken. 4. Undesirable outcomes associated with excessive fishing are – a. Inefficient use of the catch (eg shark finning where sharks are caught, the fins cut off and the rest of the body thrown wastefully back into the sea) b. By-catch (untargeted waste fish) c. Habitat destruction (bottom trawling). 5. Each country with a coastline has legal jurisdiction over an area stretching 200 km from the coastline into the sea, called the Exclusive **Economic Zone** (EEZ).	This is an ideal topic on which a research project can be submitted by students	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

6. The **Tragedy of the Commons** occurs when humans exploit a shared resource in such a way that the demand exceeds supply, and the resource becomes unavailable to some people or even for all. In the oceans it is in the areas beyond the EEZ, for which there is no legislation – referred to as the "High Seas", where unsustainable exploitation regularly occurs.
7. Over time, exploitation of fish stocks has increased. Images of the total catch by fishers in the past illustrate that fish were much larger, more plentiful and more diverse than at present. In 1988 the exploitation of fisheries peaked. Since then, fish caught are smaller and fisheries are currently catching species down the food chain.
8. All the ocean's resources are finite.
   a. However, if certain populations of living resources are harvested in a way that allows for natural breeding to occur (sustainable use), the abundance of the resource can be replenished.
   b. Typically, present harvesting of seafood is unsustainable.
   c. Without stringent measures to control the harvesting of natural resources, those resources will collapse.
9. Very little is known about the full consequences of the impacts associated with industrialised large-scale fishing, such as bottom trawling, which has severely impacted upon sea floor habitats.
10. Realistic alternatives to the above impacts exist and are practised by fishers committed to sustainable harvesting. These methods include declaring "no-take" zones (Marine Protected Areas, MPAs), sustainable seafood initiatives, (SASSI) and the farming of seafood (aquaculture).
11. Fishery scientists and policy makers are contributing by scientifically evaluating resources, their habitats, and how resources can be harvested without compromising their future availability.
12. *Discussions should be encouraged about harvesting resources. Topics include: habitat damage, bycatch (impact on "non-targeted resources"), subsistence and commercial quotas, and resource research.*

36. Important Metabolic Processes

	Term 1	Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
8 hours 4 theory plus 4 hours practical	**Photosynthesis** **The Depth of this topic is at a level where learners understand that the flow of energy from the sun to the cell to maintain life.** **Respiration** **Chemosynthesis**	**Photosynthesis** *Describe the process of* ***photosynthesis*** *using words and symbols:* 1. Intake of **raw materials.** 2. Trapping and storing of **energy.** 3. Formation of **food or** other important organic compounds and their storage. 4. Release of **oxygen.** *Mention light and dark phases in relation to chloroplast. No biochemical details of light and dark phases are required.* **Importance of photosynthesis:** **1.** **Produces oxygen in the ocean**. **2.** Enables the **cellular uptake** of **carbon dioxide** and other nutrients. **3.** **Produces food** and other important organic compounds. 4. Effects of certain **variables** on the **rate** of photosynthesis: **a.** **Light-** Different wavelengths of light penetrate to greater depths, which will dictate the kinds of algae that can grow there. The presence of photosynthetic organisms in the water column will dictate the amount of consumers that can live there. b. The amount of **dissolved carbon dioxide** will dictate the potential rate of photosynthesis in the photic zone. c. **Temperature.** There is an optimal temperature for photosynthesis to occur. Higher or lower temperatures will slow or even prevent photosynthesis. The **relationship** between **photosynthesis** and **respiration** (diagram). *Define* ***compensation depth***: 1. The depth at which the oxygen and carbohydrate consumption of a producer at night equals the oxygen and carbohydrate produced by day. 2. At this depth, approximately 1% of surface light is available. 3. This represents the bottom of the **euphotic zone** and the depth will depend on the clarity of the water. (diagram to show/define: Photic, Euphotic, Disphotic and Aphotic zones) **Respiration** ***Discuss the process of respiration*** *using words and symbols.* *1.* **Aerobic respiration** in cytoplasm and mitochondria- ***brief*** *description of each phase and products:* **Glycolysis, Krebs Cycle, Oxidative phosphorylation.** **2.** **Anaerobic respiration** – production of lactic acid in animals, under certain conditions. **3.** **Importance** of respiration **ATP – energy carrier for metabolism.** ***No biochemical detail of process required;*** *each phase is mentioned with the resultant products to highlight the complex nature of the process and importance of mitochondria.* **Chemosynthesis** **1.** **This process was thought to be insignificant until the early 1990s.**	Investigate photosynthesis by showing that - starch is produced during photosynthesis - light is necessary for photosynthesis *The following investigations can be done by learners as experiments, or as demonstrations:* - carbon dioxide is necessary for photosynthesis - chlorophyll is necessary for photosynthesis - oxygen is produced during photosynthesis OR - data can be provided and interpreted by learners Design an investigation or demonstration to show that: - oxygen is used by living organisms during respiration - carbon dioxide is produced by living organisms during respiration OR - provide relevant data that can be interpreted by Learners (identify variables, suggest controls, and record observations) Internet research on extremophiles and chemosynthesis	Textbooks Living plants Suitable equipment Chemicals Textbooks Snails or seedlings Chemicals Appropriate equipment

		2. Research has shown it to be quite significant at submarine **hydrothermal vents**, in **marine sediments** and even in the **sea floor crust**. Chemosynthesis is performed by bacteria and **extremophiles** (archaea capable of living in extreme conditions, including very high **temperatures, pressures and corrosive environments)**. 3. The process can be **described in words: A typical example of chemosynthesis** involves the conversion of carbon dioxide, hydrogen sulphide and oxygen into carbohydrates and sulphates. Energy is gained from oxidation of the hydrogen sulphide. **4.** The process can also be **described with symbols:** $CO_2 + H_2S + O_2 \rightarrow (CH_2O)_x + SO_4$		

37. Nucleic Acids – DNA and RNA

Term 1		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
5 hours	**Nucleic Acids – DNA and RNA** **The Depth of this topic is at a level where learners understand foundational knowledge in order to be able to understand Genetics.**	*A basic understanding of nucleic acids and their operation and significance is required to understand processes such as cell division, growth and differentiation, sexual reproduction, genetics, and DNA or mitochondrial DNA testing and fingerprinting. The protein synthesis process should not be examined in detail; students need to be made aware of nucleic acids and their structures and their vital importance in life processes.* 1. **Structure of DNA (d**eoxyribo**n**ucleic **a**cid**) – deoxyribose** sugar, **nitrogen** bases (adenine, thymine, guanine and cytosine) and **phosphate** group to form **nucleotides**. 2. Nucleotides are arranged into strands, linked to form a **double strand** by hydrogen bonds (nucleotides join A to T, and G to C) and are twisted to form a **double helix.** 3. DNA **replication** mechanism is governed by enzymes. *4.* **DNA fingerprinting** is used to establish the relatedness of species. The basic process is extraction; PCR; gel electrophoresis; fingerprint. *Illustrate with example (eg relatedness of coral colonies in KZN to colonies in Mozambique).* 5. **Structure of RNA** (**r**ibo**n**ucleic **a**cid) – **ribose** sugar, nitrogen bases (adenine, **uracil,** guanine and cytosine). 6. Form a single strand and may be folded, depending on function and where it is found. 7. Functions of mRNA, tRNA and rRNA. 8. The importance of proteins: structural, enzymes, some hormones, cell recognition, active transport. 9. Explanation of protein synthesis: DNA provides a **template** which is **transcribed** to an **mRNA** strand. This leaves the nucleus to be processed at **ribosomes**. Specific **amino acids** are transported by tRNA strands, ensuring the mRNA strand is **translated** into a specific **sequence of amino acids**, giving rise to a **particular protein**. The process is governed by enzymes.	Build DNA model Video clips of DNA fingerprinting	DNA model kit Videos

38. Cell Division

Term 1		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
5 hours	**The Depth of this topic is at a level where learners understand the basic requirements for growth and sexual reproduction.**	*Students do not need to be able to draw or recognise individual stages. The important concepts to understand are the general processes in each cell division type, the difference between mitosis and meiosis mechanisms, and the reasons for these cell division processes.* 1. *Discuss and define:* chromatin, replication, chromosomes, gene, diploid (2n), haploid (n). 2. A chromosome or chromatid is a histone protein chain with a strand of DNA wrapped around it. 3. Different organisms have different chromosome numbers. **Mitosis:** 1. Cell undergoes a series of changes which **replicate** the **chromatin** material or DNA strands, and **condense** them to form **chromosomes**. 2. These are then arranged so that the replicated strands can be **separated** and **divided into two new cells**. 3. Mitosis enables **growth, repair and asexual reproduction**. **Meiosis:** this process occurs in special **sex organs** or structures. 1. Cells undergo two division phases after replication of the chromatin strands. 2. The first is a **reduction** division, the second a **mitotic** one. 3. *Point out that the process has stages in which genetic recombination or diversity is ensured.* 4. The end result is **four cells** with **half** the chromosomes or genetic information of the original. (**One diploid** cell **replicated** and then divided to give rise to **four haploid** cells.) 5. The haploid cells are normally **gametes**. **Male and female gametes fuse** to form a **zygote**, which grows into an **embryo** and then a **new individual**. *(This process is a bit more complicated in organisms that undergo an alternation of generations – these details can be highlighted when the relevant organism is discussed.)* 6. Meiosis is crucial for **sexual reproduction**, enabling **recombination** of genetic material within the gametes and significant **variation** possibilities through the fusion of **gametes from different individuals**. 7. There are several stages at which **mutations** can arise. *(Discuss.)*	Prepare a simulation model using play dough, paper strips, string or wire enabling modelling of “chromosomes” to show replication, division, bivalent formation, random assortment and formation of daughter cells and gametes Learners work with kits at their desks to understand chromosome replication and division	Textbook and micrographs YouTube clips

39. The Ocean Planet – The Chemistry of Sea Water

Term 2		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
6 hours	Basic Marine Sciences Chemistry **Revise Polar Bonding; Covalent Bonds; a focus on Hydrogen Bonding**	**Basic Marine Sciences Chemistry** *1. Define: matter, atom, molecule, ions, elements, compounds and mixtures.* **Polar Bonding and Covalent Bonds in Water** 1. Chemical bonds hold water molecules together: one **oxygen** and **two hydrogen** molecules. 2. The electrons in the molecule are **shared** by the atoms. 3. In a covalent bond the electrons spend more time, on average, **closer to the oxygen nucleus** than the hydrogen nucleus. This is a result of the geometry of the water molecule, with H atoms having a higher electronegativity difference in relation to O atoms. 4. This pattern of unequal association results in a charge separation in the water molecule. The section closer to O has a partially negative charge and that closer to H has a partially positive charge. Hence water has polar covalent bonds. **Hydrogen Bonding** 1. A hydrogen bond is formed when a charged part of a molecule having polar covalent bonds forms an electrostatic interaction with a substance of opposite charge. Molecules that have **nonpolar covalent bonds** do not form hydrogen bonds. 2. They are considered weak bonds as they are easily formed and broken under normal conditions. 3. These bonds are extremely important in biological systems. They stabilise and determine the structure of large macro-molecules such as proteins and nucleic acids. They are involved in the mechanism of enzyme catalysis. 4. Hydrogen bonding between water molecules results in various physical properties – for example, ice floating. 5. The property of ice floating on water is crucial in cold aquatic ecosystems, because floating ice partly insolates the underlying water, enabling aquatic organisms to survive the cold season. (This would not be possible were a pond to freeze from the bottom up.)		Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

40. Energy Transmission through Water- Sound

Term 2		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**Energy transfer** **An introductory level of understanding is required. Learners should understand how to reference to Sound energy traveling in water in a discussion for example on a topic concerned with the impact that sound has on whale communities.**	**Transmission of Sound Energy Through Water** 1. Sound travels through **particles bumping** against each other as they vibrate. The medium passes on the energy, movement or pressure-wave away from the source. 2. **Sound does not travel through a vacuum**, as in a vacuum there are no particles to bump against each other. 3. In water the particles are much closer together than in air. Sound waves therefore travel further – and four times faster – through water compared with air. 4. More energy is required to start a sound wave in water than is required to start a sound wave in air, because water is denser. 5. The **speed of sound** is influenced by temperature, pressure and the salinity of water. The warmer or more saline the water, the faster the speed of sound travelling through it. 6. **Echo sounders (SONAR)** use sound to measure the depth and shape of the ocean floor, and to locate objects on the sea floor. Density, currents and suspended particles affect SONAR and can create false readings. Researchers need to take this tendency into account when interpreting SONAR data.	How do various birds adapt to refraction and pressure when diving from air into water?	Excerpts from videos

41. pH

Term 2		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**pH scale** **Learners should understand the detail relating to pH and its application in discussions about water quality and Ocean Acidification.**	1. The pH scale indicates acidity and alkalinity by measuring the concentration of hydrogen ions in a solution. 2. A pH of 7 is neutral. There is an increase of **acidity from pH of 6 to 1**, and there is an increase of **alkalinity from pH of 8 to 14**. 3. When CO_2 combines with sea water it forms carbonic acid (H_2CO_3). 4. The carbonic acid dissociates to form bicarbonate (HCO_3^-) and hydrogen ions (H^+). The bicarbonate ion can further dissociate into a carbonate ion (CO_3^{2-}) and another hydrogen ion. 5. These molecules and ions exist in equilibrium. 6. The ⇄ arrows mean the reaction proceeds to the right or to the left to reach equilibrium, thus both producing and taking up hydrogen ions. 7. This is illustrated in the equation below: $CO_2 + H_2O \rightleftarrows H_2CO_3 \rightleftarrows HCO_3^- + H^+ \rightleftarrows CO_3^{2-} + 2H^+$ 8. The above equation describes a series of reactions that allows CO_2 to act as a **buffer**. 9. This means that CO_2 prevents sudden changes in acidity or alkalinity of a solution. 10. The buffering capacity of CO_2 is important for organisms, most of which require a steady pH and chemistry of sea water for their life processes – which depend in part on pH. 11. The pH range of sea water is 7.5 to 8.5, with an average of 7.8.	Using a hand-held pH meter, test the pH of commonly found liquids	Handheld pH meter Vinegar Lemon Juice Coke Black coffee Sea water All-purpose cleaner (eg Handy Andy) Milk

42. Currents

Term 2		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**Currents** Learners should understand the processes involved in current development and patterns. They should understand how currents are intricately involved in Ocean habitats and trends found.	1. **Wind** blowing over a water body sets the surface layer in motion. 2. The **surface layer** is pushed or dragged by the prevailing wind. 3. Wind blowing over the open ocean drives **large-scale surface currents** in a (nearly) constant pattern. 4. Relative to someone who stands looking at the ground, the earth rotates in an anticlockwise direction in the southern hemisphere, and in a clockwise direction in the northern hemisphere. 5. **Coriolis Effect**: the deflecting force that acts on a body in motion owing to the rotation of the earth. 6. Moving water is deflected by the Coriolis Effect. In a similar way, the Coriolis Effect influences moving air. *(Explain using diagrams or models.)* 7. Deflection caused by the Coriolis Effect occurs in a leftward direction in the southern hemisphere, and to the right in the northern hemisphere. 8. Large **surface current gyres** are formed in the ocean basins – anticlockwise in the southern hemisphere and clockwise in the northern hemisphere. 9. Water moves more slowly than air. The deflection experienced by water is far greater than the deflection experienced by air. 10. When deflection of water is compared with that of air, a difference of up to 45° is noted in the deflection of these two mediums. 11. Currents have been named the “rivers of the sea”. 12. Changes to a current’s strength and location differ in response to the variations in seasonal wind as well as the latitude in which the current is found. **Patterns of Wind-Driven Currents** 1. **The South Atlantic** a) In the South Atlantic, westerlies continue in the Southern Ocean in what is called the West Wind Drift. b) South-East Trade Winds move water in a westerly direction. c) The Bulge of Brazil splits the South Equatorial Current. d) Most of the water in the Equatorial Current is deflected over the equator, northwards towards the Caribbean (Florida) where this water joins the Gulf Stream. e) The other portion of the current, the South Atlantic Equatorial Current, moves south of the Brazilian bulge on the West Atlantic, forming the southward-moving Brazil Current. f) The Benguela Current moves north in the East Atlantic, completing the South Atlantic Gyre. **2. North Atlantic** a. In the North Atlantic, westerlies move water eastwards in a current called the North Atlantic Drift. b. The NE Trades push the water to the west, forming the North Equatorial Current. c. The northward-moving water in the west of the North Atlantic forms the Gulf Stream. d. The Gulf Stream is fed by the North Equatorial Current, the South Equatorial Current and the Florida Current.	CO_2 Global warming	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic Refer to NOAA resources which are freely available for teaching purposes and covers more than is required in this topic. Eg Perpetual Ocean

e. On the western side of the North Atlantic is the southward-moving Canary Current. This completes the clockwise-moving North Atlantic Gyre.

3. Indian Ocean Currents

a. The Indian Ocean is predominantly a southern hemisphere ocean.

b. South-East trade winds push water to the west, creating the South Equatorial Current which splits in the region of Madagascar. Firstly the Westerly trade winds push water back towards Australia where it joins the West Australia current completing the South Indian Gyre. Secondly the west part of the split forms the Agulhas current which travels southwards from there along the African coast.

c. The summer (June) monsoon winds move water eastward.

d. Winter winds blow in a westerly direction.

