Marine Science 2019 v1.3

General Senior Syllabus

This syllabus is for implementation with Year 11 students in 2019.

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1 Course overview

1.1 Introduction

1.1.1 Rationale

At the core of all science endeavour is the inquiry into the nature of the universe. Science uses a systematic way of thinking, involving creative and critical reasoning, in order to acquire better and more reliable knowledge. Scientists recognise that knowledge is not fixed, but is fallible and open to challenge. As such, scientific endeavour is never conducted in isolation, but builds on and challenges an existing body of knowledge in the pursuit of more reliable knowledge. This collaborative process, whereby new knowledge is gained, is essential to the cooperative advancement of science, technology, health and society in the 21st century.

Tertiary study in any field will be aided by the transferable skills developed in this senior Science subject. It is expected that an appreciation of, and respect for, evidence-based conclusions and the processes required to gather, scrutinise and use evidence, will be carried forward into all aspects of life beyond the classroom.

The purpose of senior Science subjects in Queensland is to introduce students to a scientific discipline. Students will be required to learn and apply aspects of the knowledge and skill of the discipline (thinking, experimentation, problem-solving and research skills), understand how it works and how it may impact society.

Upon completion of the course, students will have an appreciation for a body of scientific knowledge and the process that is undertaken to acquire this knowledge. They will be able to distinguish between claims and evidence, opinion and fact, and conjecture and conclusions.

In each of the senior Science subjects, students will develop:

- a deep understanding of a core body of discipline knowledge
- aspects of the skills used by scientists to develop new knowledge, as well as the opportunity to refine these skills through practical activities
- the ability to coordinate their understandings of the knowledge and skills associated with the discipline to refine experiments, verify known scientific relationships, explain phenomena with justification and evaluate claims by finding evidence to support or refute the claims.

Marine Science provides opportunities for students to study an interdisciplinary science focusing on marine environments and the consequences of human influences on ocean resources. In Unit 1, students develop their understanding of oceanography. In Unit 2, they engage with the concept of marine biology. In Unit 3, students study coral reef ecology, changes to the reef and the connectivity between marine systems. This knowledge is linked in Unit 4 with ocean issues and resource management where students apply knowledge from Unit 3 to consider the future of our oceans and techniques for managing fisheries. Students will learn valuable skills required for the scientific investigation of questions. In addition, they will become citizens who are better informed about the world around them and who have the critical skills to evaluate and make evidence-based decisions about current scientific issues.

Marine Science aims to develop students':

- sense of wonder and curiosity about the complexity of marine life and a respect for all living things and the environment
- appreciation of global stewardship, which involves an understanding of the value systems associated with the marine environment and its importance in maintaining biological support systems
- interpretation of scientific evidence to make judgments and decisions about the effective management of the marine environment
- investigative skills that can be used to evaluate environmental issues and their potential to affect the fragility of marine environments
- understanding of how marine systems interact and are interrelated; the flow of matter and energy through and between these systems, and the processes by which they persist and change
- understanding of major marine science concepts, theories and models related to marine systems at all scales, from species to ecosystem
- appreciation of how marine knowledge has developed over time and continues to develop; how scientists use marine science in a wide range of applications; and how marine knowledge influences society in local, regional and global contexts
- ability to plan and carry out fieldwork, laboratory and other research investigations, including the collection and analysis of qualitative and quantitative data and the interpretation of evidence
- ability to use sound evidence-based arguments creatively and analytically when evaluating claims and applying biological knowledge
- ability to communicate marine science understanding, findings, arguments and conclusions using appropriate representations, modes and genres.

Assumed knowledge, prior learning or experience

The Australian Curriculum: Science P–10 is assumed knowledge for this syllabus.

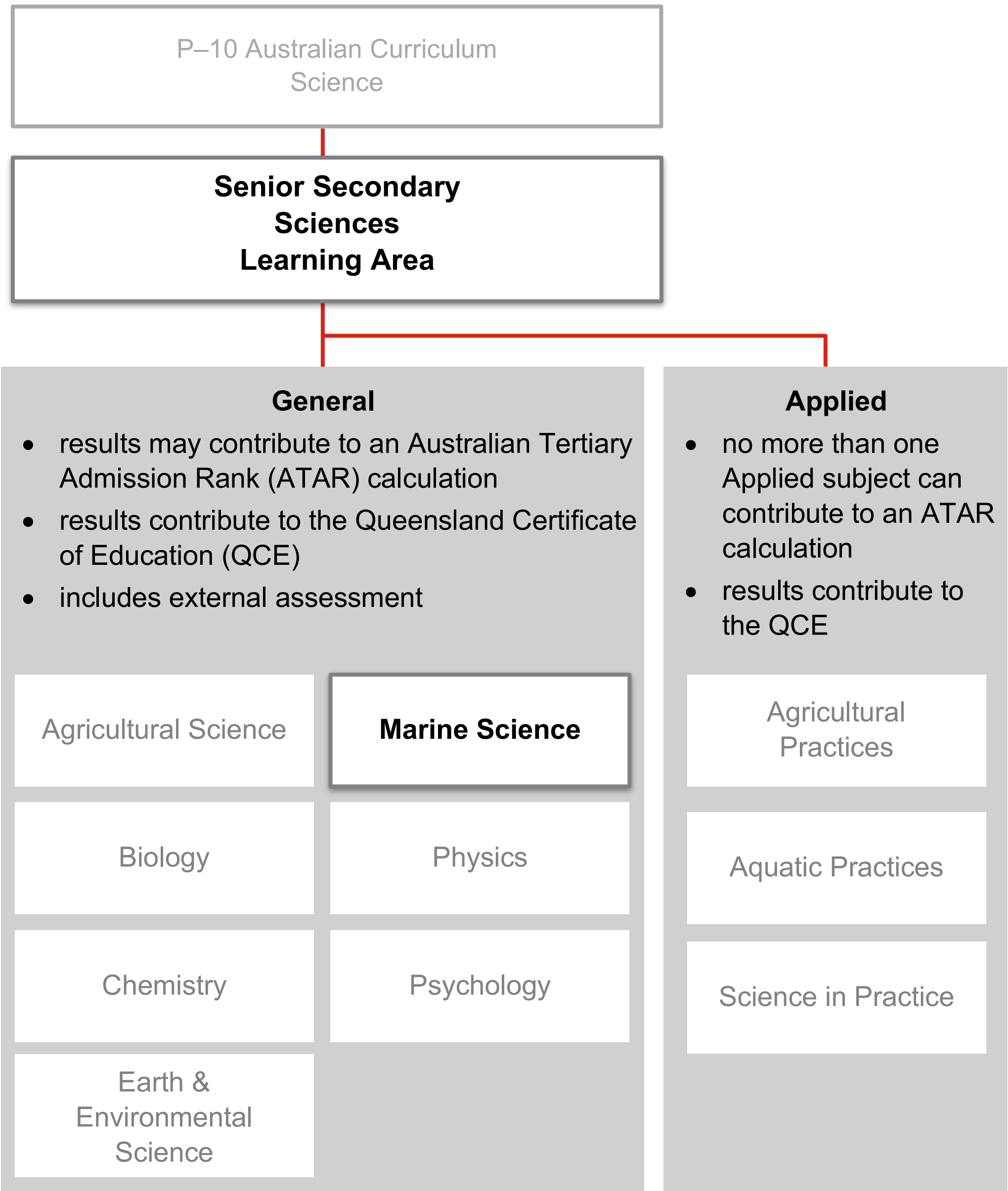
Pathways

Marine Science is a General subject suited to students who are interested in pathways beyond school that lead to tertiary studies, vocational education or work. A course of study in Marine Science can establish a basis for further education and employment in the fields of marine sciences, biotechnology, aquaculture, environmental rehabilitation, biosecurity, quarantine, conservation and sustainability.