43. Genetics

	Term 2	Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
5 hours	**Genetics** **The Depth of this topic is at a level where learners understand the basic concepts of genetics at a simple introductory level.**	**Genetics** is the scientific study of how genes are passed down from parents to offspring. Most of the original work in this very significant field was done by **Gregor Mendel** in the 1860s. 1. In conventional Mendelian inheritance, each characteristic has a **pair of genes** in a **diploid individual**. **Only one gene can be expressed,** and this expression follows a **set pattern**. **2.** **Genetic predictions** use an understanding of meiosis and the above definitions. *Simple monohybrid crosses can be shown, using marine examples, but the ability to do* ***worked examples is not required.*** ***3.*** *Define:* ***allele, dominant, recessive, phenotype, genotype, homozygous, heterozygous, monohybrid cross, dihybrid cross, independent assortment, polygenetic characteristics, incomplete dominance, codominance, continuous and discontinuous variations.*** 4. *Discuss:* ***genetic engineering (modification).*** *Discuss the concepts, not the details.* *Stress that not all genetic mechanisms are fully understood and this is an* ***ongoing field of research and discovery.***	Find a worksheet on genetically governed external features in **Cichlid Fish** and humans. Do a statistical study using the class, grade or school. Present the results in graph form.	Relevant YouTube videos

44. Viruses and Bacteria

Grade 11	Term 2	Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**Viruses** 1. Technically, viruses are **not living** organisms. Their significance in the ocean has only been **established recently** with the ability to micro-filter sea water samples using unglazed porcelain filters. 2. They are **extremely small**, ranging from 0.02 to 0.2 micrometres. 3. They have been found to **inhabit sea water** that houses cyanobacteria and phytoplankton in **concentrations of 10 million to 100 million per ml** of sea water. **4.** Viruses are classified as particles rather than organisms, as they are **obligate parasites or holoparasites, which exhibit metabolic activity and reproduction only when infecting a specific host.** 5. Structure of a **bacteriophage –** *Provide a diagram* 6. **Reproductive cycle** of bacteriophage. 7. Viruses are responsible for **destroying large amounts of bacteria** as part of the **microbial nutrient loop;** they also destroy **phytoplankton**, causing them to be **lost from food chains.** **Bacteria** *Discuss basic structure and some significant examples (diagram to show definitive features*). **1.** Bacteria are **prokaryotic**. **2.** Important **decomposers**, vital in all nutrient cycles found everywhere in the oceans. **3.** **Anaerobic bacteria** can function in **absence of oxygen**. **4.** **Extremophiles** can live at **great temperature and pressure**, even deep in ocean floor sediments. **5.** **Chemosynthetic bacteria** around **hydrothermal vents** drive unique **deep water food webs.**	Show micrographs Grow bacteria on agar plates and investigate under a strong microscope, using gram + and – stains	Slides Photographs Diagrams Charts Video clips Agar mix Petri dishes Microscope

45. Cyanobacteria and Phytoplankton (Microalgae)

Term 2		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
3 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**Cyanobacteria** 1. These organisms are referred to as **picoplankton;** they are 0.2 to 2 micrometres in size. 2. They were **discovered only recently**. 3. They are responsible for **huge levels of photosynthesis**, but are **not available to conventional food chains** as they are too small to be collected by consumers. *4.* They enter the **microbial nutrient loop.** *(Explain and draw the microbial loop.)* **Diatoms – Members of Chromista** 1. These are single cells with clear **silica (glass) walls** called a **frustule**. 2. The frustule consists of two **closely fitting halves or valves.** (*Diagram and photos to show structures*). 3. **Perforations in the frustule** enable **transport** of substances into and out of the cell. 4. Perforation patterns are specific to each species. 5. **Chlorophyll** and **accessory pigments** colour diatoms **yellow-green**. 6. Food is stored as **fatty acids and oils**, which help buoyancy. 7. Diatoms undergo **binary fission (mitotic divisions)** to form chains, with new individuals emerging smaller and smaller until silica walls weigh them down and they sink. 8. A **sexual reproductive** process gives rise to new large **auxospore**, which can **stay dormant** until conditions are **favourable**, then forms frustule and starts the asexual cycle. 9. Dead cells litter the ocean floor to form thick layers of **silica-rich mud**. **Coccolithophores – Calcium-forming Chromista.** **1.** They are single-celled with shields of **calcium carbonate** on the cell walls. (*Photos and diagrams to show structure and functions.*) **2.** Found in bright light **near surface**; shields may act to reduce incoming light. **3.** Dead cells are deposited in thick layers on the sea bed, forming **chalk and limestone**. **Dinoflagellates – Members of the Protista** **1.** They are single-celled, with two **flagellae** enabling them to rotate and move up and down in water column. (*Diagrams and photos to inform a discussion of structure and function.)* **2.** Some inhabit **ectoderm of coral polyps as mutualistic symbiotic partners (Zooxanthellae)**. They photosynthesise, using nutrients from the polyps, providing food for both. **3.** Can reproduce rapidly in good high-nutrient environments, to form **harmful algal blooms (HABs**), which are visible as “red tides”. Some form toxins that are harmful to consumers or humans who harvest affected filter feeders. **4.** The HAB types are also **bioluminescent** (*define*), glowing blue or green when they are subjected to force (for example, a propeller or paddle striking the water or breaking waves). *Emphasise the significance of Phytoplankton, ecologically, as a massive biomass of primary producers, feeding most oceanic food webs and producing between 50% and 80% of the world’s oxygen.*	Photo identification exercise (or with a microscope if suitable samples can be obtained) Include drawing exercise in the practical	Phytoplankton ID charts. Light microscopes or USB microscope device

46. Seaweeds (Macroalgae) – Introduction Green and Red

Term 2		**Strand – Marine Biology**		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
7 hours	**Seaweeds (Macroalgae)** The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**"Seaweed" is a common name for macroalgae.** The term "sea plant" is used in some texts because authors view "weeds" as alien and problematic. Strictly speaking, "plants" refers to members of the Kingdom Plantae, but not all macroalgae belong to this group. The classification of macroalgae is in a state of flux, but prevailing research classifies them under Chromista and Plantae. Until recently, they were all classed as Protista. **Macroalgae can be classified in three groups, based on the photosynthetic and accessory pigments they contain: green, brown and red.** These are often seen in the colour of the seaweed, but may be masked. **Accessory pigments** enable **different wavelengths** of light to be absorbed and passed to chlorophyll, which normally utilises **red and violet** light. 1. **Macroalgae grow** on solid structures, mainly rocks**, in the euphotic zones** of the ocean and **in rocky intertidal zones.** *(Revise the spectral colours and how they are filtered out as water depth increases, and the implication for plants. Define* ***benthic*** *and* ***epiphytic****.)* 2. They need to **attach themselves to the substrate,** and possess a structure that allows a **broad surface area for photosynthesis** and also helps the algae to cope with abiotic stresses in their specific habitat. These stresses include wave action, predation, desiccation, competition and sand inundation. 3. As they are normally covered by water, they can absorb nutrients, water and carbon dioxide through all their surfaces. This renders specialised **roots and complex vascular or conducting tissue unnecessary**. 4. Shapes include filaments, cylinders, branched or feathery structures, thin sheets and encrustations. Depending on their specific habitat, they are flexible, streamlined, abrasion resistant and strong. 5. Algae are very **efficient producers**, but are limited in size and abundance (but **not necessarily diversity**) in environments where temperature is high and/ or nutrient levels are low. Consequently, they are **abundant on cold-current shorelines**, where **upwelling** provides ample nutrients, but are greatly **reduced in tropical regions** where the temperature is high and nutrient levels are low. **6.** Algae have **complex reproductive cycles**, often involving an **alternation of generations.** (*Illustrate this with a diagram to show typical alternation)*. The (2n) **sporophyte** produces (n) **spores** through meiosis, germinating to (n) male and female **gametophytes,** producing (n) gametes which fuse to form (2n) zygote, which grows to become a sporophyte. **7.** Although we are far more familiar with these relatively visible marine algae, and they are **significant producers along certain coastlines**, the group accounts for **only about 5% of ocean productivity, with the rest being attributed to (less visible) phytoplankton.**	Visit to rocky shore or aquarium to see other sea plants in situ Plants and structures selected for discussion should be recognisable from diagrams and photographs. Ideally they should be highlighted for study during field trip Paper chromatography of crushed samples: a comparison to observe different pigments in the three groups	Pestle and mortar Suitable solvent Filter paper Beakers Fresh samples of algae

Green Algae

Term 2		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**Green Algae** The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**The green and red algae are both regarded as Plantae.** Although they can form large multicellular structures, these are **thallus** structures exhibiting **very little or no cell differentiation.** **Green Algae fall within the Division Chlorophyta:** 1. **Green Algae** are the most diverse group of algae. 2. They exhibit a range of algal forms. *(Photos and diagrams.)* 3. They have **chlorophyll a and b** and the **same accessory pigments** as the terrestrial green plants, such as beta carotene (yellow) and some xanthophylls (yellow/brown). 4. Consequently, they **use the same part of the light spectrum** for photosynthesis as terrestrial plants, and are found **close to the surface of water or in intertidal zones.** 5. Their cell walls are made up of **cellulose**. 6. They store food as s**tarch, fats and oils**. 7. Chloroplasts are enclosed by a **double membrane**. 8. Most reproduce with a typical alternation of generations, with the sporophyte and gametophyte appearing similar **(isomorphic**), and the gametes looking the same as each other (**isogametes**). **Example: Sea Lettuce** (*Ulva sp.*) *(Show photos and diagrams). Note:* ***If the prescribed examples of seaweeds are not available, a suitable local example should be selected and discussed in similar detail.*** 1. **Sea lettuce** forms flat sheets, generally two cells thick. 2. It is found all along the South African coastline in **calm gullies and high shore rock pools**, where **wave action** is **minimal**. 3. It can survive a **range of temperatures, salinities and chemical** concentrations. 4. All of its cells can photosynthesise and divide, so growth is rapid, making it an excellent **pioneer** in recently cleared areas (sand inundation, storm scouring etc.) *(Define and discuss* ***Succession****.)* 5. The exposed upper sheets **can dry out** to resemble dark cellophane.	Live samples of the prescribed examples should be obtained for examination Visit to rocky shore or aquarium to see other sea plants in situ	*photos and diagrams* Sea lettuce samples

Red Algae

Term 2		Red Algae Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**Red Algae** The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**Red Algae fall within the Division Rhodophyta:** 1. They have high species diversity, **accounting for almost two thirds** of all algae. 2. They exhibit all the typical algal forms, many being thick and rubbery and some being partly or highly calcified. These structures are all adaptations to specific habitats. (*Provide photos and diagrams.)* 3. They possess chlorophyll-a and **red pigments** including **phycoerythrin,** which absorbs **blue light.** Blue light penetrates deeper through water than any other colour of the light spectrum. The **phycoerythrin traps energy** for the chlorophyll-a in the chloroplasts to be able to function normally. 4. They can grow at **depths of 40 cm to 250m,** depending on water clarity, but are also well represented **in shallow water and into the intertidal zone.** 5. Their cell walls contain cellulose, **agars and carrageenans** (all complex polysaccharides). 6. They store food as a complex starch, **floridian starch,** similar to animal glycogen. 7. Chloroplasts are bound by a **double membrane.** 8. Many species are **epiphytes** on other plants, normally kelp. 9. While some red algae reproduce by means of an alternation-of-generations cycle, many exhibit a **third generation** between the gametophyte and sporophyte generations. This is known as a **carposporophyte** generation. (*Details are beyond the scope of this curriculum*.)* **Example** (West and South Coast)**: Purple Laver** *(Porphyra capensis)* (*Provide photos and diagrams.*) 1. **Purple laver** grows high up in the intertidal zone, close to the spring high-tide level, and is found along most of the South African coastline except for the far North East. 2. The **sporophyte is microscopic** and it is the **gametophytes that are prominent.** 3. These grow as clumps of **overlapping thin, folded sheets or fronds**, up to 15 cm in length. 4. The male fronds have a yellowish fringe whereas the female fronds have a pink fringe. 5. The exposed upper sheets **can dry out** and then resemble dark cellophane. 6. Extreme desiccation is possible by losing fluid from a gel-like material in between the cells, rather than from cells themselves. The dry top layer **insulates** those below. 7. Purple laver can grow in lower intertidal zones as well, but tends to be removed by aggressive **grazing**. **Example** (East Coast)**: Stalked Roseweed** *(Rhodymenia natalensis)* (*Provide photos and diagrams.*) 1. **Stalked roseweed** is found mainly on lower shore rocks and into the infratidal zone. It is found all along the coastline but is particularly common on the KZN coast. 2. This bright red seaweed spreads across rocks as a branched rhizome-like **stolon,** a bit like spreading grass**,** from which "hairy" stalks grow. These flatten out into dichotomously forked fronds at the ends.	Live samples of the prescribed examples should be obtained for examination Visit to rocky shore or aquarium to see other sea plants in situ	Fresh Purple Laver

		Note for text writers:** *The sporophyte (2n) produces spores (n), giving rise to isomorphic (n) male and female gametophytes. The male gametophyte releases sperms which are chemically attracted to* ***eggs in cysts on the *fronds of* ***female gametophyte****. After fertilisation, the zygote grows to form a microscopic multicellular (2n)* ***carposporophyte in the cyst****. All the carposporophytes produce* ***(2n) carpospores*** *by mitosis and these are released to sink to the surrounding rock, where they grow into* ***(2n) sporophytes****. This third generation capitalises on the less successful sexual phase by giving rise to far more potential sporophytes through mitosis.*		

47. Brown Algae-*Chromista*

	Term 3	Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**The significant brown algae fall under the Kingdom Chromista,** Division **Ochrophyta,** Class **Phaeophyceae.** **1.** They form multicellular **thallus structures,** but the larger varieties may undergo some **cell differentiation to form tissues**. ***2.*** They exhibit all typical algal forms, but some species (**kelps**) grow very big (up to 70 m long) and exhibit a level of specialisation with **differentiated body parts – holdfast, stipe, fronds and pneumatocysts (bladders)**. (*Provide photos and diagrams.)* **3.** They also possess the **photosynthetic pigments** chlorophyll-a **and -c,** as well as, typically, **fucoxanthin,** giving the algae a brown colour. This enables them to utilise colours from the middle of the light spectrum and to grow at greater depths. **4.** They can grow at **depths of 40 m to 250 m,** depending on water clarity, but are also well represented **in shallow water and into the lower intertidal zone**, where wave action can be significant. 5. Their cell walls contain cellulose and **alginic acid (alginate),** an insoluble gelatinous polysaccharide. 6. They store food as a complex polysaccharide called **laminarin**. 7. Chloroplasts are bound by a **quadruple membrane,** the outer two being associated with the **endoplasmic reticulum.** This strongly suggests an endosymbiotic origin. 8. Simple brown algae reproduce by a typical alternation of generations, while others (eg sea bamboo) have a large sporophyte (the visible kelp), but **microscopic (reduced) gametophytes** that live only long enough to release **gametes**, which fuse to give rise to new **sporophytes**. Other more advanced forms have a much reduced gametophyte on the sporophyte, or no visible gametophyte at all, appearing to produce gametes in the same way land plants do. **Example** (West and South Coast)**: Sea bamboo** *(Ecklonia maxima)* (*Provide photos and diagrams.)* 1. **Sea bamboo** is the largest kelp variety found on the South African coastline and the primary component of the West Coast Kelp Forest ecosystem. Distribution is limited to the western coastline of SA from Namibia to Cape Agulhas. 2. It grows in shallow water below the low tide mark, down to a depth of about 15 m. 3. It anchors firmly to reefs with holdfasts, and grows hollow stipes until the surface is reached, after which the top expands to form a gas-filled bladder. 4. A short flat stalk forms at the top of the bladder, from which flat strap-shaped fronds grow. These can grow up to 13 mm per day in ideal conditions. **Example** (South and East Coast)**: Long-leafed Sargassum** *(Anthofycus longifolius)* 1. This noticeably brown seaweed is abundant in deeper gullies and on rocks below the low tide mark, all along the South and East Coast. 2. It has a hard, twisted, stem-like base, which flattens further along to give rise to blade-like fronds. 3. The fronds have serrated margins with spur-like outgrowths. 4. Alternating with the fronds are bladders (for floatation) with leafy clusters at their ends. 5. They have special reproductive branches, resembling small clusters of berries.	Live samples of the prescribed examples should be obtained for examination Visit to rocky shore or aquarium to see other sea plants in situ	Fresh Sea Bamboo

48. Vascular plants

Term 3		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**Relatively few Tracheophyta plants (vascular or true land plants) grow in marine settings. Some can be found in shallow calm sea beds, but most are limited to estuaries.** They are all representatives of the Division **Magnoliophyta (previously Angiospermae)** or flowering plants. **Sea or eel grasses:** 1. Most marine magnoliophytes **resemble grasses**, with underground stems or **rhizomes** producing **upright branches** with **long flat leaves**. 2. Their entire **life cycle** (flowers, pollination and seed dispersal) **happens underwater**. 3. Estuarine versions can cope with varying **salinities** and being exposed to **desiccation** at low tides. 4. South African examples are estuarine, and include ***Zostera capensis*** and ***Thalassodendron ciliata***, both referred to as **eel grass**. (*Provide photos and diagrams.)* **Mangrove trees:** These are more noteworthy but are limited to **tropical and subtropical tidal estuaries,** where they can form dense forests. Some **common features** include: **1.** **An extensive root system** to provide anchorage. **2.** Some roots which **extend above the water** level to enable **gaseous exchange**, either upright outgrowths or loops (**pneumatophores**) or **prop roots** growing from the trunk above the high-tide level. **3.** To deal with **salt**, some **filter it out at the roots** and add any excess to old leaves that are dropped. **4.** Others take in the salt water and have **glands on their leaves** to **excrete** a saline fluid. **5.** Most produce **seeds** with long **spear-like outgrowths (hypocotl),** enabling them to stab into the mud and take root when dropped. *6.* SA examples are limited to northern KZN, and include the black (Bruguiera gymnorrhiza), white (*Avicennia marina*) and red (*Rhizophora mucronata*) mangroves. (*Photos and diagrams.)* *7. Illustrate and study reproduction in flowering plants, particularly mangroves, highlighting the flowers, pollination, mechanism of fertilisation, and production of seeds. Include suitable diagrams. Only general reproductive structures need to be known; do not give detail on alternation of generations.*	Mentioned plants and structures should be recognisable from diagrams and photographs, and ideally highlighted for study during a field trip Flower dissection	Videos Internet Fresh flowers

49. Mollusca and Mollusc Classes

Grade 10	Term 4	Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
7 hours	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved	***-Refer to the Phylogenetic tree to place this Phylum in its Evolutionary context.*** **The molluscs are a very morphologically diverse group.** *(Use labelled diagrams to illustrate detail.)* 1. All are: a. **Triploblastic**, **coelomate.** b. Unsegmented. c. Mainly **bilaterally symmetrical.** d. At an organ level of organisation, all have a through gut, possess **an open blood system** and use muscle contraction and hydrostatic pressure to move. 2. Most have: a. **Soft body; divided into a** head, foot, **visceral mass and mantle;** protected by externally secreted **shell.** b. A **radula** tongue. c. **Ctenidial gills** and **osphradium.** d. A reasonable level of **cephalisation**. 3. Some have: a. A highly **modified radula.** b. Advanced nervous coordination. c. “Lungs”. d. A reduced shell, modified internal shell or no shell. 4. The **different shapes and configurations** of the **shells** (or the absence thereof) are the basis for **the main distinction between classes**, coupled with some significant aspects of anatomy. a. Shells consist of **three layers**: **periostracum** (protein and organic mix), **prismatic and nacreous** (mostly $CaCO_3$ in various crystalline orientations). b. All shell material is produced by cells in the mantle. c. **Shells enable** protection, streamlining, storage of water, ability to burrow, and other innovations. 5. **Locomotion:** a. Varies greatly, even within individual classes from sedentary, with various ways of attaching. b. to **slow moving** on a muscular foot. c. **to floating**, **swimming** and **jet propulsion**. 6. **Nervous coordination:** a. In many molluscs this function is fairly simple. b. Molluscs have a **cerebral ganglion** and some sense organs (varies by class). c. They have a **double ventral cord** with branches and limited ganglia. 7. **Nutrition:** a. The **diet** of molluscs varies hugely, as does the means to take in food. b. In all molluscs, once food enters the **through gut**, it travels through the oesophagus to a crop and stomach, and then to the intestine where absorption takes place.	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) and shell collections Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

		c. Salivary glands and a large digestive gland add **enzymes for extracellular digestion.** d. However, many molluscs have an elaborate sorting system and rely on **intracellular digestion** in tubes within the digestive gland. e. Herbivores have characteristically long guts (up to 8 times their body length). 8. **Circulation:** a. An **open blood system** exists. b. This consists of a few reduced haemocoels and some blood vessels. c. Pigment **haemocyanin or -globin** is present in the plasma. d. A simple heart pumps blood through gills and around the body. 9. **Gaseous Exchange:** a. Most molluscs have a chamber enclosed by the mantle in which **gill-like structures** are found. b. They are covered with a **ciliated membrane**. c. This membrane enables water to be directed in an **opposite direction to the flow of blood inside the gills.** d. This ability to "**self-ventilate**" is unique to molluscs and earns them a distinct title: **Ctenidia.** 10. **Excretion and osmoregulation:** a. Vary with the lifestyle and habitat of the animal. b. Nephridial system in primitive classes. c. Most have a type of **kidney**, which regulates water balance and waste removal via a duct to the outside. **11. Reproduction:** a. Most molluscs are unisex. b. Fertilisation of eggs is external. c. Eggs hatch as meroplanktonic trochophore or veliger larvae. d. The larvae settle to the sea floor when they reach maturity. e. **Some species, particularly cephalopods,** have internal fertilisation and lay eggs, from which miniature adults hatch.		