1.1.2 Learning area structure

All learning areas build on the P–10 Australian Curriculum.

Figure 1: Learning area structure



1.1.3 Course structure

Marine Science is a course of study consisting of four units. Subject matter, learning experiences and assessment increase in complexity from Units 1 and 2 to Units 3 and 4 as students develop greater independence as learners.

Units 1 and 2 provide foundational learning, which allows students to experience all syllabus objectives and begin engaging with the course subject matter. Students should complete Units 1 and 2 before beginning Units 3 and 4.

Units 3 and 4 consolidate student learning. Only the results from Units 3 and 4 will contribute to ATAR calculations.

Figure 2 outlines the structure of this course of study.

Each unit has been developed with a notional time of 55 hours of teaching and learning, including assessment.

Figure 2: Course structure

Marine Science

Unit 1 **Oceanography**	**Unit 2** **Marine biology**	**Unit 3** **Marine systems — connections and change**	**Unit 4** **Ocean issues and resource management**
• Topic 1: An ocean planet • Topic 2: The dynamic shore	• Topic 1: Marine ecology and biodiversity • Topic 2: Marine environmental management	• Topic 1: The reef and beyond • Topic 2: Changes on the reef	• Topic 1: Oceans of the future • Topic 2: Managing fisheries
Assessment Formative internal assessment/s	**Assessment** Formative internal assessment/s	**Assessment** Summative internal assessment 1: Data test (10%) Summative internal assessment 2: Student experiment (20%)	**Assessment** Summative internal assessment 3: Research investigation (20%)

Students should have opportunities in Units 1 and 2 to experience and respond to the types of assessment they will encounter in Units 3 and 4.
For reporting purposes, schools should develop at least *one* assessment per unit, with a maximum of *four* assessments across Units 1 and 2.

Summative external assessment: Examination (50%)

1.2 Teaching and learning

1.2.1 Syllabus objectives

The syllabus objectives outline what students have the opportunity to learn. Assessment provides evidence of how well students have achieved the objectives.

Syllabus objectives inform unit objectives, which are contextualised for the subject matter and requirements of the unit. Unit objectives, in turn, inform the assessment objectives, which are further contextualised for the requirements of the assessment instruments. The number of each objective remains constant at all levels, i.e. Syllabus objective 1 relates to Unit objective 1 and to Assessment objective 1 in each assessment instrument.

Syllabus objectives are described in terms of actions that operate on the subject matter. Students are required to use a range of cognitive processes in order to demonstrate and meet the syllabus objectives. These cognitive processes are described in the explanatory paragraph following each objective in terms of four levels: retrieval, comprehension, analytical processes (analysis), and knowledge utilisation, with each process building on the previous processes (see Marzano & Kendall 2007, 2008). That is, comprehension requires retrieval, and knowledge utilisation requires retrieval, comprehension and analytical processes (analysis).

By the conclusion of the course of study, students will:

Syllabus objective	Unit 1	Unit 2	Unit 3	Unit 4
1. describe and explain scientific concepts, theories, models and systems and their limitations	●	●	●	●
2. apply understanding of scientific concepts, theories, models and systems within their limitations	●	●	●	●
3. analyse evidence	●	●	●	●
4. interpret evidence	●	●	●	●
5. investigate phenomena	●	●	●	●
6. evaluate processes, claims and conclusions	●	●	●	●
7. communicate understandings, findings, arguments and conclusions	●	●	●	●

1. describe and explain scientific concepts, theories, models and systems and their limitations

When students describe and explain scientific concepts, theories, models and systems and their limitations, they give a detailed account of a concept, theory, model or system by making relationships, reasons or causes evident. They reflect on relevant social, economic, ethical and cultural factors.

2. apply understanding of scientific concepts, theories, models and systems within their limitations

When students apply their understanding of scientific concepts, theories, models and systems within their limitations, they explain local, regional and global phenomena and determine outcomes, behaviours and implications. They use algebraic, visual and graphical representations of scientific relationships and data to determine unknown scientific quantities or variables. They recognise the limitations of models and theories when discussing results.

3. **analyse evidence**

   When students analyse evidence, they recognise the variety of forms of evidence, and distinguish between quantitative, qualitative, primary and secondary evidence. When students analyse evidence in the form of qualitative data, they identify the essential elements, features or components of the data. When students analyse evidence in the form of quantitative data, they use mathematical processes to identify trends, patterns, relationships, limitations and uncertainty in the data.

4. **interpret evidence**

   When students interpret evidence, they use their knowledge and understanding of scientific concepts, theories, models and systems and their limitations to draw conclusions based on their analysis of qualitative and quantitative evidence and established criteria.

5. **investigate phenomena**

   When students investigate phenomena, they plan and carry out experimental and/or research activities in order to obtain evidence for the purpose of reaching a conclusion. They collect, collate and process evidence. Students ensure that relevant ethical, environmental and safety considerations have been incorporated into their practice.

6. **evaluate processes, claims and conclusions**

   When students evaluate processes, claims and conclusions, they critically reflect on the available evidence and make judgments about its application to a research question, and its use to inform further investigation. When students evaluate processes, they use the quality of evidence to evaluate the validity and reliability of the method used, the appropriateness of assumptions made and possible refinements required. When students evaluate claims, they identify the evidence that would be required to support or refute the claim. They scrutinise evidence for bias, conjecture, alternatives or inaccuracies. When students evaluate conclusions, they consider the credibility of the supporting evidence.

7. **communicate understandings, findings, arguments and conclusions**

   When students communicate, they use scientific representations and language within appropriate genres to present information. They use technology to share knowledge by exchanging information and creating information products.

1.2.2 Underpinning factors

There are three skill sets that underpin senior syllabuses and are essential for defining the distinctive nature of subjects:

- literacy — the set of knowledge and skills about language and texts essential for understanding and conveying Marine Science content
- numeracy — the knowledge, skills, behaviours and dispositions that students need to use mathematics in a wide range of situations, to recognise and understand the role of mathematics in the world, and to develop the dispositions and capacities to use mathematical knowledge and skills purposefully
- 21st century skills — the attributes and skills students need to prepare them for higher education, work and engagement in a complex and rapidly changing world.

These skill sets, which overlap and interact, are derived from current education, industry and community expectations and encompass the knowledge, skills, capabilities, behaviours and dispositions that will help students live and work successfully in the 21st century.

Together these three skill sets shape the development of senior subject syllabuses. Although coverage of each skill set may vary from syllabus to syllabus, students should be provided with opportunities to learn through and about these skills over the course of study. Each skill set contains identifiable knowledge and skills that can be directly assessed.

Literacy in Marine Science

The skills of literacy in science (distinct from 'scientific literacy') are essential for successful scientific inquiry (Douglas et al. 2006, Saul 2004, Yore et al. 2003). In any scientific inquiry activity, literacy skills support students by enabling them to grapple with ideas, conduct research, discuss their thoughts, enhance conceptual understanding and solve problems (Krajcik & Southerland 2010).

The literacy skills important to this subject are those related to the comprehension and composition of texts that provide information, describe and explain events and phenomena, report on experiments, present and analyse data, and offer opinions or claims (ACARA 2015a). Marine Science students comprehend and compose multimedia texts, such as reports, charts, graphs, diagrams, pictures, maps, animations, models and other visual media. They understand and apply language structures that are used to link information and ideas, give descriptions and explanations, formulate research questions and construct evidence-based arguments capable of expressing an informed position (ACARA 2015a).

Students learn these skills by having opportunity to engage with:

- rich and varied science and media texts
- class activities that use literacy as a tool for learning
- strategies for reading scientific texts (Moore 2009).

The learning opportunities described above can be integrated with stimulus questions, Science as a Human Endeavour subject matter and mandatory practicals. Students could be asked to:

- explain links between new ideas and prior knowledge and experiences
- engage in learning experiences directed by a question that is meaningful to their lives
- connect multiple representations of a concept, e.g. written texts, formulas, graphs or diagrams of the same concept
- use scientific ideas to compose evidence-based conclusions in the mandatory practicals
- engage with the discourses of science such as those found in scientific literature and media texts (Krajcik & Southerland 2010).

These strategies will promote students' ability to read, write and communicate about science so that they can engage with science-related issues throughout their lives.

These aspects of literacy knowledge and skills are embedded in the syllabus objectives, unit objectives and subject matter, and instrument-specific marking guides (ISMGs) for Marine Science.

Numeracy in Marine Science

The skills of numeracy in Marine Science are essential for successful scientific inquiry. In any scientific inquiry activity, numeracy skills support students by enabling them to make and record observations; order, represent and analyse data; and interpret trends and relationships (ACARA 2015b).

The numeracy skills important to this subject are those related to the interpretation of complex spatial and graphical representations, and the appreciation of the ways in which scientific concepts, theories, systems and models are structured, communicated, interact or change across spatial and temporal scales (ACARA 2015b). Students will use knowledge and skills in areas such as:

- graphing
- ratio and proportion
- converting from one unit to another
- scientific notation
- an understanding of place in number (significant figures)
- estimation and calculation in order to analyse data
- determining the reliability of data
- interpreting and manipulating mathematical relationships in order to calculate and predict values (ACARA 2009, 2015b).

Students will learn these skills as they:

- measure and record data during the mandatory practicals
- use or interpret meaning from formulas
- interpret graphical information presented in science and media texts
- undertake class activities that use numeracy as a tool for learning
- use mathematics or equations as justification or evidence for conclusions
- interpret and represent information in a variety of forms.

These opportunities will promote students' ability to develop and use numeracy skills in Marine Science.

These aspects of numeracy knowledge and skills are embedded in the syllabus objectives, unit objectives and subject matter, and ISMGs for Marine Science.

21st century skills

The 21st century skills identified in the following table reflect a common agreement, both in Australia and internationally, on the skills and attributes students need to prepare them for higher education, work and engagement in a complex and rapidly changing world.

21st century skills	Associated skills	21st century skills	Associated skills
critical thinking	• analytical thinking • problem-solving • decision-making • reasoning • reflecting and evaluating • intellectual flexibility	creative thinking	• innovation • initiative and enterprise • curiosity and imagination • creativity • generating and applying new ideas • identifying alternatives • seeing or making new links
communication	• effective oral and written communication • using language, symbols and texts • communicating ideas effectively with diverse audiences	collaboration and teamwork	• relating to others (interacting with others) • recognising and using diverse perspectives • participating and contributing • community connections
personal and social skills	• adaptability/flexibility • management (self, career, time, planning and organising) • character (resilience, mindfulness, open- and fair-mindedness, self-awareness) • leadership • citizenship • cultural awareness • ethical (and moral) understanding	information and communication technologies (ICT) skills	• operations and concepts • accessing and analysing information • being productive users of technology • digital citizenship (being safe, positive and responsible online)

Marine Science helps develop the following 21st century skills:

- critical thinking
- creative thinking
- communication
- collaboration and teamwork
- personal and social skills
- information and communication technologies (ICT) skills.

These elements of 21st century skills are embedded in the syllabus objectives, unit objectives and subject matter, and ISMGs for Marine Science.

1.2.3 Aboriginal perspectives and Torres Strait Islander perspectives

The QCAA is committed to reconciliation in Australia. As part of its commitment, the QCAA affirms that:

- Aboriginal peoples and Torres Strait Islander peoples are the first Australians, and have the oldest living cultures in human history
- Aboriginal peoples and Torres Strait Islander peoples have strong cultural traditions and speak diverse languages and dialects, other than Standard Australian English
- teaching and learning in Queensland schools should provide opportunities for students to deepen their knowledge of Australia by engaging with the perspectives of Aboriginal peoples and Torres Strait Islander peoples
- positive outcomes for Aboriginal students and Torres Strait Islander students are supported by successfully embedding Aboriginal perspectives and Torres Strait Islander perspectives across planning, teaching and assessing student achievement.

Guidelines about Aboriginal perspectives and Torres Strait Islander perspectives and resources for teaching are available at www.qcaa.qld.edu.au/k-12-policies/aboriginal-torres-strait-islander-perspectives.

Where appropriate, Aboriginal perspectives and Torres Strait Islander perspectives have been embedded in the subject matter.

1.2.4 Pedagogical and conceptual frameworks

Defining *inquiry* in science education

This syllabus provides guidance to support schools in aligning a chosen pedagogical framework with the curriculum and assessment expectations outlined in this syllabus. This guidance clarifies the use of the term *inquiry* and articulates a framework to describe the process of inquiry. The purpose of this guidance is to prevent misunderstandings and problematic conflations and their subsequent negative impact on student learning. As Abrams, Southerland and Silva (2008, p. xv) stated in their book, *Inquiry in the Classroom: Realities and opportunities*:

> Inquiry in the classroom can be conceived as a complex set of ideas, beliefs, skills, and/or pedagogies. It is evident that attempting to select a singular definition of inquiry may be an insurmountable and fruitless task. Any single definition of inquiry in the classroom would necessarily reflect the thinking of a particular school of thought, at a particular moment in time, or a particular goal, and such a singular definition may serve to limit legitimate and necessary components of science learning. **However, operating without a firm understanding of the various forms of inquiry leaves science educators often 'talking past' one another, and often results in very muddled attempts in the classroom**.

Uses of the term *inquiry*

Common phrases involving the term *inquiry* have been listed below:

- science inquiry
- science inquiry skills
- the inquiry process
- inquiry-based learning.