Marine Mollusc Classes

Grade 10	Term 4	Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
4 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**Polyplacaphora (chitons)** *(Provide diagrams and photos only to highlight definitive features for each class.)* 1. Chitons are **limpet-like** animals, which glue themselves to rocks in the same way: a large flexible foot secreting a thin layer of mucus. 2. Their **shell is divided into 8 plates**, providing great flexibility and protection. 3. They lack eyes or "feelers" on their head, but have numerous **simple eyes** within the periostracum. 4. Most chitons spawn, leaving gametes to fend for themselves as planktonic larvae before settling as tiny versions of the adults. **Gastropods 1 (limpets, winkles, whelks and slugs)** 1. These is by far **the largest mollusc class,** with some **35 000 species.** 2. They are typical in structure, having a head with eyes and sensory tentacles, a large muscular foot, and a **twisted visceral mass** above. 3. The origin of this twisting is in the larval stage, resulting in a typically coiled shell and a figure-8 twist in most of the internal systems (gut and nerve cord). 4. This torsion twists the mantle cavity, gills and anus to the front, over the head. It is useful for **the gills and osphradia** (gills modified to be chemical sensors). It causes complications with regard to the anus and potential fouling of the gills. 5. The problem has been solved by the development of a hole at the top, or holes along the side, modified gills around the foot or a single modified gill on the inhalant side, and an anus on exhalent side. 6. **Most are herbivores**, using the radula to rasp in small bits of plant. Carnivorous whelks have modified radulas to break up food. 7. Predatory whelks may also have **modified salivary glands** to secrete acids, with which they bore through shells of other molluscs. 8. Cone shells have a sharp, venomous tooth-like radula. 9. The bubble raft snail (*Janthina sp.*) floats with plankton community and feeds on bluebottles. 10. The one class **Pulmonates** moved to land. Gills were lost and the vascular mantle cavity acts as a lung. Some returned to the ocean (False Limpet). **Gastropods 2 (Sea slugs and nudibranchs)** 1. Have **rudimentary shells**, often under the skin **or completely lost**. 2. They have a relatively **bilateral structure** and are thought to have burrowing ancestors; this helps them to dig and they require no protection; gills have been lost (having external gills would lead to them being fouled with sand or silt while burrowing)	**Visit an Aquarium or Shell museum to explore this incredibly phylum**	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

		3. On the surface they have re-evolved **gills as finger-like folds** on the skin **or feathery folds** around the anus; these folds increase the surface area. They have also developed **rhinophores instead of osphradia.** 4. **Protect themselves** with camouflage, poisonous secretions (bright warning colours) and even recycled stinging cells and spicules from their prey. 5. All **are hermaphroditic**, laying internally fertilised eggs in mucous strings or sheets. **Bivalves (mussels, clams, oysters and scallops)** 1. This class is typified by having **two shells joined with a hinge**. Almost all are **filter feeders**, with the enlarged pair of gills doubling up as filtration plants. The head and sense organs have been lost. 2. Mussels may **burrow in sand using a spade-like foot**. Special siphons reach to the surface to bring in clean water. Others attach to rocks with **byssal threads**. 3. **Clams** fasten to the substrate, **oysters** cement one shell to their home rock once the larvae settle, and **scallops** lie on the seabed (some swim using their shells as bellows). **Cephalopods** (Octopus, Squid, Cuttlefish and Nautilus) **-**They have heads and tentacles**.** 1. This group has evolved from the basic plan to be **fast-moving** and distinctly **bilateral**. 2. Foot has become **tentacles**; a mantle encloses the organs and is used to create **jet propulsion**. 3. Shell can be external, internal, modified or absent. 4. Tentacles catch prey, **beak-like mouth** cuts up the food. 5. **Cephalisation** is advanced, with well-developed sense organs and nervous coordination. These are the most **intelligent of invertebrates**. 6. Most have a skin with **chromatophores, iridiophores and papillae.** 7. Many have elaborate courtship rituals and internal fertilisation; they lay eggs that they might look after. 8. **Nautilus –** Closest to the fossil ancestors, with prominent multi-chamber shell. 9. **Cuttlefish –** Internal chalky shell with microscopic chambers. 10. Fluid-filled chambers are a buoyancy aid: salt is extracted, pressure drops, and gas forms. 11. **Squid –** Shell is reduced to a flexible pen. Buoyancy is achieved by means of ammonium concentration in tissue. 12. **Octopus –** Has no shell at all. Hides in rock crevices, swims in an emergency. Masters of camouflage.	Dissection of a black mussel. A specimen may be collected and euthanased by refrigeration; or download and view virtual dissections Squid dissection, using purchased frozen squid; or download virtual dissections	Fresh mussels Internet Frozen squid Internet

50. Marine Life Cycles: Larvae

Term 3		Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
1 hour	**Marine Life Cycles: Larvae** **The Depth of this topic is at a level where learners understand** **How various organisms have adapted to different stages in their life cycles for survival purposes.**	1. For most invertebrates and many fish species, once eggs have been fertilised, they **float with local currents** or sink to the ocean floor. 2. Once hatched, there will be various **motile larval** stages. 3. Different phyla have **distinctive larvae,** such as Planula, Trochophore, Velliger, Nauplius and others (as discussed in the sections on individual phyla). **4.** Generally these larvae **circulate in the water column of the planktonic body**, as **meroplankton.** **5.** They then **swim or settle out** once they reach a **particular stage** or encounter the **correct cue**. **6.** Cues could be **chemicals released by a suitable substrate**, or **adults of the same species.** **7.** These complex planktonic life cycles make it very **difficult to culture** certain commercially important animals (such as rock lobsters). **8.** In some animals, eggs are kept **on or in the body of an adult**, to hatch before entering the planktonic circulation. **9.** Larval development strategies can be classified according to the **length of time,** if any, that the larva spends in planktonic circulation. **10.** Each strategy provides for different levels of **distribution** and ensures that developing **larvae do not compete with the adult** population for food.	Choose two animals having larval stages in their life cycle, to illustrate the concept This could be a good section for students to investigate further and prepare a short article or presentation	Internet and YouTube videos

51. Bryozoa

Term 3		Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
1 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	***-Refer to the Phylogenetic tree to place this Phylum in its Evolutionary context.*** Although regarded as a "minor phylum", this classification refers more to the size of the organism than the distribution. **Bryozoans are typically colonial, often polymorphic and form colonies that are flat sheets, upright folded sheets, or upright branched structures.** 1. The majority are tropical, but there are examples from **almost all marine ecosystems**. 2. They grow **on any available surface**, especially **where there is a current**. They can be found on rock surfaces, mollusc shells, sea plant fronds, and the hulls of ships and boats. 3. When they **colonise man-made structures**, they can **cause drag** and need to be cleaned off; hence they are known as **fouling organisms**. Some **alien invasive species** can be especially problematic. 4. The colony consists of individuals termed **zooids**, often **clones** of a single individual. 5. Zooids are about 0.5 mm in size; they grow and divide rapidly and build up the colony in a pattern unique to each species. 6. Colonies average 10 cm in extent, but range from 1 cm to more than 1 m. 7. The most typical zooid in a colony is the feeding zooid **(autozooid**). 8. Individual autozooids produce a **box-like body wall (cystid),** inside which they remain. 9. The body wall material may be soft or contain $CaCO_3$ (the latter resembling miniature corals). 10. Inside the cystid is a coelom containing the rest of the zooid (**polypide**). 11. An opening on the top surface of the body wall enables the autozooid to extend a crown of **cilia-covered tentacles (the lopophore)** to **filter feed** particles into a central mouth. 12. There is a U-shaped **through gut**, leading to an anus just outside the lopophore. 13. Other zooids in the colony **(heterozooids)** have specific **modifications or appendages** to help the colony with: a) Protection b) Reproduction c) Colony growth d) Water circulation across the colony e) Cleaning off sediment deposits.	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible, or arrange lesson or course with nearest aquarium As a project, Virtue discs can be cultured and bryozoan colonies identified	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

52. Population Dynamics

Term 3		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	**Population dynamics** **The Population Dynamics topic is one for which discussions and applications should be done at a deeper level. The content should be applied as other Marine Biology and Ecology topics are introduced.**	**Population dynamics** is the branch of life sciences that studies the size and age composition of **populations** as **dynamic** systems, and the biological and environmental processes that affect those populations (such as birth and death rates, immigration and emigration). Key terms include **demographics, population size, population density, population distribution** and **age structure** Patterns of dispersion: 1. Nucleated: near resources (food, shelter, living space) and good abiotic conditions. 2. Uniform or regular dispersion: through, for example, competition for territory (eg penguins). 3. Random dispersion: absence of strong attractions or repulsion. Population size is dynamic 1. An **increase** occurs through births (natality) and immigration. 2. A **decrease** occurs through deaths (mortality) and emigration. Deaths can be subdivided into natural causes versus predation or hunting and human-induced cause. Zero population growth (excluding immigration or emigration) implies a balance between births and deaths. Key terms related to population growth: 1. **Birth rates, death rates** and **nett overall rate of growth** in relation to a **base population**. 2. **Geometric or exponential** growth patterns. 3. **Logistic** growth curves, equations and carrying capacity (K). 4. **Predator–prey** relationships. 5. Variables that are either **density-dependent** (predation and overexploitation of resources – food, light and space) or **density-independent**. 6. **Resource fluctuation and variability**. 7. **Age structure graphs**. (*Students should be able to discuss the above terms.)*	Population growth simulations Sustainable vs unsustainable resource harvesting simulations and games	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

53. South African Marine Ecosystems

Term 3		Strand – Ecology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**SA Marine Ecosystems** **Learners should understand the South African Context and conditions under which Marine Sciences can be researched. This topic as laid out in the key concepts should form the basis upon which case studies are contextualised.**	**The Two Oceans of South Africa** The ocean off the **west coast of South Africa**, as far as Cape Agulhas, is indicated as being **the Atlantic Ocean**, while the ocean off our **eastern seaboard is the Indian Ocean.** 1. This distinction is reinforced by both these coastlines experiencing two **different major currents and very different weather conditions.** 2. The **warm Agulhas Current**, one of the **strongest flowing ocean currents in the world**, moves at speeds up to 13 km/h. 3. The Agulhas Current **flows from Mozambique**, past the KZN coast, before being **deflected south-west by the Agulhas Bank.** 4. This then turns south and **back on itself in a series of eddies**. 5. The largest eddy joins **the Indian Ocean circulation**, with smaller ones **recirculating into the Agulhas** current. 6. Some eddies **break off to move up the West Coast**. 7. At the West Coast **cold current moves northward,** out of the Southern Ocean. 8. This northward moving current is called the **Benguela Current**. **Three fairly distinct coastal regions** can be identified, **based on water temperatures** owing to the currents; these regions can be **further subdivided into five inshore biogeographic zones (BGZ**) based on geographical features and distinctive local biodiversity: 1. **Cold Temperate Region** on the West Coast, with average temperatures ranging from 9 ^{0}C to 15 ^{0}C. This region is divided into the **Namaqua BGZ** down to Cape Columbine, and the **South Western Cape BGZ** to Cape Point. a. Experiences **frequent upwelling** of cold nutrient-rich water. b. The nutrient-rich water promotes extensive **phytoplankton blooms,** coastal algae and **kelp forests**. c. In turn these provide **food for large populations** of consumers. 2. **Warm Temperate Region** on the South Coast, with average temperatures ranging from 16 ^{0}C to 20 ^{o}C. Referred to as the **Agulhas BGZ.** a. From **Cape Point to just north of East London**. b. This region **fluctuates on a seasonal** basis. c. It often experiences an **influx of colder water from the west along the shallower coastal shelf.** d. There are **some species overlaps** with the bordering regions, but the warm temperate region has **numerous endemic species** (eg Red Stumpnose, Knysna Seahorse, Leopard Catshark and Basket Star). 3. **Subtropical Region** from East London into Mozambique, with average temperatures ranging from 18 ^{0}C to 27 ^{o}C. This region is subdivided into the **Natal BGZ** up to St Lucia, and the **Delagoa BGZ** further to the north. a. Water in the Agulhas Current is **nutrient-poor**. b. Prevailing onshore winds cause **downwelling, maintaining nutrient-poor conditions**. c. **Algae** are **low-growing (tend to be moss-like, carpeting most rocks)** and often **coralline (cells incorporate $CaCO_3$ which makes the algae hard and unpalatable)**. However, the **species diversity** is very **high**. d. Animal **species diversity is also high**, but population sizes are smaller. e. Coastal fish exhibit **tropical characteristics,** such as being generally **smaller and very colourful.** **Further BGZs are identified in deeper water,** beyond the continental fringe to the end of the South African Economic Exclusion Zone**.** **(*Not required for the scope of this course.)***	Investigate endemic species along the coast Investigate endangered species along the coast	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

54. The Open Ocean

	Term 3	Strand – Ecology		
Time			**Investigations**	**Resources**
2 hours	**Individual ecosystems should be viewed with reference to the ecological concepts introduced in Gr10 and highlight the unique components and interactions within each.** **Understanding of the complexity of ecosystems is critical for learning about the multi disciplinarily of Marine Sciences. Class discussions, field trips and projects should be used to integrate ecosystem studies and other appropriate topics in this curriculum.**	**General** Large sections of the **mid oceanic environments can be termed deserts, as nutrient levels are low** and subsequent food chains limited. Closer to coastal margins, and **particularly on continental shelves**, conditions are more dynamic and **complex communities evolve**. 1. Most **oceanic food chains start with phytoplankton**, which require **light and nutrients** to thrive. 2. Nutrient supplies may **become restricted off the South** Coast by the formation of a **thermocline in summer**, limiting abundant **phytoplankton populations to spring, early summer and autumn**. 3. The **West Coast** experiences regular **fluctuations in nutrient supplies** and subsequent **phytoplankton blooms due to upwelling.** 4. The **East Coast** has **smaller** but relatively **stable phytoplankton populations,** owing to a constant supply of warm relatively nutrient-poor water all year. **Planktonic food webs** Whenever the **phytoplankton populations increases, the consumer chain will increase as well**. 1. **Zooplankton** (including radiolarians, foraminiferans and copepods) **float with phytoplankton and feed on them**. 2. **Close to coastlines**, the **larvae of coastal invertebrates and fish** may **temporarily join the zooplankton (as meroplankton)**. 3. All are fed on by **larger carnivores** such as krill, jellies, bluebottles and small fish. 4. These carnivores in turn become **food for schools of pelagic fish** like pilchards, mackerel, anchovies and maasbanker. 5. The next step up in the food chain is **schools of dolphins and predatory fish** like tuna, hake, yellowtail and elf (shad). 6. **Sea bird**s such as gannets, cormorants and penguins also feed off the fish. 7. The **Southern Ocean experiences huge summer productivity**, giving rise to **planktonic explosions** of krill in particular. 8. These provide an **abundant food supply for many larger animals, including whales**. 9. Many of these whales **migrate to the South African coastline in winter**, to **mate and calve**. 10. **Southern Right** and **Humpback Whales** are examples. 11. They **live off fat reserves** built up during the summer feeding season. **Pelagic fish** **Variable nutrient supplies around our coastline** dictate the distribution of **pelagic fish.** 1. Two main factors lead to a far **richer food supply along the West Coast**: a) The generally **higher nutrient content** of water from the **Benguela Current.** b) Frequent **summer upwelling** events along the western shoreline. 2. The rich food supply results in a potential **abundance of pelagic fish** along the **West Coast**. 3. The cold **nutrient-rich water often extends along the continental shelf of the South Coast.** 4. The **pelagic schools follow** up as far as Mossel Bay or even further **during sardine runs.** 5. The **East Coast**, with relatively **stable conditions** and warm water, has a much **lower abundance** of pelagic schools.	Blue Planet and other documentary excerpts Provide worksheet and questions The worksheet should include supplementary notes	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

55. Shores – Introduction

Term 3		Strand – Ecology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours Shores intro and Rocky Shores	**Individual ecosystems should be viewed with reference to the ecological concepts introduced in Gr10 and highlight the unique components and interactions within each.**	In coastal areas, land and sea are joined in an area called a **shore**. 1. The coast is an active place. Waves break and release their energy. 2. Tides bring water onto the land that reaches the high tide mark – the extreme point being the spring high tide mark. 3. The shore is the area on land between spring low and spring high levels, also referred to as the **intertidal zone**. 4. This section of the shore is either **fully covered** at spring high tide or **uncovered** at spring low tide. 5. The water level fluctuates between these two points twice during a day.	**Visit a shore or arrange a skype call with someone who has easy access to the shore**	**Living Shores by George Branch**

Rocky Shores

Term 3 and 4		Strand – Ecology		
Time	**Depth**	**Key concepts**	**Investigations**	**Resources**
4 hours Shores intro & Rocky Shores **Continued Gr 11 Term 4 Another 4 hours**	**Individual ecosystems should be viewed with reference to the ecological concepts introduced in Gr10 and highlight the unique components and interactions within each.** **Understanding of the complexity of ecosystems is critical for learning about the multi disciplinarily of Marine Sciences. Class discussions, field trips and projects should be used to integrate ecosystem**	**Rocky Shore ecosystems are characterised by the following features:** 1. They are covered by water and exposed to air as tides change. 2. Have a **rock substrate**. 3. The rock exhibits **exposed and sheltered surfaces** as well as **eroded gullies and holes** according to the **parent material, aspect and strata** of the rock. 4. The eroded areas fill with water to form **rock pools**. 5. Many marine creatures can inhabit these **rock pools**, but require some adaptations to **unique abiotic conditions**; specifically **high light intensities** and **fluctuating temperatures** and **salinities**. The **higher the pool is** on the shore, the **greater these stresses** will be. 6. As tides rise and fall the **exposed areas** experience rapidly **changing combinations** of **temperature, salinity, moisture, pH, dissolved O_2 and food supply.** 7. Organisms must cope with periods of **desiccation**, **extreme temperature fluctuations**, **rain, wave action, sea water flow, turbulence, and predation by land animals – especially sea birds.** 8. Where several organisms occupy an area**,** particularly in **the lower shore where abiotic factors are less stressful, there is more competition for space and food. These biotic interactions further influence the distribution of organisms in the mid to lower shore.** 9. An organism's **adaptation** to **cope with specific abiotic stresses** in rocky shore areas determines **the distribution** of that organism in the mid to high shore zones. 10. **High shore** species are: a) **Relatively tolerant to desiccation** and **temperature extremes** (which are normally higher than in the surrounding ocean). b) Generally **poorly adapted to** dealing with **heavy wave action** and **predation.** **Middle shore** species are: a) adapted to survive **limited desiccation** b) exposed to and adapted for dealing with **wave action**, t**urbulence,** and **predation** by marine organisms. **Lower shore species** are: a) Out of the water for limited times only. b) Not well adapted to **desiccation**. c) Able to tolerate **heavy wave action, by being firmly anchored and streamlined.** d) Well adapted to **compete** for food and space. *e)* Adapted to **avoid predation** by other marine organisms.	Rocky shore study- Incorporate id sheets for animals and algae; Mapping of a rock pool; quadrat studies and line transects to see zonal species distribution. **Collect (for return after session) specific algae and animals relating to this curriculum.**	Id sheets; square quadrats (or round ones made from string) Rope for transect lines. Tape measures. *Photographs and diagrams to show intertidal zonation*

	studies and other appropriate topics in this curriculum.	11. **There is strong evidence** to suggest that organisms in the lower shore are also distributed **according to specific feeding, competitive and symbiotic interactions,** rather than purely **adaptations to stress.** Examples include **barnacles competing** for space, **limpets grazing all algae** around them **except those they "cultivate",** and **predatory sea stars limiting where mussels** can establish themselves. 12. Biologists have noted a clearly visible **vertical zonation pattern** or **intertidal zonation**. Each zone has specific **resident species**, with the **name of each zone** often **indicating one of them.** 13. **Zonation** is the defining feature of rocky shores. (*Photographs and diagrams to show intertidal zonation.)* 14. The resident species may differ on different coastlines, depending on the overall characteristics of the bordering ocean. 15. Typical **rocky shore zonation** exhibits **three generic zones:** These are roughly demarcated by the **high and low tide** marks and the **tidal mean**. The term **eulittoral** is often used to describe the intertidal zone. **a)** The **upper eulittoral zone**, around the **spring high tide mark, bordering on the spray or splash zone**, is characterised by small **winkles**. **b)** The **middle eulittoral zone**, approximately between **neap low and neap high tide** marks, is characterised by **barnacles**, limpets and larger winkles – amongst many other invertebrates and **algae**. This zone is often divided into upper and lower zones around the tidal mean. **c)** The **lower eulittoral** zone, around the spring low **tide** mark, has **more algae** and **wave-resistant animals** such as limpets and mussels, as well as soft-bodied animals in calmer water. 16. In South Africa**, these zones can be renamed according to the common species** in each zone: a. The **upper eulittoral** is the **littorina zone**, characterised by **small winkles**, especially ***Afrolittorina Africana***. b. The **mid eulittoral** zone is divided into two: **I.** The **upper balanoid zone** is named after the acorn barnacle family, **Balanidae.** The zone falls around the **neap high** point, down **to the tidal mean**. It has **more animals than algae**, including winkles, limpets and barnacles. **II.** The **lower balanoid** zone is below the **tidal mean to around the neap low** point. It has fewer **barnacles** (being the lower extent of their range) **but more limpets, winkles and mussels,** and **far more algae**. c. The **lower eulittoral** is distinct on each coastline, varying from a specialised **extension of the balanoid** on the **East** Coast to a **limpet belt** on the **South and West** Coasts. d. **Additional zones in the SA coastline: For each coastline, an additional zone is noticeable in the intertidal area.** I. **On the East Coast** there is a band of **oysters** towards the top of the upper balanoid, **the oyster belt**. There are also large **zoanthid colonies** in the lower balanoid and into the lower eulittoral. II. **On the South Coast** there is an additional band of **pear-shaped limpets** in the lower eulittoral, t**he cochlear zone.** The littorina zone also has the addition of the **algae purple laver** (also found on the West Coast). III. **On the West Coast,** the cochlear zone also features increasing proportions of another limpet (which is dome-shaped), making this the **cochlear or argenvillei zone.** Moving **west**, **algae** become far more **prominent**.		

Sandy Beaches

	Term 4	Strand – Ecology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
2 hours theory +2 hours practical	**Individual ecosystems should be viewed with reference to the ecological concepts introduced in Gr10 and highlight the unique components and interactions within each.** **Understanding of the complexity of ecosystems is critical for learning about the multi disciplinarily of Marine Sciences. Class discussions, field trips and projects should be used to integrate ecosystem studies and other**	**Large sections of the South African coastline have sandy beaches overlying deep bedrock. They are also thriving ecosystems:** 1. Beaches are **unstable**, made up of **sand particles** which are constantly **in motion**. 2. Sandy shores provide **no hard substrate** for **organisms to attach** themselves. 3. The shores are **too unstable for sea plants** to grow; animals here **burrow** into the sand. **Tubes** are created in sheltered environments with finer sand, while animals push between the coarse sand particles in more **turbulent environments.** 4. The **size and frequency of waves** determine whether beaches are **eroded or built up.** 5. Beaches subject to **energetic conditions** have **larger sand grains**; **calmer conditions** deposit **finer grains**. 6. Coarse sand **drains quickly** but allows **air** to penetrate. 7. Very **fine sand** retains its **moisture** but **excludes oxygen**. **Organic material is trapped** and **broken down** by abiotic **bacteria**, releasing **hydrogen sulphide** – not an ideal environment for burrowers. 8. Animals **aggregate to a beach** with **conditions to which they are adapted**, generally avoiding very coarse or fine extremes. 9. **Burrowing** enables them to **avoid predators**, extreme **wave action**, high **temperatures** and **desiccation**, while still finding ample dissolved oxygen. 10. All **organic matter** available to animals in the sandy shore **drifts in** with the **tide** or by **wave action**. 11. Some animals **feed on organic particles** and decomposition bacteria that drain through the sand, and **others emerge to scavenge** the shoreline for dead plants and animals. **Commonly found intertidal beach animals** **Upper shore:** Animals that burrow into sand in the upper shore generally **breathe air.** 1. **Sand hoppers** (*Talorchestia sp.)* and **giant pill bugs** (*Tylos sp.)* are common on the West and South Coasts, where **dislodged kelp and other sea plants** are **deposited** by the high tide. These animals – a. **Burrow** in the sand or shelter in the rotting plants. b. **Emerge at low tide**, at **night**, and seek out plants to feed on. 2. They are replaced on the East Coast by the **ghost crab** (*Ocypode spp*.), which – a. Is a scavenger with similar habits to the sand hopper and giant pill bug, but feeds on dead animals. b. **Burrows** deep enough to rest in wet sand. c. Emerges to **scavenge** on damp sand.	Meiofauna investigation Many activities can be developed with a beach excursion .	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

	appropriate topics in this curriculum.	**Middle shore:** Apart from several small crustaceans, mainly copepods, this zone is typified by the **plough snail** (*Bullia spp*). Plough snails – a. Prefer **moderate wave action** and water with little turbulence. They emerge with the rising tide to "surf" to the high tide mark, where dead animals can be found and fed on. b. Have an **excellent sense of smell** that guides them to food. c. Retreat with the tide to burrow back into the mid tide sand. **Low shore:** Animals **shelter in the sand** at the low tide mark and **migrate up** the beach as the tide rises. 1. **White Mussels** (*Donax spp)* move in the sand, **filtering out** microscopic organic material that is deposited by rising waves. 2. Small surf shrimps (*Gastrosaccus sp*) **swim in the turbulent water** behind the rising tide to **scoop up dead plant and animal material**. 3. The **mole crab** or sand louse (*Emerita sp*) emerges to be **rolled** by the **rising tide** and kept in the turbulent water, which is rich in food and organic matter. 4. All these animals **return to the low tide** mark with the tide and bury themselves again. **Sandy shores are significant nutrient cyclers** 1. Huge populations of **bacteria and microscopic animals (protists and simple worms)** inhabit the spaces between sand particles. 2. These small organisms are termed **meiofauna**. 3. Bacteria **break down organic particles to release nutrients**. 4. In well aerated soil this happens quickly. 5. Some bacteria-covered **particles are food for protists and worms**. 6. Their **faeces and wastes are broken down further** by bacteria. 7. The released nutrients leach **into the sea** to **feed phytoplankton**. 8. Thus, **much organic material is efficiently broken down** as it filters through sand. This is the **meiofaunal food chain**, which is **independent of the macrofaunal food chain (larger animals).**		

56. Echinoderms and Echinoderm Classes

	Term 4	Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
6 hours	The depth of this topic is at a level where pupils appreciate and understand: • Evolutionary trends • The definitive differences between phyla • Specific adaptations, relating to structures to functions • The richness of marine biodiversity and Why it must be conserved	***-Refer to the Phylogenetic tree to place this Phylum in its Evolutionary context.*** The variety between the classes is huge, but the **general anatomy and physiology is similar** across the phylum. Exceptions will be dealt with per class. *(Use labelled diagrams to illustrate detail.)* 1. **Symmetry:** a. Bilateral larvae. b. Larvae give rise to **pentaradially symmetrical** adults. 2. Most can regenerate limbs and organs. 3. **Body plan:** a. Triploblastic coelomates. b. The coelom forms several fluid-filled compartments. c. These compartments include a **water vascular system** which controls **tube feet** or podia. 4. **Ectoderm:** a. The ectoderm gives rise to a skin covering **$CaCO_3$ ossicles or plates held together by collagen fibres** and other proteins. b. The amount of space between the plates is specific to each class. c. Skin can incorporate spines and nippers. 5. **Locomotion:** a. All are slow moving, using tube feet. b. Almost sessile. c. Varies per class. 6. **Nervous coordination:** a. There is a loosely arranged network of nerves feeding each arm or sector. b. No centralised ganglion. c. Sensitive to light, touch and chemical substances. 7. **Nutrition:** a. Most groups have a through gut. b. Gut branches into arms (gastric caecae with digestive glands). c. Intake depends on group. d. All have the ability to extract organic compounds from the surrounding water into the skin. 8. **Circulation:** a. The coelom and water vascular system are ciliated and contain proteins and coelomocytes. b. The cilia circulate the fluid and this enables transport of substances. 9. **Gaseous exchange:** a. Diffusion from water in the water vascular system and coelomic pouches. b. Special adaptations may exist to increase surface area. c. Tube feet are part of this system.	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips	https://study.com/academy/lesson/echinodermata-respiratory-system.html https://www.youtube.com/watch?v=n4uDD5-mD-Q

		10. **Excretion:** a. No specific organs exist. b. **Phagocytic** coelomocytes in the coelom engulf wastes and exit through vascular system and gut. c. Chemical wastes can be excreted through exposed tube feet. d. Osmoregulation does not occur (Stenohaline vs Euryhaline). 11. **Reproduction:** a. As with most examples so far, spawning is common. b. Spawning includes a bilaterally symmetrical planktonic larval stage (settling as a small adult). c. There are a variety of unique larval stages, normally named according to the individual class. d. Some species have internal fertilisation and retain the eggs. Hatched offspring later emerge as advanced larvae or tiny adults.		

Echinoderm classes

Term 4		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**Asteroidea: Sea Stars or Starfish** 1. Classic pentaradial layout. 2. Skin has dorsal papillae, short spines and **pedicellaria**. 3. Mouth on under-surface. 4. Feed by extruding part of the stomach to partially or totally digest food outside. 5. Have eye spots and very sensitive tube feet at arm ends. 6. Move by means of **tube feet** in **ambulacral** groove. **Ophiuroidea: Brittle Stars** 7. Central disc with loose skin, thin arms with vertebral plates and spines. 8. Tube feet are reduced to tentacles (**podia**) and these aid in sensing and feeding. 9. Move by dragging themselves with legs. 10. Most filter feed; some scavenge larger meals. Mouth is situated underneath and there is no anus. 11. Young may be reared in brooding pouches. **Crinoidea: Feather Stars** 12. They have many thin, upward-facing arms; a small central disc with mouth and anus, facing upwards. 13. Cling to substrate using special **cirri**. 14. Arms have **pinnules**, with small podia or tube feet and cilia. 15. Filter feed small particles, encasing them in mucus and pass food down to mouth. 16. Gonads are situated in the lower pinnules. **Echinoidea: Sea Urchins** 17. Pentaradial symmetry is not immediately noticeable but is obvious on closer inspection. 18. Ossicles are enlarged with very little connective protein to form a **teste**. 19. Skin has spines and a range of **pedicellaria** or nippers. 20. The spines are used for protection and "walking'. 21. Tube feet penetrate through the teste; the urchin holds on and drags its body. Mouth is underneath, with 5 prominent teeth, and the anus is on top. Omnivorous. 22. Water vascular system extends into folds to form "gills". **Holothuroidea: Sea Cucumbers** 23. The Sea cucumber exhibits a more bilateral symmetry, but the Pentaradial ancestry can be seen in the rows of tube feet.	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic There are very valuable Aquarium videos which are readily available

		24. There are fewer ossicles under the skin than in the Sea stars, but comparatively more collagen and elastic fibres. 25. Tube feet to hold on; modified around mouth to form sticky tentacles. 26. Sea cucumbers feed by using their tentacles to catch small particles. 27. They have a through gut. 28. **Respiratory tree** extends from **cloaca** into body: contains sea water and aids gaseous exchange.		

57. Human Exploitation of Marine Resources and Indigenous Knowledge

Term 4		Strand – Humans and the Ocean		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**A broad overview of understanding of South African Scientists to the Marine Sciences. The history of Marine Science discovery should encourage learners to make a contribution themselves in the future.**	**Archaeological Evidence of early human relationships with the sea and seafood.** 1. South Coast Our Prehistorical Birthplace 2. Early human reliance on the coast 3. Middens displaying evidence of sea food consumption by early humans 4. Prehistoric Resource Depletion 5. Middens displaying evidence of sea food consumption by early humans 6. Reference to marine materials in middens 7. Stone wall fish traps vyfers on the South Coast and the Norhern KZN fish traps in Kozi Bay. 8. Reference to quality proteins that came from eating food from the sea.	Museums and Archaeological sites display an enormous amount which can be visited and further enrichment dealt with. Visit Vywers and fish traps Arniston or Stilbaai Or the N KZN in the Kosi Bay area.	**A range of YouTube clips and resources are available in Archeologic libraries and on the internet. George Branch Living Shores 2018 pg 204. see prehistoric resource depletion pg 206 Reliance on the coast pg 207 and see South Coast: Our ancestral birthplace.**

58. Overfishing and SASSI

Term 4		Strand – Humans and the Oceans		
Time			**Investigations**	**Resources**
2 hours	**The depth at which this topic should be understood is one in which learners should apply their knowledge of other topics studied up to this point. In addition this topic will form as a frame of reference as further topics in the Ecology and Humans and the Ocean strands are introduced. The topic lends itself to higher level solutions based applications**	**Overfishing** 1. **Three specific areas** need to be studied when considering humans and the sustainable use and management of South African oceans: a. Aquaculture of marine species. b. Marine Protected Areas (MPAs). c. Marine ecotourism. **2. Marine scientists are working to develop a scientific basis for making management decisions and restoring certain fish stocks to sustainable levels.** **3. Solutions for overfishing include:** a. Fish only what is consumed. b. Stop incurring bycatch or incidental mortality. c. Fishing companies and fishermen must follow fishing legislation – such as quotas, total allowable catches and permit conditions. d. Establish no-take zones. e. Develop marine protected areas (MPAs). f. Change equipment so habitat destruction is reduced. g. Identify habitats that should not be touched by harvesting equipment. h. Prevent use of destructive fishing gear (eg circle hooks and trawling nets). **4. Seafood consumer awareness** programmes such as the Marine Stewardship Council and the South African Sustainable Seafood Initiative (**MSC, SASSI)** These programmes propose a set of **sustainable measures** which **require compliance** by participating companies, or a **consumer awareness initiative** requiring consumers to establish: a. What species is the seafood? b. Where was it caught? c. How was it caught? d. Has it been listed as a Green, Orange or Red by marine scientists? e. What do FishSMS and websites say about the species? **Note:** Research also indicates that not all changes in fish stocks are the result of human over-exploitation.	**Using the SASSI App Discussions and activities considering the variables used to calculate the SASSI guidelines.** **Investigate a case study in which a scenario is laid out for consideration for a Green, orange or red listed species.**	**SASSI cards and App** http://wwfsassi.co.za/sassi-app/ **as well as the Marine Stewardship Council** https://www.msc.org/ **material and web sites.** http://wwfsassi.co.za/ **George Branch Living Shores 2018 pg 211. Harvesting of the seas**

59. Marine Protected Areas

	Term 4	Strand – Humans and the Oceans		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**The depth at which this topic should be understood is one in which learners should apply their knowledge of other topics studied up to this point. In addition this topic will form as a frame of reference as further topics in the Ecology and Humans and the Ocean strands are introduced. The topic lends itself to higher level solutions based applications**	***Marine Protected Areas*** (MPAs) are *areas* of the oceans that are *protected* for a *conservation* purpose. 1. **Marine Protected Areas** (MPAs) are one of the **measures positively contributing** to protect marine environments, enabling sustainable use of marine resources and ensuring that the areas remain healthy for generations to come. 2. MPAs are selected areas where **human activities are restricted by regulations**. This provides special protection in the area for the conservation of a species, a habitat or an ecosystem, and cultural resources such as shipwrecks and archaeological sites **as identified by scientists**. 3. MPAs **differ by country** and take many differing forms – such as marine sanctuaries, estuarine research reserves, ocean parks, and marine wildlife refuge zones. 4. **Scientists propose areas where MPAs should be established,** based on a) Places which are critically important to specific developmental stages of marine species (eg **feeding, spawning and nursery areas).** b) **Areas rich in biodiversity** and zones where important cultural artefacts are found. 5. **MPAs provide undisturbed sites for scientific research** and benchmarking that allows long-term monitoring, which helps to guide management of fishery resources in exploited areas. 6. **South Africa has 22 proposed MPAs** under the **Operation Phakisa** initiative. In South Africa, MPAs are "no-take" zones. 7. The **resources** in these protected areas become **replenished** and **fish stocks recover inside,** and act as a **spill-over** to surrounding areas, improving their fisheries. Female fish in MPAs grow older and larger than fish outside of MPAs, and are able to produce eggs that are both healthier and more numerous, providing **efficient breeding**. 8. The Tsitsikamma MPA, at the Storms River mouth, can be used as a case study of a MPA which if opened will have dire consequences for certain fish stocks. 9. Key benefits of MPAs are therefore – a. **Conserving** representative samples of marine biodiversity and ecosystems. b. **Protecting** critical habitats for the reproduction and growth of species. c. **Supporting** marine species' **growth areas** to allow for "spill-over" into surrounding exploited areas. d. **Maintaining biodiversity** and providing refuges for endangered and commercial species. e. **Protecting critical habitats** from damage by destructive fishing practices and other human activities, and allowing them to recover.	Explore no take MPAs verses limited catch MPAs. Investigate MPAs in other countries and the associated data.	https://www.environment.gov.za/mediarelease/molewa_22newproposed_mpas **Guidelines for Establishing Marine Protected Areas** By Graeme Kelleher, R. A. Kenchington, Great Barrier Reef Marine Park Authority

		f. **Allowing sensitive ocean** areas **to recover** from the stresses of exploitation, so that fish are able to reproduce, spawn and grow to their adult size. g. **Increasing fish catches** (both size and quantity) **in surrounding fishing grounds.** h. Building resilience to protect against damaging external impacts, such as climate change. i. Helping to **maintain local cultures**, economies, and livelihoods that are intricately linked to the marine environment. j. **Contributing to healthy marine sites** for sustainable and responsible ecotourism and environmental education.		

60. Marine Ecotourism

Term 4		Strand – Humans and the Oceans		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	**The depth at which this topic should be understood is one in which learners should apply their knowledge of other topics studied up to this point. In addition this topic will form as a frame of reference as further topics in the Ecology and Humans and the Ocean strands are introduced. The topic lends itself to higher level solutions based applications**	**Introduction to Ecotourism opportunities along the coast** 1. **Nature-based tourism** takes tourists to natural venues; this is the largest growing tourism sector in South Africa. 2. According to The International Ecotourism Society, ecotourism is defined as "responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education of guests and staff" (TIES, 2015). 3. Ecotourism is based on the following principles, as set out by TIES: a. **Minimise** physical, social, behavioural, and psychological **impacts**. b. **Build environmental awareness**, cultural awareness and respect. c. Provide **positive experiences** for both **visitors** and **hosts**. d. Provide direct **financial benefits for conservation**. e. Generate financial benefits for both local people and private industry. f. **Deliver memorable interpretative experiences** to visitors, thus raising sensitivity to host countries' political, environmental, and social climates. g. Design, construct and operate **low-impact facilities**. h. Recognise the **rights and spiritual beliefs of indigenous people** in the community and **work in partnership** with them to **create empowerment**. i. Implement practices that are sustainable ("meets the needs of the present without compromising the ability of the future generations to meet their own needs"; Bruntland Commission, 1987). j. With this concept in mind, sustainable tourism was defined in the 1992 Agenda 21 for the Travel and Tourism Industry as tourism that "meets the needs of present tourists and host regions while protecting and enhancing opportunities for the future." 4. MPAs function as ideal areas to provide income from recreation and ecotourism to subsidise conservation efforts. 5. Tour guides should deliver **accurate information** and **keep their knowledge current** with recent information about the **species**, **ecosystems** and **biological values** of the region. 6. Efforts have been made to **use the ocean for tourism** and to **promote ocean awareness,** by operators of: a. aquariums b. shark cage diving c. surfing	Investigate local marine and coastal tour operators In a project, explore opportunities for ecotourism that might not yet have been attempted in a local community Explore comparative settings in other countries, to stimulate discussion about local entrepreneurial opportunities	Videos relating to marine ecotourism, such as marine tour guiding, shark cage diving, whale watching, shore studies and botanical touring https://www.ecotourism.org/

		d. free-diving with seals e. recreational fishing f. boat sight-seeing trips g. whale watching. 7. Many of these initiatives have been drivers for better conservation through – a. **Protection** in demarcated MPAs. b. Conducting **strict environmental impact assessment procedures** before allowing coastal development to occur. A number of regulations govern tour operations along the SA coast, which require adherence to activities such as fishing quotas and permits for activities such as fishing and scuba diving. These regulations are aimed at increasing sustainable tourism practices.		