This syllabus refers to the first three uses listed above. The first, *science inquiry*, defines the practical work of a scientist (Harlen 2013). The second, *science inquiry skills*, refers to the skills required to do the work of a scientist (Harlen 2013). The third, *the inquiry process*, is a framework that can be used to describe the process of asking a question and then answering it.

The final phrase, *inquiry-based learning*, refers to a variety of teaching and learning strategies an educator may choose to use within their school's pedagogical framework. Although a school may choose to adopt an inquiry-based pedagogy, this syllabus is *not* intended to endorse or recommend an inquiry-based learning approach.

Science inquiry and science inquiry skills

Science inquiry involves identifying and posing questions and working to answer them. It is concerned with evaluating claims, investigating ideas, solving problems, reasoning, drawing valid conclusions and developing evidence-based arguments. It can easily be summarised as the 'work of a scientist' (Hackling 2005).

Within this syllabus, it is expected that students will engage in *aspects* of the work of a scientist by engaging in science inquiry (Tytler 2007). This expectation can be seen, for example, in the inclusion of the student experiment, research investigation and mandatory practicals.

Science inquiry skills are the skills required to do the work of a scientist. They include writing research questions, planning, conducting, recording information and reflecting on investigations; processing, analysing and interpreting evidence; evaluating conclusions, processes and claims; and communicating findings (ACARA 2015).

It is expected that students are taught science inquiry skills (Krajcik et al. 2000). The syllabus outlines a number of these skills in the subject matter. Some science inquiry skills will be used to complete the mandatory and suggested practicals. The selection, application and coordination of science inquiry skills will be required in the student experiment and research investigation.

Teachers decide how the science inquiry skills are to be developed. For example, teachers will determine how mandatory practicals are used as opportunities to:

- develop, rehearse and refine science inquiry skills
- engage students in scaffolded or open-ended science inquiry tasks
- formatively assess science inquiry skills.

Framework to describe the inquiry process

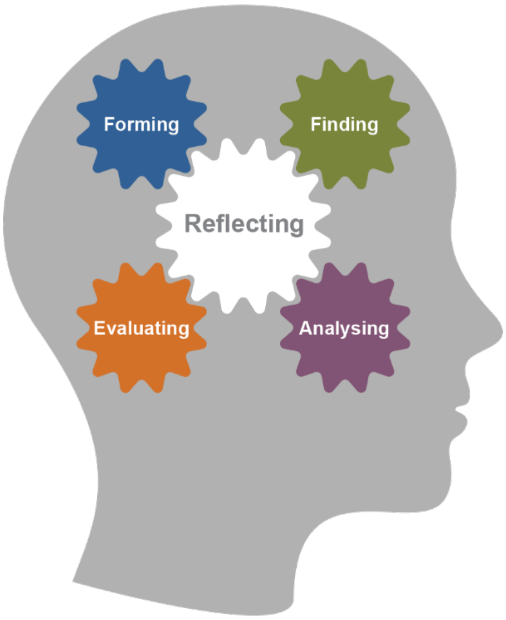
In order to support student engagement in activities involving inquiry, it is useful to establish a common language or framework to distinguish between stages of the process.

The stages involved in any inquiry are:

- forming and describing the inquiry activity
- finding valid and reliable evidence for the inquiry activity
- analysing and interpreting the evidence selected
- evaluating the conclusions, processes or claims.

This framework uses reflection as the connection between, and driver of, all the stages. The progression through the inquiry process requires reflection on the decisions made and any new information that has emerged during the process to inform the next stage. Each stage of the inquiry process is worthy of reflection, the result of which may be the revision of previous stages (Marzano & Kendall 2007).

Figure 3: Stages of inquiry process



Safety and ethics

Workplace health and safety

Marine Science is designed to expose students to the practical components of science through practical experiences in the laboratory and the field. These experiences expose students to a variety of hazards, from biological and poisonous substances to injury from equipment. Besides a teacher's duty of care that derives from the *Education (General Provisions) Act 2006*, there are other legislative and regulatory requirements, for example the *Work Health and Safety Act 2011*, that will influence the nature and extent of practical work.

All practical work must be organised with student safety in mind. The *Department of Education and Training (DET) Policy and Procedure Register* provides guidance about current science safety protocols.

It is the responsibility of all schools to ensure that their practices meet current legislation requirements. References to relevant legislation and regulations are supported by the Reference list located on the Marine Science subject page of the QCAA website.

Care and use of animals for scientific purposes

Governing principles

The QCAA recognises that school personnel involved in the care and use of animals for scientific purposes have legal obligations under the *Animal Care and Protection Act 2001* (the Act). Queensland schools intending to use animals for scientific purposes must apply for and receive animal ethics approval from the Queensland Schools Animals Ethics Committee (QSAEC) prior to conducting these activities. The purpose of the Act is to promote the responsible care and use of animals, provide standards for the care and use of animals, protect animals from unjustifiable, unnecessary or unreasonable pain, and ensure that the use of animals for scientific purposes is accountable, open and responsible.

The Act also requires mandatory compliance with the *Australian Code of Practice for the Care and Use of Animals for Scientific Purposes 2013 (8th edition)*, available from the 'Guidelines and publications' section of the National Health and Medical Research Council website.

It should also be recognised that school personnel and students are not carrying out essential, groundbreaking research. Therefore, standards in schools should be more stringent than those used in universities and research and development organisations.

Separate to the Act and ethical approval, best practice includes referring to the *3Rs* principle of animal welfare:

- **replacement** — any investigations involving animals should initially consider replacing the animals with cells, plants or computer simulations
- **refinement** — refinement of the investigation should aim to alleviate any harm or distress to the animals used
- **reduction** — reduce the number of animals used.

Respect for animals must underpin all decisions and actions involving the care and use of animals. The responsibilities associated with this obligation apply throughout the animal's lifetime, including acquisition, transport, breeding, housing, husbandry and the use of animals in a project. Experiments that require the endpoint as the death of any animal (e.g. lethal dose LD_{50}) are unacceptable.

Animal dissections

There is no requirement for students to witness or carry out a dissection of any animal, invertebrate or vertebrate in this course. If animal dissections are chosen by the teacher as an important educational experience, best practice should be emulated at all times by referring to the *3Rs* principle of animal welfare (replacement, refinement and reduction — see above for more information). Teachers should always discuss the purpose of the dissection and allow any student, without requirement for explanation, to opt out if they wish. Teachers should be respectful of the variety of reasons students may choose not to participate.

1.2.5 Subject matter

Subject matter is the body of information, mental procedures and psychomotor procedures (see Marzano & Kendall 2007, 2008) that are necessary for students' learning and engagement with Marine Science. It is particular to each unit in the course of study and provides the basis for student learning experiences.

Subject matter has a direct relationship to the unit objectives, but is of a finer granularity and is more specific. These statements of learning are constructed in a similar way to objectives. Each statement:

- describes an action (or combination of actions) — what the student is expected to do
- describes the element — expressed as information, mental procedures and/or psychomotor procedures
- is contextualised for the topic or circumstance particular to the unit.