Section 3.3 Grade 12

61. Diving Science Water Gas Laws

Term 1		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	The gas laws include opportunities for problem solving by applying the content to real examples which are used in the Science of Diving by commercial divers in the field.	Combined Gas Laws **1. Boyles and Charles Laws** illustrate the relationship between **pressure, volume and temperature.** 2. For a fixed amount of an ideal gas kept at a fixed temperature, the pressure and volume are inversely proportional. 3. Room temperature should be constant. 4. [Volume x pressure] is a constant. 5. $P_1V_1/T_1 = P_2V_2/T_2$ 6. Changing subjects of the formula with Boyles Law. *7. Teach the concept of converting degrees Kelvin to degrees Centigrade.*	Examples of diving science Pressure at a depth (calculate) Demonstrate the relationship between volume, pressure and temperature Increased pressure in a bicycle pump increases the temperature Air released from a cylinder reduces the temperature	Bicycle pump Air cylinder (to demonstrate the release of air reduces temperature) tube graduated according to the volume

62. Estuaries

Term 1		Strand – Ecology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
3 hours	**Individual ecosystems should be viewed with reference to the ecological concepts introduced in Gr10 and highlight the unique components and interactions within each.** **Understanding of the complexity of ecosystems is critical for learning about the multi disciplinarily of Marine Sciences. Class discussions, field trips and projects should be used to integrate ecosystem studies and other appropriate topics in this curriculum.**	**Estuaries are river mouths and their associated banks and beds, which are subject to the tidal ebb and flow of the sea water they discharge into.** 1. Estuaries are home to **unique plant and animal communities** that have adapted to **brackish water –** a mix of fresh water (draining from the land) and salty sea water. 2. The length of the estuary stretches **from the mouth of the river** as far back as **salt water can still be detected.** 3. **Conditions fluctuate** considerably, with changes in **tides** and **seasonal river discharge.** 4. **The rivers** are in their **lower course** and **normally flow calmly. Sand bars form at the river mouth, protecting the estuary from turbulent wave action.** As a result, a. **Deposition** of **river sediment** and **sea sand** is promoted. b. The deposition results in broad **tidal sand, silt or mud flats**. c. Many coastal **marine species** that favour **calm water live here.** d. **This area is an important breeding ground and nursery for juvenile line fish**. 5. **Salinity fluctuates** substantially, with **salt water** entering at **high tide** and **fresh water flowing down the river during rainy seasons in the catchment area.** a. The **salinity gradient** changes **moving upstream**, but **also with depth**, as freshwater flows over the denser salt water and mixing is slow. b. When **estuaries become closed** because of a lack of **river discharge** and the formation of **sand bars** across the river mouth, estuarine **salinity may increase well above that of the sea, owing to evaporation.** c. Animals have a range of **adaptations to deal with salinity changes**. d. They are referred to as **euryhaline –** able to cope with a wide range of **salinity**. 6. **Temperature ranges** can also be much more **extreme** than in the ocean. a. Animals **dig into the sediment** or create **water-filled burrows** to avoid high temperatures and desiccation (eg sand or mud prawns, blood worms and mussels). b. The many **scavengers** on exposed flats have **adaptations to enable them to breathe, regulate temperature and avoid desiccation** (eg crabs). 7. A **high organic load** exists in the water and sediment. a. Organic load results in a thriving **decomposition** process, **releasing nutrients**. b. Most of the **burrowing animals** are **filter feeders**. 8. **Adapted land plants** thrive, such as **reeds** in relatively fresh water, **salt-resistant** plants on the higher shore, and **eel grass** on the intertidal flats.	Practical investigation: test pH of water; test salinity Effect of human activity on salinity Effect of seasonal changes to pH and salinity Investigate different species of plant and animals found in an estuary Life Cycle of animals that use estuaries as breeding grounds Adaptation of animals to survive changes in salinity	Models Charts Pictures Live specimens

		a. In sub-tropical and tropical areas, **mangroves** can establish themselves. b. These plants help to **calm water turbulence** and **promote sedimentation**. c. Estuaries are among the **most productive ecosystems** in the world. 9. **Many marine animals**, especially fish, enter estuaries to **spawn;** or juvenile fish move into estuaries after hatching. a. Examples include Kabeljou, Garrick or Leervis, Mullet, Grunter and White Steenbras. b. The young fish **hatch and/or mature** in the estuary. 10. Estuaries provide a perfect habitat for **water birds**. **Some** are permanent **residents**, **others** seasonal **migrators**.		

63. Chordata Urochordata

	Term 1	Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
2 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**Revise life patterns and classification** ***-Refer to the Phylogenetic tree to place this Phylum in its Evolutionary context. Introduce a new Phylogenetic tree for the Chordate Phylum.*** 1. The **phylum Chordata** – a. Includes all animals with a **tubular dorsal nerve cord.** b. The nerve cord is supported by some sort of protective rod, a **notochord.** c. The notochord might, however, **be present** only in the **larval** stages. 2. The sub-phylums **Urochordata** and **Cephalochordata** have no **vertebral column**, and are thus invertebrates, often referred to as **protochordates**. **Urochordates: Ascidiacea or Tunicates** 1. This group is significant on our shores, thus requires discussion. 2. Only the tadpole-like larva **has the required notochord and dorsal nerve cord**. 3. The adult is **glued to one spot** and becomes a bag-like structure with a **tunic of jelly or cellulose**. 4. A **through gut** exists, taking water in through one tube or siphon and expelling it out through the anus; hence they are sometimes called "sea squirts". 5. The water is filtered through **pharangeal gill slits** to obtain food (and O_2). 6. Larger species are **solitary**, while smaller **colonial** species cluster together in a sheet; some even share a central exhalent siphon. 7. Some tunicates **remain in the planktonic community** rather than becoming benthic. Of particular interest is ***Appendiculara sp*,** which sets a "net" of jelly and uses it to trap food. Discarded jelly nets sink to the bottom and can provide substantial amounts of "nutrient snow" in certain areas.	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips	Charts illustrating cladograms Phylogenetic diagrams Time frame to origin of organisms

64. Vertebrates: Introduction

Term 1		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
1 hour	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	Vertebrates comprise all chordates with a **vertebral column** protecting the dorsal nerve cord and, in most, an endoskeleton of bone or cartilage. Vertebrates are divided into seven major classes: 1. **Agnatha*** 2. **Chondricthyes** 3. **Osteicthyes*** 4. **Amphibia** 5. **Reptilia** 6. **Aves** 7. **Mammalia.** *Agnatha and Osteicthyes are actually super-classes: Agnatha, the jawless fish, includes classes Petromyzontida and Myxini. Osteicthyes, the bony fish, includes classes Crossopterygii (lobe-finned fish) and Actinopterygii (ray-finned fish). *Names are used here for reference only, to illustrate the complexity within the group and highlight taxonomic changes owing to research. Names need not be remembered.* *For each vertebrate class, discuss the following headings. Emphasise comparisons and contrasts in relation to lifestyle and general habitat:* • *Definitive differences.* • *Body covering.* • *Body plan and external features.* • *General locomotion.* • *Nervous coordination and sense organs.* • *Nutrition.* • *Circulation* • *Gaseous exchange surfaces.* • *Excretion and osmoregulation.* • *Temperature regulation.* • *Reproduction.* • *Biology and adaptations of terrestrial classes that have returned to life in the ocean.*		Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic See Shaped for life series

65. Agnatha

Term 1		Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
1 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	***-Refer to the Chordate Phylogenetic tree to place this class in its evolutionary context.*** The Agnatha includes the **hagfish**, eel-like scavengers found on the sea floor in many cold ocean environments. (*Use labelled diagrams to illustrate detail.)* **1.** This group is sometimes excluded as vertebrates, as they have a **cartilage skull** and skeletal elements, but **no vertebrae.** 2. **Swim** with a frill around the tail. 3. Have **eye spots** and 3 or 4 pairs of touch and chemical sensitive **tentacles** around the mouth. 4. Have very **glandular (scale-free) skins** capable of secreting large amounts of **slime,** unpalatable to predators. Exhibit knotting to feed. 5. **Breathe** by taking water through **pharyngeal openings** into internal **gill pouches,** which may vent through **several pores** or a communal tube leading to a single ventral opening. 6. Have two half-rings of **teeth around a horny tongue**, with which they fasten onto and tear off dead flesh.	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips	Animation video clips on dissections

66. Chondrichthyes

Term 1		Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
5 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**Jawed fish** share many common features, including: 1. A generally **streamlined body shape** to swim with minimal effort. 2. **Swim** using a broad **tail** and other **fins**. 3. **Breathe** by means of **gills**. *(Explain ventilation mechanism.)* 4. Are **ectothermic**, with some exceptions. 5. Have **kidneys** to deal with some aspects of excretion. ***-Refer to the Chordate Phylogenetic tree to place this class in its evolutionary context.*** (*Use labelled diagrams to illustrate detail.)* 1. Include **sharks, skates, rays and chimearas** (St Joseph's shark). All have a **cartilage** skeleton. 2. **Chimearas** have some characteristics of bony fish, but are cartilaginous. 3. The rest (**Elasmobranchs**) share the following: a) **Skeleton** is entirely **cartilage**, with limited bone in larger species. Upper jaw is not fused to cranium. b) Skin is covered in dermal **denticles**. c) **Locomotion –** Fins are not retractable; there are **caudal**, **dorsal (2)**, **anal**, **paired pectoral, and pelvic**. The fins are designed to provide propulsion, steering and lift. **Neutral buoyancy** is also maintained through cartilage, large liver with oil, and air gulping. d) **Nervous coordination –** Have very **good senses: eyes** with pupils and variable tapetum; l**ateral line**; **nasal pouches** or nostrils; **Pits of Lorenzini**. e) **Nutrition –** All are **carnivorous**, food ranging from plankton to whales. **Multiple layers of teeth** are modified to diet. f) **Compartmentalised through gut** with a unique **spiral valve** in the intestine. g) **Circulation** Have a two chambered heart with a single atrium and ventricle, enabling a single circulation from the heart, through the gills, to the body and back. h) **Gaseous exchange – Gills** extract O_2 from water, which enters mouth or spiracles and exits through the 5–7 pairs of gill slits. i) **They are ectothermic**, losing whatever heat may be generated in the muscles via gills Some sharks generate excess heat in their core and maintain it with counter-current heat exchange (CCHE) capillary networks. j) **Excretion and osmoregulation –** Marine fish tend to lose water by osmosis to their surroundings, whereas **sharks retain urea in blood** and tissues, thus increasing cell solutes. Salt is excreted through gills and a gland into the gut. k) **Reproduction –** Sharks all have **internal fertilisation** (male claspers); most are **ovoviviparous, some are oviparous, and a small group is viviparous.**	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

67. Osteicthyes

Term 1		Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
5 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	***-Refer to the Chordate Phylogenetic tree to place this class in its evolutionary context.*** 1. This group typically includes all fish with a **skeleton of bone and, generally, fins with bony rays** (a small group; lobe-finned fishes are a separate class). *(Use labelled diagrams to illustrate detail)*. 2. Most have **scales** of **dermal origin**, covered by a thin glandular skin. 3. Most are **streamlined** and "oval", but the range of shapes, sizes and colours is very diverse. 4. **Locomotion:** a. They generally swim, but some "walk" along the sea bed. b. Buoyancy is controlled by a swim bladder (in most). c. Fins all play a role. Typically have caudal fin, single dorsal and anal fins, and paired pectoral and pelvic fins. 5. **Nervous coordination:** a. A **lateral line organ** senses vibration, pressure change and sound. b. Inner ear for sound and balance; nostrils sensitive to chemicals. c. Eyes for (colour) vision, no pupillary mechanism or eyelid. 6. **Nutrition:** Very **wide range of diets** (generally carnivore or omnivore, rarely herbivore) and feeding mechanisms, jaw shapes and arrangements, tooth types; mouth leads to a **through gut, egesting via cloaca**. Urine is added to faeces. 7. **Circulation** Have a two chambered heart with an atrium and ventricle. Enabling a single circulation from heart, through the gills, to the rest of the body and back. 8. **Gaseous exchange:** a. Breathe through gills. b. Water enters mouth, flows over broad vascular surface, and out through single large gill slits on either side of throat. c. Variety of ventilation mechanisms. 9. **Excretion:** a. Excretion occurs through kidneys and gills. b. Marine fish lose water to their surroundings, so they drink a lot and excrete salts. c. Freshwater fish absorb water and produce much diluted urine. 10. Most are **ectothermic**, some very sensitive to temperature change, but exceptions exist (similar to sharks). 11. **Reproduction:** a. Mainly oviparous, with mass spawning being common. b. Some lay eggs in "nests" and a few have brood pouches. c. Many species are hermaphroditic and some exhibit sex change at a certain life stage. 12. **Bioluminescence:** Several fish (and other animals) that live in dark or low-light conditions emit a form of light, which may be permanent or can be switched on and off. Pockets of cells	Photographs, slide show and videos Study live examples (aquarium or rock-pool study) Fish dissection Observation of as many live species as possible, or arrange lesson or course with nearest aquarium Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips	Fresh or frozen pilchards

		(photophores) contain bioluminescent chemicals (switchable) or symbiotic luminous bacteria (maskable).		

68. Terrestrial Vertebrate Classes and Returning to the Sea

Term 1		**Strand – Marine Biology**		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
2 hours	**Terrestrial vertebrate timeline** The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved **indicator**	*Revise life patterns, classification and the animal phyla already covered*. ***-Refer to the Chordate Phylogenetic tree to place these classes in their evolutionary context.*** 1. These classes are most likely to have **evolved from lobe-finned fish** or ancestors similar to mudskippers. 2. The change was possibly driven by a move to **feed on land-living invertebrates or lay eggs** where they were safe from predators. 3. The **fossil record** shows: a. **Amphibians** appeared first, about 330 million years ago (mya), giving rise to **amniotes** (animals that produce amniotic eggs) about 310 mya. b. **Reptiles** and early **mammals** appeared around 300 mya, with reptiles becoming dominant (as **dinosaurs**) from 250 mya until 65 mya (also several examples of marine dinosaurs). c. **True birds** evolved from reptiles from about 140 mya onward. d. Dinosaurs suffered mass extinction around 65 mya, after which birds and mammals radiated to fill empty niches, some becoming marine creatures. The amphibians represent the first group of vertebrates that can be regarded as terrestrial. There are now **no marine amphibians**, with the only known exception of one frog (the crab-eating frog) that can enter sea water after a few days of acclimatising. Amphibians have: 1. **Soft, thin glandular skin.** 2. Head and trunk, sometimes a tail, and four distinct limbs with digits. 3. **Large eyes** that enable good eyesight. Reasonable sense of smell. **Ear drum** on head leads to middle and inner ear – they have **good hearing and balance**. 4. They are **carnivores** using sight and smell to find food. **Simple teeth** are outgrowths of the jaw. 5. They **breathe** by means of **rudimentary lungs**, the lining of the mouth (buccal cavity) and skin. 6. The breathing surfaces are thin, moist, often folded, and well supplied with blood vessels. **Tadpoles** and some adults have external and/or internal **gills.** 7. **Reproduction** retains its marine roots: **external fertilisation** and **soft** yolk-filled eggs, normally laid in water.	Photographs, slide show and videos Study live examples Observation of as many live species as possible, or arrange lesson or course with nearest museum	Recognise types from diagrams and photos Diagram or photo of local animals to show definitive features Internet and YouTube

	Returning to Sea The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved .	Inevitably, as vertebrates became adapted to terrestrial niches, 1. Competition may have forced some to forage from coastlines and, eventually, **return to the sea.** 2. To hunt successfully, these animals needed to be able to – a) **Dive to some depth** b) Stay underwater long enough to find food. 8. Several **limiting factors** would have to be dealt with by **critical adaptations:** a) **Locomotion –** Need to swim again. b) **Oxygen –** Oxygen needs to be carried along and used very efficiently. c) **Osmoregulation –** A diet of seafood and salt water requires the excretion of excess salt. d) **Temperature –** As depth increases, temperatures drop to close to freezing point. e) **Pressure –** Diving to great depths calls for as few internal air spaces as possible, or an exoskeleton. f) **Avoiding the bends –** A build-up of nitrogen in the blood can lead to bubbles forming as pressure decreases. This is called “the bends” and needs to be dealt with or avoided. g) **Reproduction –** Unless this occurs on land (often still the case) special measures are called for.		

69. Marine Reptiles

Term 1		Strand – Marine Biology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
3 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	**Reptilian characteristics and Marine reptiles** ***-Refer to the Chordate Phylogenetic tree to place this class in its evolutionary context.*** Reptiles were the first vertebrate group to **successfully conquer dry land.** 1. Waterproof skin with **epidermal scales** enables them to survive very dry conditions. 2. They have a **head, trunk, tail, and four limbs** with digits, generally under the body. 3. Have **good eyesight** and a reasonable sense of smell. **Ear drum** recessed in head leads to middle and inner ear – they have **good hearing and balance**. 4. **Homodontic** teeth grow from sockets. Food is chewed and processed by a compartmentalised through gut. 5. **Circulation –** Most reptiles have three chambered heart with two atria and a single partially divided ventricle. Oxygenated blood from the lungs enters one of the atria and can be selectively distributed to critical parts of the body by the ventricle. 6. They **breathe** by means of **spongy lungs**. Inner surfaces are thin, moist, often folded and well supplied with blood vessels. 7. Mostly **ectothermic.** 8. Have internal fertilisation and produce **amniotic** eggs. **Eggs** have large yolk, amnion and a leathery or **calcareous** water-proof shell. Some species are **ovoviviparous**. In the **Mesozoic** period, many reptiles had returned to the ocean, with an even greater variety than sea mammals today. The **Ichthyosaurus** closely resembled **modern dolphins.** 1. Certain **marine crocodiles** spend some time on land and lay their eggs there. 2. **Sea snakes** are almost entirely aquatic, with flattened bodies and tails, salt glands in their mouths, skin flaps over their nostrils, and large lungs; they may even give birth to live young. 3. The most prominent and locally relevant marine reptile is the **turtle**. 4. Of the seven species of turtle, the Leatherback and Loggerhead nest on our shores, and the green turtle and hawksbill are frequent visitors. **Turtle adaptations to marine life:** 1. The **carapace** (shell) is flattened and streamlined. 2. Limbs have evolved into **flippers.** 3. **Fat deposits** and lightened bones aid buoyancy and temperature conservation. 4. Large **lungs** enable turtles to hold their breath for long periods: if active, about 40 min; when sleeping, for many hours; when hibernating, for some weeks. 5. **Heart rate slows** radically. Non-vital organs are shut off and vital organs make do with less (diving **bradycardia**). 6. Large number of red blood cells contain high concentrations of **haemoglobin**. 7. Muscles have **myoglobin.**	Photographs and illustrations of marine reptiles Local marine reptiles to be identified in practical lessons or exams	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

		8. **Ectothermic** metabolism has a relatively small O_2 demand, and hibernating metabolism can be radically lowered. 9. Turtles have strong, sometimes serrated **beaks** to eat a range of food (sea plants, many invertebrates, fish and jellies). 10. Specialised **salt glands** in the nasal passages excrete excess salt. 11. **Reproduction –** a) Mature turtles mate at sea. b) Females can store the sperm for several years. c) They **return to the beaches** on which they were born… d) To **lay eggs** in several batches over many weeks. e) Egg **incubation** takes a few weeks. f) The **sex of babies is dictated by temperature** during incubation. g) Hatchlings **emerge at night** to crawl back to the sea. h) Infant mortality rates are huge. 12. Turtles are all **endangered species, some of them critically.**		

70. Marine Birds

	Term 1	Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
3 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	***-Refer to the Chordate Phylogenetic tree to place this class in its evolutionary context.*** This group built on the successes of the **reptile revolution** and took to the air. Birds have: 1. Waterproof skin with epidermal scales and feathers. 2. Head, trunk and tail. Rear limbs (legs) with digits; forelimbs modified to form wings. 3. Endothermic ability. 4. **Good eyesight** and a poor sense of smell. **Ear drum** recessed in head leads to middle and inner ear; **excellent hearing and balance**. 5. Beaks – huge **variety of beak shapes** to enable food sources to be utilised. **No teeth**. 6. **Circulation –**Have a four chambered heart with two atria and two ventricles enabling a **double circulation; Pulmonary circulation** to the lungs and back and **Systemic circulation** to the body. 7. **Tube-filled lungs** leading to **air sacs** for breathing. The tubes are vascular and enable constant ventilation. 8. **Reproduction** by means of internally fertilised eggs, which have large yolk, amnion and a calcareous waterproof shell. Hatchlings can be altricial or precocial, depending on the lifestyle of the species. **Penguins** *(Provide labelled photos and diagrams to show penguin structures and variety.)* Many birds inhabit and nest along the coastlines of oceans and inland waters, and rely on aquatic organisms as their source of food. Some fly out and dive for it, floating on the water surface to rest or gliding on air currents above the waves, often for days. Other species forage on shores, and some swim. 1. For all bird species, it is ideal to have **oily, waterproof feathers** (and **preen glands**). Air can be trapped between the feathers and keep body warmth **insulated**. 2. While the adaptations of birds that fly out to sea and dive for their food are remarkable, the **penguin** truly captures our attention as marine-adapted birds. The African penguin is endemic to the South African and Namibian coastline. 3. Penguins **nest and roost on land** but spend a lot of their time foraging in the water. 4. Their bodies are **hydrodynamic**. 5. Their **wings** are adapted to “fly” underwater. 6. **Barbed tongues** enable the swallowing of fish. 7. **Salt glands** deal with salt excretion. 8. **Waterproof feathers** trap air to keep the bird warm and dry; penguins also carry fat reserves. 9. Blood flow can be cut off to non-essential organs, and muscles can operate anaerobically (diving **bradycardia**	Sea bird identification Photographs and illustrations of marine birds Local marine birds to be identified in practicals or exam	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

71. Marine Mammals

Term 1		Strand – Marine Biology		
Time	**Depth**	**Key Concept**	**Investigations**	**Resources**
3 hours	The depth of this topic is at a level where pupils appreciate and understand: 1. Evolutionary trends 2. The definitive differences between phyla 3. Specific adaptations, relating to structures to functions 4. The richness of marine biodiversity and 5. Why it must be conserved	Mammals were a suitable group to take over the reign of the **dinosaurs**, in whose shadow they had survived for eons. Land mammals have: 1. Waterproof skin with hair or fur (with a few exceptions). 2. Four limbs with digits, generally under the body and similar in size. 3. **Good eyesight** and sense of smell. **Pinna** directs sound to **ear drum** which is recessed in head, leading to middle and inner ear. **Good hearing and balance**. 4. Generally, **heterodontic teeth** growing in sockets, with teeth adapted to type of diet. 5. Circulation- A four chambered heart, as in the birds, provides for an effective double circulation. 6. Large spongy lungs for breathing. **Diaphragm** isolates thoracic cavity and aids breathing mechanism. 7. **Separate digestive and urinogenital openings** – all other vertebrates have a **cloaca**. 8. **Endothermic ability**. 9. **Viviparous reproduction** and internal fertilisation; embryo develops in **uterus** and is nurtured via a **placenta** (except **monotremes**, and **marsupials** to a limited extent). 10. Offspring are fed **milk** from **mammary glands,** once they are born. *(Use labelled photos and diagrams to illustrate variety and characteristics.)* As with reptiles, many mammals have returned to the sea. Marine mammals include whales, dolphins, porpoises, seals, sea-lions, walruses, otters, dugongs, manatees, platypuses and polar bears. An excellent fossil record shows the evolution of **whales** from bear-like ancestors. Marine mammals may be partially aquatic (**platypus and otter** find food in water), highly aquatic (**seals** use land only to bask and breed), or entirely aquatic (**manatees, dolphins and whales** live and reproduce in the water). 1. Prominent marine mammals include the **Pinnipeds (seals and sea lions or fur seals)**. The Cape Fur Seal is endemic to the South African and Namibian shoreline. a) They have dog-like heads, and limbs that are modified to act as flippers. b) Sea lions have limbs suited to moving around on land and swimming, and small pinnae. c) **Waterproof fur traps air** and thick **blubber** layers are common. d) A counter-current blood network is common. e) Fur seals mate and breed on land, normally forming large colonies, where the young are birthed and then tended for by the female. She has to leave the pup on the breeding beach in order to forage for	Photographs, slide show, videos and diagrams to illustrate variety Study live examples Observation of as many live species as possible, or arrange lesson or course with nearest museum or zoo Use a specific locally available example, but ensure ability to recognise major sub-groups or classes and defining characteristics Incorporate into ecosystem field trips	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

food. The mothers can recognise the call of their pups in order to find them again. The pups are more vulnerable to predators when the mothers are away.

2. **Cetaceans: whales and dolphins.** Whales common to our shoreline include the Southern Right, Humpback and Brydes’. Dolphins seen on our shoreline include the Common, Bottlenose, Dusky, Humpback and **Heavisides** (endemic to the West Coast of SA). Killer whales are occasionally spotted and are also considered to be dolphins. Cetaceans have the following features:
    a. Bodies are hydrodynamic and limbs are modified to form flippers or flukes.
    b. The rear limb bones are totally reduced, and tail flukes of connective tissue have evolved.
    c. Food can be caught using **echolocation** and (**homodontic**) teeth (**Odontoceti**).
    d. Others **filter food** out of plankton-rich waters using baleen plates (**Mystecet**i).
    e. Kidneys are capable of excreting high concentrations to deal with high salt intake.
    f. **Nostrils** are on top of the head (**blow hole**).
    g. Replacement of lung air is rapid and each breath replaces almost all lung volume.
    h. **Lungs collapse** as diving commences, to reduce **bends** and buoyancy.
    i. Recent research shows that very high levels of red blood cells and **myoglobin** retain O_2.
    j. Thick fat layers (**blubber**) conserve temperature.
    k. Non-vital organs are shut off and vital ones make do with less; heart rate slows radically (**bradycardia**). Dives to 1000+ m have been recorded.
    l. Mating and birthing take place at sea. In the case of the Southern right whale, the whales migrate to the south coast of South Africa, in the winter months, to give birth to their calves and mate. They will have thick layers of blubber from which they can source milk for the rapidly growing calves. As summer approaches, the mother and calf migrate to the plankton rich waters of the Southern Ocean, where they can feed and replenish their blubber layers.

72. Kelp Forests

Term 2		Strand – Ecology		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**Individual ecosystems should be viewed with reference to the ecological concepts introduced in Gr10 and highlight the unique components and interactions within each.** **Understanding of the complexity of ecosystems is critical for learning about the multi disciplinarily of Marine Sciences. Class discussions, field trips and projects should be used to integrate ecosystem**	The **entire West Coast of** Southern Africa is dominated by Kelp Forest habitats. Kelps – 1. Require **rock surfaces** to grow on. 2. Grow from the **infratidal zone to as far as 3 km away** from the shore, wherever **reefs are shallower than 30 m.** 3. Form the ocean equivalent of a **tropical forest**. 4. Encounter **frequent heavy wave action.** 5. Also encounter south to easterly **gales,** mainly in **summer**, which cause **upwelling.** 6. Thrive in water that is nutrient-rich (*see "Upwelling" in Oceanography section*). **The dense growth of kelp and other algae** forms **three distinct zones**: 1. **Inshore zone** a. Here smaller **sea bamboo** (*Ecklonia maxima*) and large amounts of **benthic algae are found.** b. Relatively **few animals** occur here. 2. **Intermediate zone** a. Water depths are less than 15 m. b. **Dense stands of *Ecklonia*** with **split fan kelp** (*Laminaria pallida*) form an understorey, along with algae that is mainly **red, benthic and epiphytic.** c. **Relatively few animals are found here;** the few that do occur are mainly **filter feeders**. d. This is a stable system, much like tropical forests, where new colonisation only occurs after older plants are uprooted or die. 3. **The offshore zone** a. Can be seen as mainly **island-like stands of *Laminaria***, with similar low animal numbers and abundance in the two previous zones. b. but with a far greater abundance of **animals** on the open reef between these stands. **Kelp forests are amongst the most productive environments.** 1. Kelp fronds **grow continuously** and their **ends fray** and break off. 2. **Growth is rapid**, especially in summer. 3. **Storm surf uproots some kelp and other algae**, which then **decompose** on beaches and **are returned to the sea as organic nutrients** and microscopic **fragments**. 4. Kelps produce large amounts of **mucus** that prevents damage as the fronds rub against each other. 5. **This mucus is rich in organic compounds** which, when released into the water by strong wave action, form a thick surface **foam**. 6. The foam promotes significant **bacterial growth**. 7. Thus, instead of the fresh plant matter, which is quite indigestible, far more food is made available as **weathered detritus, organic compounds** and large amounts of **bacteria.**	Videos Kelp forest Ecology lesson at The Two Oceans Aquarium	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

	studies and other appropriate topics in this curriculum.	8. **After an upwelling** event (which stops when the wind subsides), **phytoplankton blooms** can occur. **Feeding interactions:** 1. Kelp particles, decomposition bacteria and phytoplankton blooms are **capitalised on by filter feeders, including mussels, sponges, red bait, sea cucumbers and feather stars.** 2. Kelp **holdfasts provide a haven** for a high diversity of small invertebrates. 3. **Kelps** also **reduce the effect of wave action**, providing **calm environments** in which animals can survive. 4. **Some herbivores** eat **fragmented kelp** fronds, including **urchins, alikreukel (Turbo sp) and abalone (*Haliotus midae*).** 5. **Few herbivores** graze on living kelp, with the exception of the **kelp limpet (*Cymbula compressa*). It is adapted to hold onto the kelp stipe, and aggressively defends it from other herbivores.** 6. **Carnivores and omnivores** in turn feed on the herbivores; these include **lobsters, octopi, Reef sharks, many species of fish, seals and penguins**.		

73. Waves: Energy transfer

	Term 2	Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	**An overview is adequate to provide a basis for learners to understand the context of oceans waves as part of the locality of Marine Sciences studies and research.**	**How do waves begin?** 1. A wave is formed by **wind contact** and **friction** on the surface of the water. This disturbance of the **water's surface tension** sets in motion the formation of a wave. Waves start as **capillary waves** (or ripples); these grow in size to become **gravity waves**. 2. The **anatomy of a wave**: the elevated part is the **crest**, the depressed part is the **trough.** The **wavelength** is the distance between two crests or two troughs. Water particles move in **orbits** as the wave moves forward. 3. **Waves in motion**: wave height increases with wind speed, wind duration and the fetch. The **fetch** is the continuous area of water over which the wind blows in a consistent direction. 4. The energy of the wave is related to the wave height. 5. Shallow-water waves occur when water depth that the wave is moving into is 5% of the wave length. The speed of shallow waves becomes slower than in deep water, and the wave height increases (wavelength = v/f). 6. Waves arriving at the coastline can be refracted, reflected and diffracted. **Refraction** is the change of direction or the bending of waves. **Reflection** is the rebounding of the wave after striking a surface. **Diffraction** is the bending of waves between or around obstacles. 7. A wave approaching the shore will break when friction on the sea bed slows the base of the wave to such an extent that the top overtakes the bottom. The force with which the wave breaks depends on the profile of the sea bed. A shallow gradient mean a slow spilling wave, and a steep gradient means a fast plunging wave. 8. At the shore's surf zone, breaking waves move water to the shore. Breaking waves are called **spillers** or **plungers**. Water moves toward the shore and then away in the form of **rip currents**, or along the shore as **longshore drift.** **Tsunami or Seismic Waves** 1. A tsunami is a wave with an extremely long wavelength produced by submarine seismic activity, such as an earthquake or sudden movement of the earth's crust. 2. Directly above the seismic event, the whole column of water moves up and down. This triggers the long-wavelength wave. 3. Tsunamis can travel across an ocean for thousands of kilometres. 4. In deep water, tsunamis typically travel without being noticed. As the wave enters shallower water, the amplitude of the of wave increases. 5. Tsunami waves behave like massive shallow-water waves, becoming very forceful. 6. Tidal waves (tidal bores) are not to be confused with tsunami waves. Tidal waves form in a narrow inlet or river mouth where there is a large tidal range. In the Yellow River, given the correct conditions, waves can last up to 11 km upstream.	**Illustrate with a miniature wave tank**	Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

74. Chemical Composition of Sea Water

Term 2		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	Basic Marine Sciences Chemistry **Revise Polar Bonding; Covalent Bonds; Hydrogen Bonding. Ionic Bonding is done in Gr 12**	**Basic Marine Sciences Chemistry** **Revise Polar Bonding; Covalent Bonds; Hydrogen Bonding** **Ionic Bonding** 1. Water is an **excellent solvent**. Water's dissolving ability is a result of the polar nature of the water molecule. 2. **Sodium chloride ($Na^{+}Cl^{-l}$)** is the most common salt, and is made up of sodium (Na^{+}) and chloride (Cl^{-}) ions. 3. An ion is an atom or group of atoms that has an unbalanced charge, owing to the atom losing or gaining an electron. 4. In water a covalent bond exists, which is an equal sharing of electrons. 5. In **$Na^{+}Cl^{-l}$** the sodium has lost electrons and the chloride gained electrons. Salt therefore has a latticed crystal structure. 6. In salt, the sodium and chlorine ions are linked by the mutual attraction of their opposite electrical charges. The ions in sodium and chloride in $Na^{+}Cl^{-l}$ are held together by ionic bonds. 7. Ionic bonds are electrostatic attractions that exist between ions that have opposite charges. 8. When $Na^{+}Cl^{-l}$ dissolves in water, the ionic bonds in Na^{+} and Cl^{-l} are weakened by the polarity of water. This results in the ions separating; as they move away from each other the water has contact with the next layer of $Na^{+}Cl^{-l}$. 9. Oil does not dissolve in water even when shaken vigorously. This is due to the oil molecule being non-polar in character. The oil molecule has neither a positive nor a negative charge to attract the polar water molecule. In living tissues this is an advantage because water does not dissolve the oils within tissue membranes.		Many YouTube Clips are available to illustrate all the defined and illustrated content on this topic

75. Ekman Spiral and Eddies

	Term 2	Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	Ekman Spiral	**Ekman Spiral and Ekman Transport** 1. Wind-driven surface water “drags” underlying water with it. 2. As a result of friction, the **deeper layer of water moves more slowly** than the surface layer of the water and is **deflected more by the Coriolis Effect**. 3. Each successive layer below follows a similar pattern: each deeper layer moves more slowly, and with a greater angle of deflection, than the layer above it. 4. At about 100 m to 150m below the surface, currents move in exactly the opposite direction to that on the surface. 5. This **current spiral** in the water column is known as the **Ekman spiral and Ekman transport**. 6. The Coriolis Effect deflects to the left in the southern hemisphere and to the right in the northern hemisphere. **Currents** 1. All patterns of flowing ocean water are called currents. 2. Large current systems are mostly named after the area where they exist (eg Agulhas Current). 3. Downwelling occurs, at times, in areas where two opposing surface currents converge. 4. Upwelling occurs on the western sides of continents in the region of the Trade Winds (eg SE wind off west coast of South Africa, also west of California, Peru and Australia). **Global Circulation** In addition to wind-driven surface circulation (explained above), a slow planetary circulation of water occurs through currents that mix water from the Indian Ocean and the Atlantic Ocean basins. This movement distributes heat in the ocean basins. The Indian Ocean water is driven southward in the Agulhas Current, then partly northwards as eddies flowing north-west from the southern tip of Africa, then driven northwards by the Benguela Current. This water joins the Gulf Stream and ends up in Arctic waters. In the Arctic, cold dense water with high salinity sinks and flows as a deep counter-current southwards in the Atlantic, then from the Antarctic Shelf in a north-easterly direction toward India. The water rises to the surface and begins its journey back to the North Atlantic. Water freezes at the poles in winter. As this occurs cold salt water or brine sinks to the ocean floor and forms a deep thermohaline current. **Eddies** 1. Narrow fast-moving currents move into the open sea, displacing the water through which they move. 2. The current oscillates, meanders and develops waves along its boundary. These pinch off as pockets of spiralling water called **eddies**.		NOAA Video on thermohaline circulation

76. Scientific Inquiry

Terms 2		**Strand – Humans and the Ocean**		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
9 hours	**The Scientific Method** **In Grade 12** **Teachers and learners need to deal with a thorough understanding of the representing data in different formats (eg. Tables and Graphs and analysing the data to come to conclusions regarding the hypothesis.** .	*This section provides the basis for the students to develop a Marine Sciences project that demonstrates their skills in applying the Marine Sciences curriculum. As scientists-to-be, students need to practise observing, inquiring, investigating, and researching the natural world. It is here that Marine Sciences as a curriculum subject comes into its own. The oceans are filled with beauty, fascinating elements and intriguing occurrences. The Marine Sciences project is the opportunity for a teacher to engender passion for the oceans among Marine Sciences students.* **The Scientific Method** 1. **Conducting an investigation** – one conducts an investigation by collecting evidence from a variety of sources, developing an explanation based on the data, and communicating and defending one's conclusions. 2. **Method** – the scientific method requires questions leading to a hypothesis that can tested by observations, in turn leading to conclusions. 3. A **theory** is proposed on the basis of evidence obtained from research conducted. **Science Process Skills** 1. **Observe** – use all the senses. 2. **Question and** h**ypothesise** – a hypothesis is a tentative explanation about possible causes or dynamics of a phenomenon. 3. **Predict** – scientific predictions are based on observations, measurements, and relationships between observed variables. 4. **Use the right terminology** – all procedures and reporting are vitally dependent on the precise use of terms. 5. **Define variables** – identify and distinguish variables that are controlled (held constant) and those which are manipulated. a. **Independent (manipulated) variable** – the measurement or condition that is regulated by the person doing the experiment. b. **Dependent (responding) variable** – what you measure and observe in response to changes in the independent variable. c. **Controlled (fixed) variable** – these refer to conditions that must be kept the same (held constant) in order to isolate the result; a controlled variable has the potential to vary but is deliberately restricted. 6. **Perform experiment.** 7. **Record results.** 8. **Analyse results.** 9. **Draw conclusions.** 10. **Produce a research report and poster** – the report should include Introduction, Hypothesis, Method, Results, Discussion, Conclusion. **Research Skills** 11. Classify – group related objects and ideas together. 12. Quantify – use numbers and measurements related to time, length, width, volume and ratio. 13. Communicate results – describe verbally (text) or visually in tables and graphs. 14. Interpret, discuss data and draw conclusions – explain an observation.	Observation Hypothesis testing Theory and truth Problem statement (initial inquiry) Hypothesis (allows for predictions) Experimental design (materials and procedure) Data collection (observations and measurements) Analysis and interpretation of data or results (inferences) Drawing conclusions (answering the research question or problem) Have we proved or disproved the hypothesis? Extension (further inquiry – pose new questions that are related to the original question and can lead to new investigations)	**A range of equipment can be used for this practical work; for example, transects, Secchi disks, and water sampling equipment**