Organisation of subject matter

The subject matter is organised as topics within each unit.

The subject matter indicates the required knowledge and skills that students must acquire. Students should experience the mandatory practicals. It is expected that approximately five hours will be required to complete the mandatory practicals that involve fieldwork.

The subject matter from Units 3 and 4 will be assessed by the external examination.

Science as a Human Endeavour

Each Queensland senior science subject requires students to learn and apply aspects of the knowledge and skill of the discipline. However, it is recognised that students should also develop an appreciation for the *nature* and *development* of science*,* and its *use* and *influence* on society.

While this appreciation will not be assessed, the syllabus provides guidance as to where it may be developed. Importantly, this guidance draws students' attention to the way in which science operates, both in relation to the development of understanding and explanations about the world and to its influence on society.

Students should become familiar with the following Science as a Human Endeavour (SHE) concepts:

- Science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility.
- Development of complex models and/or theories often requires a wide range of evidence from multiple individuals and across disciplines.
- Advances in science understanding in one field can influence other areas of science, technology and engineering.
- The use and acceptance of scientific knowledge is influenced by social, economic, cultural and ethical contexts.
- The use of scientific knowledge may have beneficial, harmful and/or unintended consequences.
- Scientific knowledge can enable scientists to offer valid explanations and make reliable predictions.
- Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability.
- ICT and other technologies have dramatically increased the size, accuracy and geographic and temporal scope of datasets with which scientists work.
- Models and theories are contested and refined or replaced when new evidence challenges them, or when a new model or theory has greater explanatory power.
- Scientific knowledge can be used to inform the monitoring, assessment and evaluation of risk.
- Science can be limited in its ability to provide definitive answers to public debate; there may be insufficient reliable data available, or interpretation of the data may be open to question.
- International collaboration is often required when investing in large-scale science projects or addressing issues for the Asia–Pacific region.

To support the development of these concepts, this syllabus identifies SHE guidance in each topic. This highlights opportunities for teachers to contextualise the associated subject matter and provides stimulus for the development of claims and research questions for investigation.

Additional opportunities include:

- the mandatory and suggested practicals provide opportunity for students to witness the *nature* of science
- the student experiment provides opportunity for students to experience how the *development* of new science knowledge is built upon existing knowledge

- a research investigation that provides opportunity for students to appreciate the *use* and *influence* of scientific evidence to make decisions or to contribute to public debate about a claim.

Finally, the SHE statements at the end of each topic may be used to support the development and interrogation of claims, and be useful as a starting point for the research investigation.

Guidance

The guidance included with each topic is designed to clarify the scope of the subject matter and identify opportunities to integrate science inquiry skills and SHE strands into the subject matter. A number of tags are used to highlight aspects of the guidance:

- **Notional time:** the depth of subject matter coverage is indicated by the amount of time needed to cover this subject matter in the sequence presented in the syllabus.
- **Formula:** defines a formula described in the subject matter.
- **SHE:** identifies an opportunity to integrate an aspect of the Science as a Human Endeavour strand and may also be used as a starting point for a research investigation.
- **Suggested practical:** identifies an opportunity for inquiry skills to be developed and may be used as a starting point for a student experiment.
- **Syllabus links:** identifies links between syllabus units.

1.3 Assessment — general information

Assessments are formative for Units 1 and 2, and summative for Units 3 and 4.

Assessment	Unit 1	Unit 2	Unit 3	Unit 4
Formative assessments	●	●		
Summative internal assessment 1			●	
Summative internal assessment 2			●	
Summative internal assessment 3				●
Summative external assessment			●	●

1.3.1 Formative assessments — Units 1 and 2

Formative assessments provide feedback to both students and teachers about each student's progress in the course of study.

Schools develop internal assessments for each senior subject based on the learning described in Units 1 and 2 of the subject syllabus. Each unit objective must be assessed at least once.

For reporting purposes, schools should devise at least *two* but no more than *four* assessments for Units 1 and 2 of this subject. At least *one* assessment must be completed for *each* unit.

The sequencing, scope and scale of assessments for Units 1 and 2 are matters for each school to decide and should reflect the local context.

Teachers are encouraged to use the A–E descriptors in in the reporting standards (Section 1.5) to provide formative feedback to students and to report on progress.

1.3.2 Summative assessments — Units 3 and 4

Students will complete a total of *four* summative assessments — three internal and one external — that count towards their final mark in each subject.

Schools develop *three* internal assessments for each senior subject, based on the learning described in Units 3 and 4 of the syllabus.

The three summative internal assessments will be endorsed and the results confirmed by the QCAA. These results will be combined with a single external assessment developed and marked by the QCAA. The external assessment results for Marine Science will contribute 50% towards a student's result.

Summative internal assessment — instrument-specific marking guides

This syllabus provides ISMGs for the three summative internal assessments in Units 3 and 4.

The ISMGs describe the characteristics evident in student responses and align with the identified assessment objectives. Assessment objectives are drawn from the unit objectives and are contextualised for the requirements of the assessment instrument.

Criteria

Each ISMG groups assessment objectives into criteria. An assessment objective may appear in multiple criteria or in a single criterion of an assessment.

Making judgments

Assessment evidence of student performance in each criterion is matched to a performance-level descriptor, which describes the typical characteristics of student work.

Where a student response has characteristics from more than one performance level, a best-fit approach is used. Where a performance level has a two-mark range, it must be decided if the best fit is the higher or lower mark of the range.

Authentication

Schools and teachers must have strategies in place for ensuring that work submitted for internal summative assessment is the student's own. Authentication strategies outlined in QCAA guidelines, which include guidance for drafting, scaffolding and teacher feedback, must be adhered to.

Summative external assessment

The summative external assessment adds valuable evidence of achievement to a student's profile. External assessment is:

- common to all schools
- administered under the same conditions at the same time and on the same day
- developed and marked by the QCAA according to a commonly applied marking scheme.

The external assessment contributes 50% to the student's result in Marine Science. It is not privileged over the internal assessments.

1.4 Reporting standards

Reporting standards are summary statements that succinctly describe typical performance at each of the five levels (A–E). They reflect the cognitive taxonomy and objectives of the course of study.

The primary purpose of reporting standards is for twice-yearly reporting on student progress. These descriptors can also be used to help teachers provide formative feedback to students and to align ISMGs.

Reporting standards

A
The student accurately describes and explains a variety of concepts, theories, models and systems, and their limitations. They give clear and detailed accounts of a variety of concepts, theories, models and systems by making relationships, reasons or causes evident. The student accurately applies their understanding of scientific concepts, theories, models and systems within their limitations to explain a variety of phenomena, and predict outcomes, behaviours and implications. They accurately use representations of scientific relationships and data to determine a variety of unknown scientific quantities and perceptively recognise the limitations of models and theories when discussing results. The student analyses evidence systematically and effectively by identifying the essential elements, features or components of qualitative data. They use relevant mathematical processes to appropriately identify trends, patterns, relationships, limitations and uncertainty in quantitative data. They interpret evidence insightfully by using their knowledge and understanding to draw justified conclusions based on their thorough analysis of evidence and established criteria. The student investigates phenomena by carrying out effective experiments and research investigations. They efficiently collect, collate and process relevant evidence. They critically evaluate processes, claims and conclusions by insightfully scrutinising evidence, extrapolating credible findings, and discussing the reliability and validity of experiments. The student communicates effectively by using scientific representations and language accurately and concisely within appropriate genres.
B
The student accurately describes and explains concepts, theories, models and systems, and their limitations. They give clear and detailed accounts of concepts, theories, models and systems by making relationships, reasons or causes evident. The student accurately applies their understanding of scientific concepts, theories, models and systems within their limitations to explain phenomena and predict outcomes, behaviours and implications. They accurately use representations of scientific relationships and data to determine unknown scientific quantities, and accurately recognise the limitations of models and theories when discussing results. The student analyses evidence by effectively identifying the essential elements, features or components of qualitative data. They use mathematical processes to appropriately identify trends, patterns, relationships, limitations and uncertainty in quantitative data. They interpret evidence by using their knowledge and understanding to draw reasonable conclusions based on their accurate analysis of evidence and established criteria. The student investigates phenomena by carrying out effective experiments and research investigations. They collect, collate and process relevant evidence. They evaluate processes, claims and conclusions by scrutinising evidence, applying relevant findings and discussing the reliability and validity of experiments. The student communicates accurately by using scientific representations and language within appropriate genres to present information.

C
The student describes and explains concepts, theories, models and systems, and their limitations. They give detailed accounts of concepts, theories, models and systems by making relationships, reasons or causes evident. The student applies their understanding of scientific concepts, theories, models and systems within their limitations to explain phenomena and predict outcomes, behaviours and implications. They use representations of scientific relationships and data to determine unknown scientific quantities and recognise the limitations of models and theories when discussing results. The student analyses evidence by identifying the essential elements, features or components of qualitative data. They use mathematical processes to identify trends, patterns, relationships, limitations and uncertainty in quantitative data. They interpret evidence by using their knowledge and understanding to draw conclusions based on their analysis of evidence and established criteria. The student investigates phenomena by carrying out experiments and research investigations. They collect, collate and process evidence. They evaluate processes, claims and conclusions by describing the quality of evidence, applying findings, and describing the reliability and validity of experiments. The student communicates using scientific representations and language within appropriate genres to present information.
D
The student describes and gives accounts of aspects of concepts, theories, models and systems. They use rudimentary representations of scientific relationships or data to determine unknown scientific quantities or variables. The student analyses evidence by identifying the elements, features or components of qualitative data. They use parts of mathematical processes to identify trends, patterns, relationships, limitations or uncertainty in quantitative data. They interpret evidence by drawing conclusions based on evidence or established criteria. The student carries out aspects of experiments and research investigations. They discuss processes, claims or conclusions. They consider the quality of evidence and conclusions. The student uses scientific representations or language to present information.
E
The student describes scenarios and refers to representations of information. They discuss physical phenomena and evidence. They follow established methodologies in research situations. They discuss evidence. The student carries out elements of experiments and research investigations. The student communicates information.

2 Unit 1: Oceanography

2.1 Unit description

In Unit 1, students explore the ways marine science describes and explains how physical and chemical processes shape and define marine environments. An understanding of oceanographic forces and actions is essential to appreciate the processes of ocean and coastal change. Students investigate the dynamics of ocean and coastal systems. They examine the geophysical features of the ocean and atmosphere in order to analyse change.

Contexts that could be investigated in this unit cover a variety of temporal and spatial scales. Examples of temporal changes could include tidal cycles, seasonal variation and geological periods. Spatial scales could include micro to meso level, such as sand grain movement to longshore drift. These understandings could be developed through the use of case studies related to the local environment (e.g. dune systems, beaches, estuaries, canals, sand islands, bays or reefs). Through the investigation of these contexts, students can explore ways in which social, economic, cultural and ethical factors apply to anthropogenic influences on the marine environment.

Participation in a range of experiments and investigations will allow students to progressively develop their suite of science inquiry skills while gaining an enhanced appreciation of the relationships between oceanographic processes. Collaborative experimental work also helps students to develop communication, interaction and self-management skills.

Throughout the unit, students develop skills in conducting real or virtual laboratory work and carrying out oceanographic, reef or coastal investigations. They will construct and use models to describe and interpret data about the physical and chemical processes that shape and define marine environments.

2.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

1. describe and explain an ocean planet and the dynamic shore
2. apply understanding of an ocean planet and the dynamic shore
3. analyse evidence about an ocean planet and the dynamic shore
4. interpret evidence about an ocean planet and the dynamic shore
5. investigate phenomena associated with an ocean planet and the dynamic shore
6. evaluate processes, claims and conclusions about an ocean planet and the dynamic shore
7. communicate understandings, findings, arguments and conclusions about an ocean planet and the dynamic shore.

2.3 Topic 1: An ocean planet

In this topic, students will:

Subject matter	Guidance
Oceanography • describe the bathymetric features of the ocean floor, including the − continental margin − ocean-basin floor − deep-sea trenches − mid-ocean ridges − abyssal plain • apply models to understand the geological features of Earth (e.g. sea floor modelling, tectonic plate movements, coastal landforms, stratigraphy) • describe the processes of the following cycles: water, carbon and oxygen.	• **Notional time:** 5 hours • **Suggested practical:** Conduct a convection experiment. • **SHE:** Development of satellite measurement techniques allows scientists to predict the direction and rate of plate movement. Consider how this has developed improved understandings of processes such as sea floor spreading and mantle convection.
Ocean currents • describe how surface ocean currents are driven by temperature, wind and gravity • describe how water, heat and nutrients are distributed across coastal regions and global ocean basins (e.g. upwelling and downwelling, El Niño and La Niña events, Langmuir circulation, Ekman spiral) • describe the physical and chemical properties of water, including structure, hydrogen bonding, polarity, action as a solvent, heat capacity and density • define thermocline, halocline and pycnocline • recognise how thermoclines and nutrients produce the oxygen minimum within the open ocean • explain how thermohaline circulation in the deep ocean is affected by salinity and water density.	• **Notional time:** 7 hours • **SHE:** Consider how advances in remote sensing have enabled scientists to map ocean currents and develop models of the complex pathways involved in regulating global climate, such as the 'global ocean conveyor belt'. • Refer to the glossary for definitions of thermocline, halocline and pycnocline. • **Syllabus link:** Thermoclines and ocean productivity link to subject matter in Unit 2 Topic 2: Marine environmental management. • **Syllabus link:** Changes in thermal regimes and their influence on ocean structure, productivity and distribution of marine organisms are covered in Units 3 and 4. • **Suggested practical:** Investigate thermoclines (using ice and water, and hot and cold coloured water); salinity (using student-made straw hydrometers); stratification (using salt and fresh water). • Students are not required to recognise specific nutrients in reference to oxygen minimums. • **Syllabus link:** Thermohaline circulation links to Unit 2 Topic 2: Marine environmental management. • **SHE:** Contemporary weather predictions are based on computer models but still

Subject matter	Guidance
	rely on human input to determine the most accurate and reliable forecast. Consider how this scientific knowledge enables scientists to inform decision-making for coastline management and marine industries.
Ocean conservation • argue that knowledge of the oceans is limited and requires further investigation • understand that the economic development of a nation and the value placed on marine environment, including the Exclusive Economic Zone (EEZ), affects decisions relating to resource management.	• **Notional time:** 1 hour • **SHE:** Marine debris accumulation is a global phenomenon (e.g. 'The Great Pacific Garbage Patch'). Consider how the causes and solutions (i.e. the use of scientific knowledge) of this issue are influenced by social, economic, cultural and ethical considerations. • **Syllabus link:** The Exclusive Economic Zone (EEZ) links to Unit 2 Topic 2: Marine environmental management.