77. South African Shoreline

Term 2		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**An overview of this topic adequately informs the learner of the South African Coastal setting in which South African Marine Sciences research is undertaken.**	The South African **coastline** stretches for over **2500 km**. 1. **Semi-desert conditions** are experienced on the north-western coastline as there is little precipitation in this area. Coastal fog is common. A **high sediment load** is deposited into the ocean by the Orange River. Research shows that over millennia, the mouth of the Orange River has meandered between Lamberts Bay and Lüderitz. Diamond dredge mining dominates the economy of this coastline. The Namaqualand area is famous for its flowers in August and widespread succulent Karoo vegetation. 2. The SW Cape from Lamberts Bay to Mossel Bay experiences a **Mediterranean climate**. This coastline includes significant estuaries at the mouths of the Olifants berg and Breede Rivers. The coastline is typically broad coastal plains with sandy and rocky shores. 3. Exceptions include the Gordon's Bay, Rooiels and Chapmans Peak shorelines, in which **sheer cliffs** plunge straight into the sea. 4. The coastline adjacent to Agulhas Bank has long stretch of **high limestone cliffs** with **wave-cut platforms** 5. Southern Cape has a higher rainfall, with an associated **evergreen Afromontane forest**. There are examples of **coastlines of submergence and emergence** between Wilderness and Plettenberg Bay giving rise to significant lakes, wetlands and estuaries (the Knysna estuary being of special significance). The emergent coastline between Natures Valley and Storms River mouth has steep sandstone cliffs incised by river valleys. The valley slopes have a north–south aspect, giving rise to markedly different vegetation types on either side of the valley. 6. The Eastern Cape and southern Kwa-Zulu Natal (KZN) coastlines are characterised by barrier dunes, covered by dense subtropical thicket and bisected by numerous **estuaries** that provide breeding grounds for fish species. The "**Hole in the Wall**" is an example of a geological feature (**arch**) and is found at Coffee Bay in Eastern Cape. 7. For approximately 17 km north of Richards Bay, in a 2-km wide strip, **heavy sands** such as **titanium, rutile, zircon** and pig iron are mined. 8. Central KZN to northern KZN is characterised by **mangrove swamps,** and coral reefs are found in these subtropical coastal waters. 9. There is higher precipitation along South Africa's east coast compared with the west coast. A larger number of rivers drain the eastern part of the country, resulting in associated estuaries at the East Coast river mouths. *Define:* a) Dunes b) Beach composition and anatomy of a beach c) Erosional forces d) Coastal movement	South African examples	Extracts from **Shoreline** series (SABC)

78. Coastal Formations

Term 2		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**An overview of this topic adequately informs the learner of the South African Coastal setting in which South African Marine Sciences research is undertaken.**	1. The coast is the land area along or near the ocean that is shaped and influenced by the sea. 2. A **primary coastline** is shaped by tectonic forces on continental margins, and is acted upon by **secondary forces** such as waves, currents and wind action. 3. **The shore** is the area from the low tide mark to the top of the wave zone. 4. **Beaches** are areas where sediment is deposited and accumulates. The beach is a dynamic balance between deposition and erosion of material. 5. A beach is either an erosional or depositional beach. 6. A beach which loses the same amount of material as the amount deposited is a beach in equilibrium. 7. **Features of a beach** are: a) offshore trough b) bar c) low tide terrace d) wave platform e) beach f) scarp g) berm 8. Beaches are **described** by the shape, size, colour and composition of the beach material. 9. Floating plastic and other marine **debris** tends to accumulate on depositional beaches. Floating debris is brought there by the movement of currents and wave action. 10. In the surf zone, breaking waves produce a current that moves sediment along the shore (**longshore current**). This is called longshore transport. 11. **Rip currents** move sediment seaward through the surf zone. 12. Estuaries are river mouths, and their associated banks and beds are subject to the tidal ebb and flow of the sea water they discharge into. 13. Estuaries play an important role in providing nursery habitats for juvenile fish. Estuaries are excellent sites to study salinity and other water quality parameters.	**Use an example of a simple wave tank to illustrate the sediment load and movement on a small scale model**	**Shoreline video plus a range of YouTube clips on the subject.**

79. Climate Change

	Term 2	Strand – Humans and the Oceans		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
2 hours	**The depth at which this topic should be understood is one in which learners should apply their knowledge of other topics studied up to this point. In addition this topic will form as a frame of reference as further topics in the Ecology and Humans and the Ocean strands are introduced. The topic lends itself to higher level solutions based applications**	1. **Weather** is the condition of the atmosphere at a particular place and time, in terms of temperature, sunshine (daylight hours), cloud cover, wind, rain, air pressure, and moisture or humidity. 2. **Climate** is an average weather condition in a locality over a relatively long period of time, at least 30 years. 3. Types of climate are defined within the **Köppen's climate classification** system. **Levels of precipitation and vegetation types** are the criteria used to distinguish between each climate type. 4. A **change of a climate** type would be from one Köppen type to another. 5. Increased CO_2 emissions from burning fossil fuels **have released CO_2 into the atmosphere.** Currently the rate of CO_2 emission is **10 times faster** than it has been at any other time in the **past** 66 million years. Other human activities have added further to the greenhouse gas emissions. 6. Greenhouse gasses have **changed the average temperature of the planet, over the past 20 to 40 years,** at unprecedented levels. Subsequent effects include **melting of ice caps**, increasingly severe **hurricanes**, and **flooding** and **drought**. 7. With the shift to dryer climates, there is likely to be a significant **change in agriculture**. In some areas agricultural activity is likely to collapse as a result of drought conditions. 8. An increase in average temperatures on earth can result in **melting ice caps, with a significant sea level rise**; this affects the coasts and low-lying coastal ecosystems as well as the infrastructure. 9. Properties and human infrastructural development at the sea shore (adjacent to the high-tide mark) are vulnerable to flooding because of higher sea levels and associated storm surges. 10. Greenhouse gas emissions **can be reduced** by management plans and by changing to **environmentally friendly lifestyles**.		http://www.physicalgeography.net /fundamentals/7v.html

80. Ocean Acidification

	Term 2	Strand – Humans and the Oceans		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
1 hours	**The depth at which this topic should be understood is one in which learners should apply their knowledge of other topics studied up to this point. In addition this topic will form as a frame of reference as further topics in the Ecology and Humans and the Ocean strands are introduced. The topic lends itself to higher level solutions based applications**	1. The chemistry of the ocean is linked to the chemistry of the earth's atmosphere. 2. **Ocean acidification is caused by CO_2 emissions** into the atmosphere. Most CO_2 in the atmosphere comes from **burning fossil fuels**. 3. An **increased amount of CO_2** in the ocean results in **increased acidity of the ocean**. a. Any solution in contact with a gas in its surrounding environment will result in chemical equilibrium with that environment. If disequilibrium is established, a new equilibrium will occur. b. The average pH of sea water is 8.1. c. CO_2 added to water forms increased quantities of carbonic acid: $H_2O + CO_2 \rightarrow H_2CO_3$. 4. Extra CO_2 in the atmosphere is absorbed by the ocean to create equilibrium. The CO_2 combines with water to form carbonic acid, which breaks down into bicarbonate molecules and hydrogen ions. 5. Carbonate combines more easily with hydrogen ions, which could lead to some marine animals being unable to form protective shells. Calcium and carbonate cannot bind together in a more acidic environment; this specifically affects the **shells** of molluscs, **carapaces** of rock lobsters, and **tests** of urchins and all other marine organisms with structures formed from **calcium carbonate**. 6. A decrease in the ocean's pH (increase of the acidity) thus has a hugely detrimental impact on marine organisms.	Conduct an investigation as illustrated in https://www.youtube.com/watch?v=a_CS0-FXfmA	Materials: tank, water, indicator, "earth platform" and dry ice https://www.youtube.com/watch?v=kxPwbhFeZSw http://www.unep.org/dewa/Portals/67/pdf/Ocean_Acidification.pdf

81. El Niño

Term 3		Strand – Oceanography		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
3 hours	The El Nino phenomenon had a profound effect upon South African weather and conditions that impact upon a South African every day life. This includes drought and sardine movements along the coast. Higher level debates, discussions and applications should be included in class discussions and assessment tasks.	**El Niño** In a previous section, the "normal" atmospheric conditions experienced in the Pacific region are described. Under certain circumstances these conditions change to an **El Niño** or **La Niña** event. **During some years, warm tropical water moves eastward across the Pacific, accumulating along the west coast of South America. This blocks the normal upwelling and is called El Niño, associated with changes in air pressure and wind direction.** 2. The trade winds of the Pacific typically blow in a SE direction each summer. (This is similar to the SE wind that occurs in Western Cape.) 3. On the western side of tropical landmasses (eg along the coast of Peru and Ecuador), the water is normally cold and highly productive with living organisms (because of upwelling). 4. At times the trade winds lose their driving force; upwelling becomes less, and warm surface water accumulates along the coast. 5. This kills off cold water species, upsetting the food chain. 6. In severe cases this can result in increased levels of hydrogen sulphide in the water. 7. During some years the water remains warmer for the full year (eg 1982–1983, it was 7°C above normal temperature levels). 8. This could be caused by a change in air pressure on either side of the Pacific disturbing the trade winds. 9. The above phenomenon is named El Niño – after the Christ child, as it has mostly occurred over the Christmas period in December. 10. This phenomenon also has an effect on South African weather conditions, with the effect varying depending on the strength and phase of the event. **La Niña (Spanish for "the girl")** 1. This name is given to periods when the surface temperature of Pacific water is lower than normal. This drop intensifies the "normal" drier conditions over coastal regions of Peru and Chile. 2. Flooding increases in India, Burma and Thailand. 3. There has been no significant occurrence of La Niña since 1975; hence, data has not been placed in sophisticated computer models to accurately predict an occurrence of La Niña.	Explore simple weather models which explain the El Nino and La Nina phenomena	http://www.unocha.org/legacy/el-nino-southern-africa

82. Aquaculture of Marine Species

Term 3		Strand – Humans and the Oceans		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	**The depth at which this topic should be understood is one in which learners should apply their knowledge of other topics studied up to this point. In addition this topic will form as a frame of reference as further topics in the Ecology and Humans and the Ocean strands are introduced. The topic lends itself to higher level solutions based applications**	1. Marine aquaculture refers to the **breeding and growing of marine organisms** such as fish, molluscs, crustaceans and plants, **in a controlled environment. Marine aquaculture is also referred to as Mariculture.** 2. Controlled measures are put in place to **enhance spawning, production, feeding and protection from predators**. 3. South Africa's aquaculture sector makes up 1% of the international aquaculture industry and 27% of African aquaculture. South Africa's largest aquaculture production is from **abalone farming**. 4. Principles guiding the **management of an aquaculture facility** include: a. **Maintaining a healthy ecosystem** and water quality. b. **Minimising the nutrient load of effluent water**, recirculation and biological filtration of effluent, and minimising environmental impact on surrounding ecosystems. c. **Optimising the use of food** and nutrition plans. d. **Managing food safety** for the consumer. e. **Application of genetics** studies to increase productivity, growth rates and animal health. f. **Animal husbandry,** including farm design for land-based or off-shore systems, and the carrying capacity of systems. g. **Managing diseases** and parasites. 5. Multidisciplinary planning is required, which includes input from disciplines such as physiology, genetics, biotechnology, ecology, nutrition, economics and engineering. 6. Careful selection should be made of species that would cope with culture technologies and breeding techniques (eg artificial controlled spawning). 7. Correct techniques should be applied with regard to condition of brood stock, rearing at the larval stage, spat production, and grow out or rearing programmes. 8. **Planning should ensure** long-term **sustainability** of a facility, with consideration of the following aspects: a. Financial and economic – **aquaculture needs to be profitable to be sustainable.** b. Markets. c. Social impact – such as sustainable employment. d. Environmental impacts. e. Product, its value and sell-ability.	**Visit an Aquarium and arrange a talk on the life support systems and mechanisms required to run a fish farm . Have an aquarium vet discuss bio security in such a facility.** **Have a mariculture manager discuss the balances between supply and demand. Costs of fish feed and the economic pressures relating to costs from electricity to food to plant materials and transport costs.**	**http://www.fao.org/fishery/countrysector/naso_southafrica/en** **http://www.nda.agric.za/doaDev/sideMenu/fisheries/03_areasofwork/Aquaculture/AquaPolGuidLeg/AquaPolicyGuide/The%20User%20Friendly%20Legal%20Guideline%20for%20the%20Aquaculture%20Sector%20in%20South%20Af....pdf**

83. Commercial use of Marine Algae

Term 3		Strand – Humans and the Ocean		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
3 hours	**Commercial use of marine plants and extracts** **The Depth of this topic is at a level where learners understand Potential commercial ventures.**	*(This material should appear in the Humans and Ocean section- A quick revision of the Macroalgae content should be done, as part of the introduction to this section))* The ocean is a **source of natural resources**, both living and non-living. 1. **Algae** are collected by many cultures for **food, fertiliser, medicine** and as **a source of specific chemicals** which can be used in industry. **2.** As the size of the human population increases, the **demand for these resources grows.** In many cases, the productivity of algae is so high that carefully managed harvesting from the wild can be kept **sustainable**. **3.** In other regions, algae harvesting has been **unsustainable for many years,** and various ways of **farming** the algae have been devised. 4. The process of farming marine organisms is called **mariculture**, which is a branch of the general farming of aquatic organisms (fresh or salt water) known as **aquaculture**. **Sea Plant Mariculture** 1. Sea-plant mariculture has been practised in the **Far East for centuries**. 2. It is now practised extensively in **South East Asia, Canada, USA, East Africa and several coastal European countries**. It remains a **labour intensive** practice. **3.** Some sea plants, like ***Ulva sp*** **and** ***Porphyra sp*****, are cultivated to be consumed in raw, dried or processed forms** (Ulva in salads, soups and stews and Porphyra to wrap sushi, amongst other products). Other sea plants are **chemically treated to extract specific useful compounds.** 4. **Kelps** can be harvested and processed to be used as **fertiliser and plant growth foods**, as they are rich in minerals and plant growth hormones. (Kelpac in Simonstown harvests local sea bamboo for this purpose.) **5.** Many mariculture facilities use harvested sea plants **as animal feed.** **Examples of sea plant products:** **Carrageenan** 1. Carrageenan is a family of complex **sulphur-containing polysaccharides** extracted from many **red algae.** 2. It is used as **stabiliser or gelling agent** in meat, dairy and vegetarian products (eg yoghurt, processed chicken, almond milk and soy milk.) 3. It **thickens the product** and prevents the ingredients in these products from separating. **Agar** 1. Agar is a jelly-like substance obtained from certain **red algae** species. 2. Used as a **gelling ingredient** in desserts.	Write a short article on food dishes produced from, or making use of, sea plant ingredients Produce agar jelly from red sea plants This section lends itself to a short literature review exercise	Internet Fresh red algae from Gracilaria and Gelidium groups See *Two Oceans, A guide to Marine Life of Southern Africa* (Branch et al.)

		3. Solid substrate to contain **culture media for microbiological work** in petri dishes (agar plates). 4. Vegetarian **substitute for gelatine**. 5. Also found in **fruit preserves**, jams and ice-cream, and used in the brewing industry to **clarify beverages** before bottling. **Algin(ate), also called alginic acid** 1. It is an extract obtained from pulped kelp. 2. It is used as a **thickener** and a **stabiliser** in many foodstuffs, such as cheese and ice-cream. 3. It also has uses in the **medical field** (iodine tablets, mineral supplements and dental moulding), **textile** industry (dyes and fibres), and many other industries (eg adhesives, explosives and welding). **Beta-carotene** 1. This is a red-orange **pigment** contained in certain seaweeds, particularly Chlorophyta. 2. It is used as an **antioxidant** as it protects the body from free radicals (free radicals damage cells and may cause several chronic diseases). 3. Human bodies convert beta-carotene into **Vitamin A.** 4. Can be used as a **yellow colourant** in certain foodstuffs (eg margarine, mayonnaise and cheese).		

84. Harvesting Ocean Energy

Term 3		Strand – Humans and the Oceans		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
4 hours	**The depth at which this topic should be understood is one in which learners should apply their knowledge of other topics studied up to this point. In addition this topic will form as a frame of reference as further topics in the Ecology and Humans and the Ocean strands are introduced. The topic lends itself to higher level solutions based applications**	**Introduction to Harvestable Energy found in the Ocean** 1. As fossil fuels become depleted and ever more costly, and their emissions increase the levels of greenhouse gasses in the atmosphere, more scientists and engineers are looking to **renewable energy sources**. **South Africa depends almost entirely on non-renewable electricity (coal and nuclear). (***Refer to Climate Change and Ocean Acidification).* 2. Associated with offshore localities are high wind speeds that can potentially drive **wind turbines to generate electricity**. Wind is the most effective renewable electricity generator associated with the ocean. 3. The **ocean is constantly moving –** in the form of associated **wind, waves, currents and tides**. There is **enormous potential for these natural forces to generate electrical energy;** the ocean alone could generate more electricity than humans need. **Ocean energy options** 4. **Challenges** to finding ocean energy solutions are the **extreme force of wind, wave action and tidal flow,** which damages equipment, and the **corrosiveness of salt water** on generator mechanisms. 5. Technology designs need to be fine-tuned to minimise their impact on habitats and species. Equipment that runs at a high torque and low speed has a relatively low impact on living organisms. 6. Significant effort is being made to find solutions in Scotland, Australia, Florida, Oregon and California. **Existing renewable energy solutions:** a) **Wave energy** mechanisms are anchored to the sea bed. At the surface a magnet is moved by the waves and passes windings that is moved by waves. Waves drive hydraulic pumps and force an airflow that drives fans. b) **Currents** are particularly strong off the Southern African east coast. These have the potential to drive generators anchored to the sea bed. c) **Wind** farms have been constructed in Caledon, Darling and Jeffrey's Bay. Some wind farms in Scotland and off the east coast of USA are mounted to the sea bed offshore and protrude above the ocean surface. d) **Tidal movement** currents off the South African coast are not viable for energy generation as the average tidal range is small (up to 1.8 m). It is estimated that current technology can effectively harvest tidal flows only if the average tide difference is 5+ metres. In places where the tidal difference is greater, the challenge is to manufacture anchor points that are large enough for the mechanisms. 7. Much research and political will is required to find future solutions that are cost-effective for harvesting the energy referred to above, using mechanisms which can operate efficiently, generate adequate wattage, and connect reliably to the current electricity grids.	Develop solar and wind power devices from a kit or components from an electronics shop. Eg Yebo Electronics	https://books.google.co.za/books?hl=en&lr=&id=SkzRBQAAQBAJ&oi=fnd&pg=PP1&dq=harvesting+ocean+energy&ots=Rth8X9WXWr&sig=IqjkUYEGzWWLtz2J_OpWnGxJG5g#v=onepage&q=harvesting%20ocean%20energy&f=false

85. Biomimicry

	Term 3	Strand – Humans and the Oceans		
Time	**Depth**	**Key Concepts**	**Investigations**	**Resources**
3 hours	**The depth at which this topic should be understood is one in which learners should apply their knowledge of other topics studied up to this point in terms of Ecology and Humans and the Ocean strands are introduced. The topic lends itself to higher level solutions based applications.**	Biomimicry is a **multidisciplinary field.** It connects a range of careers and specialities with the purpose of better understanding **designs found in nature,** and how those designs can be **imitated to efficiently answer technical, design and construction challenges.** 1. **Nature has probably solved every technological problem humans are likely to face**. Whether we are trying to heat up or cool down, glue surfaces together, fly, transport ourselves, provide shelter, package, preserve, synthesise or destroy (to mention but a few), nature has done the task before. 2. In nature we witness the **perfect R&D** (research and development) programme in the process of natural selection. (*Revise Natural Selection.)* 3. The implication is that **designs in nature have been refined** over millennia and have literally stood the test of time. **4.** Technologists, designers, engineers and architects **can find solutions to their problems in nature.** 5. The connecting of biologists with designers is an example of how the field of Biomimicry lowers barriers between professional specialities. Professionals in this field find **cooperative inter-disciplinary group effort** to be more effective than working alone. 6. Once a problem is identified, biologists or microbiologists are called to explain or investigate how nature has found solutions to a similar problem. 7. The challenges are put to the team, which then sets out to find **solutions that might exist in nature and can be emulated** in terms of structure, process or system. 8. Technologists, designers and engineers then design a nature-inspired solution. (*Mention marine related examples.)* Biomimicry's recognised guiding principles are: 1. Use **abundantly available materials.** 2. Manufacture **at standard temperature and pressure.** 3. Biomimicked designs themselves become an inspiration for new designs; the **design process evolves**.	Find the *Ask Nature* website Investigate the design of shark skin and sharkskin-mimicking paint Investigate the byssal threads used by mussels to anchor themselves on rocks despite violent wave action	https://sites.google.com/site/biomimicrysa/home http://www.biomimicryinstitute.org/ http://www.asknature.org/

SECTION 4: ASSESSMENT IN MARINE SCIENCE

4.1 Introduction

Assessment is a continuous planned process of identifying, gathering and interpreting information on learners' performance, using various forms of evaluation. It involves four steps: generating and collecting evidence of achievement; evaluating this evidence, recording the findings and using this information to understand and thereby assist the learners' development in order to improve the process of learning and teaching.