2.4 Topic 2: The dynamic shore

In this topic, students will:

Subject matter	Guidance
Coastlines • identify that coastlines are shaped by a number of factors, including tectonic plate movements, shifts in climate patterns and sea level change, weather patterns, and movement of sediments and water (e.g. waves, currents) • recognise tidal movement in terms of gravitational pull, current strength and wave action • define sand budget and longshore drift • define refraction, reflection and diffraction • describe the factors of wave action, wind and longshore drift in the management of the movement of water, nutrients, sand, sediment and pollutants (e.g. oil spills, debris) • describe the processes of coastal erosion (in terms of accretion and erosion) • identify the factors between the atmosphere and the oceans that drive weather patterns and climate (e.g. temperature, wind speed and direction, rainfall, breezes, barometric pressure) • recall wave formation processes (e.g. fetch, relationship of wave height and type to water depth and wave celerity) • explain how the properties of waves are shaped by weather patterns, natural formations and artificial structures (e.g. interference patterns, fetch, wave sets).	• **Notional time:** 14 hours • Refer to the glossary for definitions of sand budget, longshore drift, refraction, reflection and diffraction. • **Suggested practical:** Conduct a wave tank experiment. • Students could model a coastal engineering system, artificial reef or beach/bar system. • **Suggested practical:** Conduct a beach profile/dune transect and use sand sifts to decide on sphericity (roundness of sand grains). • **SHE:** Historical local planning decisions on dynamic shorelines have influenced the selection of coastal management strategies. Analyse evidence from the use of groynes, river walls and sand bypass systems to determine the effects on longshore drift for a beach system resource (e.g. the *Delft report*; Griffith University Centre for Coastal Management).
Coastal impacts • explain how coastal engineering regulates water or sediment flow, affects currents and impacts the coastline, including marine ecosystems • recognise that longitudinal studies allow scientists to observe changes occurring in marine environments (e.g. satellite imagery, aerial photography, field research) • identify how organisms populate areas following changes in habitats (e.g. succession) • assess population density data of coastal areas to identify the impact on the health of coastal water • recall types of pollution of coastal zones, including organic wastes, thermal, toxic compounds, heavy metals, oil, nutrients and pesticides.	• **Notional time:** 5 hours • **Syllabus link:** Coastal impacts and types of pollution in coastal zones link to Unit 2 Topic 1: Marine ecology and biodiversity and Unit 4 Topic 2: Managing fisheries. • Examples of coastal engineering could include beach nourishment, sand bypassing systems, rock walls and revetment, canal, loch and/or weir systems, flood mitigation schemes, groynes, breakwaters and training walls.

Subject matter	Guidance
Coastal conservation and monitoring impacts • define sustainable management practice • discuss that the education of stakeholders is essential to encouraging sustainable management practices • compare the terms *point source* and *non-point source* forms of pollution • describe two direct methods of monitoring water pollution levels using an abiotic test (e.g. nitrate, phosphate, heavy metals) or a biotic test (e.g. faecal coliform) • define the term biochemical oxygen demand (BOD) • describe how BOD is used to indirectly assess water pollution levels • define the process of eutrophication • identify and describe land management practices that contribute to the health of marine ecosystems, including siltation, algal blooms and agricultural practices • describe and explain an indirect method of measuring pollution levels using a biotic index • recall a bio-indicator with an example. • **Mandatory practical:** Conduct water quality tests on a water sample.	• **Notional time:** 13 hours • This sub-topic should be considered within a case study context. • Refer to the glossary for definitions of sustainable management practice, biochemical oxygen demand and eutrophication. • Examples of marine bio-indicators could include marine bivalves such as mussels (*Mytilus galloprovincialis*), 'sentinel' fish species such as mudskippers (*Scartelaos histophorus*), seagrass (*Zostera* spp.) and changes in concentration of pigments in certain corals. • Field and laboratory techniques should be used to examine abiotic and biotic factors (e.g. Secchi discs, dissolved oxygen meters). • **Syllabus link:** Coastal conservation and monitoring impacts link to Unit 3 Topic 1: The reef and beyond. • **SHE:** Impact levels from pulse events alter as populations increase and landscape dynamics change. This leads to increased pressure on infrastructure designed to mitigate risk. Analyse evidence used by stakeholders to inform the monitoring, assessment and evaluation of risk in relation to pulse events (i.e. cyclone, storm surge, tsunami and floods).
Science as a Human Endeavour (SHE) • SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for a research investigation.	• Diver-propelled vehicles with customised high-definition cameras and automated image-annotation methods have dramatically increased the size, accuracy, and geographic and temporal scope of the datasets that marine scientists work with. • The effectiveness of land-based management practices has a direct impact on the health of marine ecosystems. Scientific monitoring of these practices can be used to develop and evaluate projected impacts on marine conservation strategies. • The use of data can inform the selection of coastal management strategies that may have beneficial, and/or harmful and/or unintended consequences.

2.5 Assessment guidance

In constructing assessment instruments for Unit 1, schools should ensure that the objectives cover, or are chosen from, the unit objectives. If one assessment instrument is developed for a unit, it must assess all the unit objectives; if more than one assessment instrument is developed, the unit objectives must be covered across those instruments.

It is suggested that student performance on Unit 1 is assessed using techniques modelled on the techniques used in Unit 3:

- a student experiment
- an examination that includes some items modelled on the data test.

3 Unit 2: Marine biology

3.1 Unit description

In Unit 2, students explore the ways marine science is used to describe and explain how marine organisms are influenced by the abiotic and biotic factors of ecosystems. An understanding of sustainability is essential to appreciate the processes that shape the future of biodiversity in marine environments. Students conduct investigations into the diversity of marine organisms and the biotic and abiotic factors influencing marine organisms. They examine the population data in order to analyse the factors affecting the distribution of marine organisms.

Contexts that could be investigated in this unit cover a variety of temporal and spatial scales. Examples of temporal changes could include seasonal variation, diurnal movement and life-cycle changes. Spatial scales could include micro to meso level, such as single species through to community. This understanding could be developed through case studies related to the local environment (i.e. the selected marine ecosystem, habitat or bioregion). Through investigating these contexts, students may explore the ethical considerations that apply to activities in or adjacent to marine environments or the application of the precautionary principle of marine environmental planning.