Assessment should be both informal (Assessment for Learning) and formal (Assessment of Learning). In both cases, regular feedback should be provided to learners to enhance their learning experience.

Assessment is a process that measures individual learners' attainment of knowledge (content, concepts and skills) in a subject by collecting, analysing and interpreting the data and information obtained from this process to:

- enable the teacher to make reliable judgements on the basis of the learners' scores;
- inform learners about their strengths, weaknesses and progress (assessment feedback is an imperative element of the process); and
- assist teachers, parents and other stakeholders in making decisions about the learning process, the progress of the learners and developing a remedial study action plan to mentor all learners I an informed way to remediate methods of learning and remediate methodologies of teaching practice in Marine Sciences.

Assessment should be mapped against the content and intended aims specified for Marine Sciences and in informal and formal assessments it is important to ensure that in the course of the year:

- all of the subject content is covered;
- the full range of skills is included; and
- different forms of assessment are used.

4.2 Informal Assessment and Daily Assessment

Assessment for learning has the purpose of continuously collecting information on learners' achievement that can be used to improve their learning.

Informal assessment is daily monitoring of learners' progress. This is done through activities such as observations, discussions, practical demonstrations, learner-teacher conferences and informal classroom interactions. Informal assessment may be as simple as stopping during the lesson to observe learners or to discuss how their learning is progressing. Informal assessment should be used to provide feedback to the learners and to inform planning for teaching, but it need not be recorded. It should not be seen as separate from learning activities taking place in the classroom. Learners or teachers can mark these assessment tasks.

Self-assessment and peer assessment actively involve the learners being assessed. This is important as it allows learners to learn from and reflect on their own performance. The results of the informal daily assessment tasks are not formally recorded unless the teacher wishes to do so. The results of daily assessment tasks are not taken into account for promotion or certification purposes.

Informal, ongoing assessments should be used to structure the acquisition of knowledge and skills and should be a precursor to formal tasks in the Programme of Assessment.

4.3 Formal Assessment

Grades	Formal school-based assessments	End-of-year examinations
R - 3	100%	n/a
4 - 6	75%	25%
7 - 9	40%	60%
10 and 11	25% including a mid-year examination	75%
12	25% including mid-year and trial examinations	External examination: 75%

All assessment tasks that make up a formal programme of assessment for the year are regarded as formal assessment. Formal assessment tasks are marked and formally recorded by the teacher for progression and certification purposes. All formal assessment tasks are subject to moderation to ensure that appropriate standards are maintained.

Formal assessment provides teachers with a systematic way of evaluating how well learners are progressing in a grade and in a particular subject. Examples of formal assessments include tests, examinations, practical tasks, projects, scientific poster presentations, oral presentations, demonstrations and performances. Formal assessment tasks form part of a year-long formal Programme of Assessment in each grade and subject.

The cognitive demands in assessment should be appropriate for the ability and developmental level of the learner. As the teaching progresses through the grades so the cognitive demand of the assessment of the content is increased.

Assessment in Marine Sciences must cater for a range of cognitive levels among learners. The assessment tasks should be carefully designed to cover the content of the subject as well as the range of skills and the cognitive levels that have been identified in the specific aims. The design of assessments should therefore ensure that a full range of content and skills are assessed within each Grade in the Phase. The specific aims, topics, content and range of skills in the subject should be used to inform the planning and development of assessments.

Teachers should use the examples of verbs in the table below to guide their assessment of the Marine Sciences curriculum at the appropriate cognitive levels. The verbs are arranged in terms of a taxonomy of thinking [Bloom (1956), Kratwohl (2002) and Arthurs (2016)]. (see. http://tos.org/oceanography/assets/docs/29-4_arthurs.pdf)

Weighting of Cognitive demands for the assessment of content in Grades 10, 11 and 12

	Recall	Comprehend	Apply	Analyse, Evaluate Create
%	40%	25%	20%	15%
Examples of Useful Verbs	• Acquire • Define • Distinguish • Duplicate • Label • List • Match • Name • Outline • Recognise • State	• Abstract • Calculate • Convert • Compare • Classify • Defend • Distinguish • Discuss • Estimate • Explain • Extrapolate • Give an example of • Identify • Illustrate • Infer • Make a generalisation • Paraphrase • Rearrange • Summarise	• Apply • Change • Choose • Compute • Construct • Demonstrate • Diagram • Generalise • Implement • Judge • Manipulate • Modify • Plan • Predict • Sequence • Solve • Use knowledge	• Adapt • Appraise • Analyse • Anticipate • Argue • Catalogue • Categorise • Contrast • Create • Critique • Compare • Contrast • Deconstruct • Defend • Discriminate • Discuss • Differentiate • Hypothesise • Infer • Invent • Estimate • Evaluate • Explore • Illustrate • Investigate • Justify • Predict • Rank • Select • Simulate • Suggest a reason

4.4 Assessment Requirements for Marine Sciences

4.4.1 Grade 10: Programme of Formal Assessment

The programme of assessment is designed to spread formal assessment tasks in all subjects in a school throughout a term.

FORMAL, RECORDED, SCHOOL-BASED ASSESSMENTS		END-OF-YEAR INTERNAL EXAMINATION 75%	
TEST/ ASIGNMENT	**PRACTICAL**	**Two Written examinations** **(2½ hours + 2½**	**Practical examination** **(1 hour)**
• Four tests = one test in each term (minimum of 50 marks each) • Three selected practical tasks in Terms 1 -3 • One mid-year examination (2½ hours, 150 marks) • One project/ assignment Started in Term 1 and Assessed in Term 4 (50 marks)	• A selection of three representative practical tasks (30 marks each), which **cover the range of skills**, these must be marked and recorded. • One in each of the first three Terms.	• These exams test knowledge on content, concepts and skills across all topics. • Knowledge of practical work as well as some of the skills related to practical work must be assessed in the written examination.	• This exam tests practical knowledge and Skills. • This should be set by each teacher taking into account the resources that are available for practical examination.

School-based Assessment (assessments completed during the year) is converted to 25% of the final mark.				Final exam and final practical exam completed in the 4th Term is converted to 75% of the final mark
term 1	**term 2**	**term 3**	**term 4**	**Final Examination**
• One test • One selected practical task • One project/ assignment Started in Term 1 and Assessed in term 4	• One test • One selected practical task • One Mid- year examination 150 marks	• One test • One selected practical task • Environmental studies: fieldwork	• One test • One project/ assignment Started in Term 1 and Assessed in term 4 • One Practical Exam	• **Two Question papers 2½ hrs each** • **150x2=300marks**
25%	**25%**	**25%**	**25%**	
Convert to 25%				**Convert to 75%**

4.4.2 Grade 11: Programme of Formal Assessment

The programme of assessment is designed to spread formal assessment tasks in all subjects in a school throughout a term.

<table>
<tr><th colspan="4">FORMAL, RECORDED, SCHOOL-BASED ASSESSMENTS</th><th colspan="2">END-OF-YEAR INTERNAL EXAMINATION 75%</th></tr>
<tr><th colspan="2">TEST/ ASIGNMENT</th><th colspan="2">PRACTICAL</th><th>Two Written examinations

(2½ hours + 2½</th><th>Practical examination

(1 hour)</th></tr>
<tr><td colspan="2">• Four tests = one test in each term (minimum of 50 marks each)
• Three selected practical tasks in Terms 1 -3
• One mid-year examination (2½ hours, 150 marks)
• One project/ assignment Started in Term 1 and Assessed in Term 4 (50 marks)</td><td colspan="2">• A selection of three representative practical tasks (30 marks each), which cover the range of skills, these must be marked and recorded.
• One in each of the first three Terms.</td><td>• These exams test knowledge on content, concepts and skills across all topics.
• Knowledge of practical work as well as some of the skills related to practical work must be assessed in the written examination.</td><td>• This exam tests practical knowledge and Skills.
• This should be set by each teacher taking into account the resources that are available for practical examination.</td></tr>
<tr><th colspan="4">School-based Assessment (assessments completed during the year) is converted to 25% of the final mark.</th><th colspan="2">Final exam and final practical exam completed in the 4th Term is converted to 75% of the final mark</th></tr>
<tr><td>term 1</td><td>term 2</td><td>term 3</td><td>term 4</td><td colspan="2" rowspan="3">Final Examination

• Two Question papers 2½ hrs each
• 150x2=300marks</td></tr>
<tr><td>• One test
• One selected practical task
• One project/ assignment Started in Term 1 and Assessed in term 4</td><td>• One test
• One selected practical task
• One Mid- year examination 150 marks</td><td>• One test
• One selected practical task
• Environmental studies: fieldwork</td><td>• One test
• One project/ assignment Started in Term 1 and Assessed in term 4
• One Practical Exam</td></tr>
<tr><td>25%</td><td>25%</td><td>25%</td><td>25%</td></tr>
<tr><td colspan="4">Convert to 25%</td><td colspan="2">Convert to 75%</td></tr>
</table>

4.4.3 Grade 12: Programme of Formal Assessment

The programme of assessment is designed to spread formal assessment tasks in all subjects in a school throughout a term.

<table>
<tr><td colspan="3"></td></tr>
<tr><th colspan="2">TEST/ ASIGNMENT</th><th>PRACTICAL</th></tr>
<tr><td colspan="2">• Three tests (minimum of 50 marks each)
• Two mid-year examination papers
(2½ hours each, 2 x 150 =300 marks)
• One trial examination (2 papers)
(2½ hours each, 2 x 150 =300 marks)
• One project/assignment
(Can be done in any term but marked in term = 50 marks).
• One practical must be done in each of Term 1; Term 2 and Term 3.</td><td>• A selection of three representative practical tasks (30 marks each), which cover the range of skills, must be marked and recorded.
• One in each of the first three Terms. The best of the three marks is used when calculating the final year mark.</td></tr>
<tr><th colspan="3">SCHOOL-BASED ASSESSMENT</th></tr>
<tr><th>Term 1</th><th>Term 2</th><th>Term 3</th></tr>
<tr><td>• One test (50 marks)
• One selected practical task
• One project/assignment. Started in Term 1 and Assessed at the beginning of term 3</td><td>• One test (50 marks)
• One selected practical task
• Mid-year examination Two papers 150 marks x2 = 300 marks). Including the Gr 11 4th Quarter content.</td><td>• One test (50 marks)
• One selected practical task.
• The trial (preliminary) examination should be set on the work completed in Terms 1, 2 and 3.
Two papers 150 marks x2 = 300 marks
•
• One project/ assignment.
Started in Term 1 and Assessed at the beginning of term 3</td></tr>
<tr><td>33%</td><td>33%</td><td>33%</td></tr>
<tr><td colspan="3">School based assessment of the three Terms is converted to 25% of the final mark</td></tr>
<tr><td colspan="3">Final National Examination in Term 4 = 75% of final mark.</td></tr>
</table>

4.5 The End-of-Year Examinations:

4.5.1 Grade 10

The examination will consist of two examination papers of 2½ hours and 150 marks each. The weighting and assessment of topics in Paper 1 and Paper 2 will be as follows:

PAPER 1		
Topic	**Weighting**	
	%	**Marks**
• Intro to Marine Sciences -to- History of Marine Discoveries • Origin of planet earth -to- Geological time • Topography of Ocean Floor -to- Light Absorption • Tides -to- Nutrient Cycles • Human Impacts -to- Biodiversity HIPPO	17 7 30 37 9	25 11 44 56 14
Total	100%	150
PAPER 2		
• Life Processes and Cell Biology • Evolution -to- Protists • Porifera -to- Platyhelminthes • Other unsegmented worms -to- Anthropod Groups	30 26 21 23	45 38 32 35
Total	100%	150

The **weighting per topic must serve as a guideline** for teachers; slight deviations in respect of the number of marks allocated to a topic are acceptable. The purpose of providing the weighting is to ensure that all topics are covered according to approximately the correct weighting

4.5.2 Grade 11

The examination will consist of two examination papers of 2½ hours and 150 marks each. The weighting and assessment of topics in Paper 1 and Paper 2 will be as follows:

PAPER 1		
Topic	**Weighting**	
	%	**Marks**
• Marine Sciences Careers -to- Harvesting of Resources	16	24
• Sediments and Chemical composition of water –to- currents	28	42
• Population dynamics -to- Open Ocean	16	24
• Shores –to- Sandy beaches	24	36
• History of Ocean Discoveries -to- Ecotourism	16	24
Total	100%	150
PAPER 2		
• Metabolic Processes -to- Cell Division	33	50
• Genetics -to- Microalgae	19	28
• Seaweeds -to- Vascular plants	20	30
• Mollusca -to- Bryzoa	17	25
• Echinoderm classes	11	17
Total	100%	150

The **weighting per topic must serve as a guideline** for teachers; slight deviations in respect of the number of marks allocated to a topic are acceptable. The purpose of providing the weighting is to ensure that all topics are covered in approximately the correct weighting.

4.5.3 Grade 12

The examination will consist of two examination papers of 2½ hours and 150 marks each. The weighting and assessment of topics in Paper 1 and Paper 2 will be as follows:

PAPER 1		
Topic	**Weighting**	
	%	**Marks**
• Shores Rocky and Sandy Beaches Gr 11 4th Quarter content	19	29
• History of Ocean Discovery -to- Ecotourism	12	18
• Diving Science Gas Laws -to- Waves	17	25
• Chemical composition of Water -to- Coastal Formations	20	30
• Climate change –to- Aquaculture	16	24
• Commercial use Marine Algae and Biomimicry	16	24
Total	100%	150
PAPER 2		
• Echinoderms Gr 11 4th Quarter content	19	29
• Chordata -to- Agnatha	13	19
• Chondrichthys	16	24
• Osteicthyes	16	24
• Terrestrial vertebrates and Marine Reptiles	16	24
• Marine Birds and Mammals	20	30
Total	100%	150

The **weighting per topic must serve only as a guideline** to teachers and examiners and is included to ensure that all topics are adequately covered in examinations. The number of marks per topic is not expected to be exactly according to this weighting in the examination papers.

4.6 Recording and Reporting

Recording is a process in which the teacher documents the level of a learner's performance in a specific assessment task. It indicates learner progress towards the achievement of knowledge as prescribed in the Curriculum and Assessment Policy Statement. Records of learner performance should provide evidence of the learner's conceptual progression within a grade and her or his readiness to progress or be promoted to the next grade. Records of learner performance should also be used to verify the progress made by teachers and learners during the teaching and learning process.

Reporting is a process of communicating learner performance to learners, parents, schools, and other stakeholders. Learner performance can be reported in a number of ways. These include report cards, parents' meetings, school visitation days, parent-teacher conferences, phone calls, letters, class or school newsletters. For all grades, teachers report learners' achievements in percentages next to the appropriate subject. The various achievement levels and their corresponding percentage bands are as shown in the table below.

Note: The seven-point scale should have clear descriptions that give detailed information for each level. Teachers will record actual marks against the task by using a record sheet; and report percentages against the subject on the learners' report cards.

Codes and Percentages for reporting in Grades R-12

RATING CODE	DESCRIPTION OF COMPETENCE	PERCENTAGE
7	Outstanding achievement	80- 100
6	Meritorious achievement	70 - 79
5	Substantial achievement	60 - 69
4	Adequate achievement	50 - 59
3	Moderate achievement	40 - 49
2	Elementary achievement	30 - 39
1	Not achieved	0 - 29

Schools are required to provide quarterly feedback to parents on the Programme of Assessment using a formal reporting tool such as a report card. The schedule and the report card should indicate the overall level of a learners' performance.

4.7 Moderation of Assessment

Moderation refers to the process that ensures that the assessment tasks are fair, valid and reliable. Moderation should be implemented at school and district level and if necessary also at provincial level. Comprehensive and appropriate moderation practices must be in place for the quality assurance of all subject assessments.

4.7.1 Grades 10 and 11

In Grades 10 and 11 Formal School-based Assessment and the Practical Assessment Tasks should be moderated by the relevant subject specialists at district and, if necessary, provincial levels in consultation with the moderators at the school. Moderation serves six purposes:

1. it should ascertain whether the subject-specific content and skills are sufficiently covered.
2. the moderator must ensure that the various levels of cognitive demand are reflected in the assessments.
3. that the assessments and marking are of an acceptable standard and consistency.

4. to ensure that assessment in different schools are more or less comparable whilst recognising that different teachers have different standards.

5. to identify areas in which the teacher may need further support and development and to provide such necessary support

6. Teachers must see the moderation process as an opportunity to evaluate their teaching skills and to seek assistance in areas where learners are generally underperforming. It is an opportunity for peer to peer teacher mentoring and elevating the Marine Sciences teaching profession.

In Grades 10 and 11 there is no compulsory national moderation. Moderation is therefore an ongoing process and not a once-off end-of-year event.

4.7.2 Grade 12

Moderation refers to the process which ensures that the assessment tasks are fair, valid and reliable. Moderation should be implemented at school, district, provincial and national levels. Comprehensive and appropriate moderation practices must be in place for the quality assurance of all subject assessments.

4.7.2.1 Formal Assessment (school-based assessment - SBA)

In Grade 12, moderation must take place at four levels:

1. *School-based moderation and verification of learner performance*

This is intended to ensure that the assessments meet the requirements in terms of content, cognitive demands and skills; that the marking has been consistent and fair and that the marks are a true reflection of learners' performance in the assessments. This will enable the school to easily identify problems related to the pacing, standard and reliability of assessment and to ensure that appropriate interventions are put in place early. This is an ongoing process.

2. *Moderation by the subject advisor*

This is also an ongoing process. Subject advisors should moderate assessments, to ascertain whether:

- Subject-specific content and skills have been covered adequately;
- The prescribed number of assessments have been complied with;
- the appropriate cognitive demands are reflected in the assessments;
- the marking is of an acceptable standard and is consistent;
- the assessments in different schools are comparable whilst recognising that different teachers teach and assess differently.

Subject advisors should provide teachers with the necessary guidance and support should any shortcomings be identified. Early identification of shortcomings and early interventions are essential. It is therefore necessary that moderation at this level should be ongoing and not a once-off end-of-year event.

3. Moderation by the province

Moderation of SBA at this level is once-off and is related to the quality assurance processes that are necessary developed jointly by the Department of Basic Education and Umalusi in terms of National Policy.

4. At a national level

Statistical moderation of learner performance in the School Based Assessment is necessary to ensure comparability across schools, districts, and provinces.

Note that, in Grade 12, the assessment of Practical work is incorporated into the SBA (per term). There is no practical examination. This is because schools are not all equally resourced and some learners may be disadvantaged because of this.

4.8 General

This document should be read in conjunction with:

4.8.1 *National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R-12*; and

4.8.2 The policy document, *National Protocol for Assessment Grades R-12.*