Participation in a range of experiments and investigations allows students to progressively develop their suite of science inquiry skills while gaining an enhanced appreciation of the relationship between organisms and the abiotic and biotic factors of marine ecosystems. Collaborative experimental work also helps students to develop communication, interaction, and self-management skills.

Throughout the unit, students develop skills in conducting real or virtual laboratory work and carrying out ecological investigations. They construct and use models to describe and interpret data about how marine organisms are influenced by the abiotic and biotic factors of ecosystems.

3.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

1. describe and explain marine ecology and biodiversity, and marine environmental management
2. apply understanding of marine ecology and biodiversity, and marine environmental management
3. analyse evidence about marine ecology and biodiversity, and marine environmental management
4. interpret evidence about marine ecology and biodiversity, and marine environmental management
5. investigate phenomena associated with marine ecology and biodiversity, and marine environmental management
6. evaluate processes, claims and conclusions about marine ecology and biodiversity, and marine environmental management
7. communicate understandings, findings, arguments and conclusions about marine ecology and biodiversity, and marine environmental management.

3.3 Topic 1: Marine ecology and biodiversity

In this topic, students will:

Subject matter	Guidance
Biodiversity • define the three main types of diversity (i.e. genetic, species and ecosystem) • recall the three unique characteristics of marine biodiversity (i.e. wide dispersal at sea, the need for structural complexity, critical nursery habitats) • identify the variety of ecosystems (e.g. estuaries, coastal lakes, saltmarshes, mangroves, seagrass, rocky shores, temperate reefs, coral reefs, lagoons, shelf and deep water) that constitute Australia's marine biomes • describe the implications of connectivity to marine ecosystems • identify factors that lead to a loss of diversity (e.g. natural hazard, loss/fragmentation of habitat, pollution, exploitation, introduction of new species, disease) • calculate the biodiversity of a marine ecosystem using Simpson's diversity index (SDI) • apply data to determine the biodiversity of a marine ecosystem using diversity indices • define ecosystem resilience, disturbance and recovery.	• **Notional time:** 6 hours • Snorkelling skills may be used to expand marine scientific inquiry skills in this unit. • Refer to the glossary for definitions of *genetic diversity*, *species diversity*, *ecosystem diversity*, *ecosystem resilience*, *ecosystem disturbance* and *ecosystem recovery*. • When referring to structural complexity, students should recognise that increased physical complexity results in an increased number of ecological niches over a variety of temporal and spatial scales. • Students are not required to recall specific biotic and abiotic factors associated with all marine ecosystems. Rather, these factors should be used to explain the implications of connectivity. • Case studies for SDI may be virtual or conducted in the field. • **Syllabus link:** Connectivity links to Unit 3 Topic 1: The reef and beyond. • **SHE:** Discuss how scientific evidence from the impact of cyclones and/or floods, allows scientists to offer reliable predictions about the loss of biodiversity of a chosen marine ecosystem.

Subject matter	Guidance
	• **Formula:** The formula used to quantify biodiversity of a habitat is Simpson's diversity index (SDI), shown as: $SDI = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$ $where:$ $N = total\ number\ of\ organisms\ of\ all\ species$ $n = number\ of\ organisms\ of\ one\ species$ • Other diversity indices could include Jaccard, Pearson's, Shannon–Wiener or Sorensen's. • Case studies for ecosystem resilience could include black teatfish (*Holothuria nobilis*), coral trout (*Plectropomus leopardus*), loggerhead turtles (*Caretta caretta*), urban coast dugongs (*Dugong dugon*), humpback whales (*Megaptera novaeangliae*) or staghorn coral species (*Acropora aspera*). • **SHE:** Discuss how scientists use the evidence from the monitoring and assessment of an ecosystem to inform scientific knowledge about ecosystem resilience and population recovery.
Biotic components of marine ecosystems • identify biotic components of marine ecosystems (i.e. trophic levels, food chains, food webs, interactions and population dynamics) • categorise biotic interactions based on the following terms – symbiosis (i.e. parasitism, mutualism, commensalism and amensalism) – competition (i.e. intraspecific and interspecific) – predation • classify organisms in trophic levels in a food web based on the following terms – producers – primary consumers – secondary consumers – tertiary consumers – decomposers • describe how matter cycles through food webs, including the process of bioaccumulation • recall the terms *population size, density*, *abundance*, *distribution* (i.e. clumped, uniform, random), *carrying capacity*, *niche*, *K-strategists and r-strategists*, *keystone species*	• **Notional time:** 8 hours • Bioaccumulation examples could include one of the following – scheduled wastes such as polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), hexachlorobenzenes (HCBs) – pesticides such as dichlorodiphenyltrichloroethane (DDT) – heavy metals (mercury, selenium, cadmium, lead, zinc, copper) – cyanide. • **Syllabus link:** Bioaccumulation links to Unit 4 Topic 2: Managing fisheries. • Examples of bioaccumulation could include ciguatera and mackerel (*Scomberomorus* spp.); mercury and blacktip sharks (*Carcharhinus* spp.); and toxin accumulation on microplastics. • The size of a population is affected by four processes: birth rate (B), death rate (D), immigration (I) and emigration (E). The rate of change of a population (R) is calculated by $R = (B + I) - (D + E)$.When a population reaches its carrying capacity due to the limitation of resources there will be zero population growth: R = 0. • **Suggested practical:** Estimate populations, e.g. survey count, quadrats,

Subject matter	Guidance
• assess population data to measure population size, density, abundance, distribution, carrying capacity.	species density, percentage coverage, indirect or direct observation, catch and release. • **Suggested practical:** Use field guides to identify to a genus level. • **Suggested practical:** Use a range of field equipment to measure biotic factors related to marine environments. • **Suggested practical:** Conduct in-field mapping of food webs via gut analysis to determine food sources. • **SHE:** Evaluate the role of biosecurity measures in preventing or responding to incursions of invasive marine species in Australian ports. Examples of invasive species could include one of the following: European fan worm (*Sabella spallanzanii*), northern Pacific sea star (*Asterias amurensis*), killer algae (*Caulerpa taxifolia*), green mussel (*Perna viridis*), black-striped zebra mussel (*Dreissena polymorpha*) or tilapia (*Oreochromis* spp).
Abiotic components of the marine ecosystem • understand that marine ecosystems are influenced and limited by abiotic factors in ways that may be different from terrestrial ecosystems due to the different physical and chemical properties of water compared to air • distinguish abiotic components of marine ecosystems: light availability, depth, stratification, temperature, currents (water and wind), tides, sediment type and nutrient availability • understand the importance of limiting factors and tolerance limits in population distributions • assess data to identify an organism's tolerance limit • apply the concept of zonation using the following terms: *intertidal*, *pelagic* (neritic, oceanic), *benthic* and *abyss*. • **Mandatory practical:** Conduct an investigation to determine factors of population dynamics (e.g. density or distribution) and assess abiotic components of a local ecosystem case study. Emphasis should be placed on assessing the processes and limitations of the chosen technique (e.g. quadrat, transect). When students identify and describe marine species, they should use field guides and identification keys.	• **Notional time:** 12 hours • An understanding of the different physical and chemical properties of water and how they impact marine organisms differently from terrestrial organisms is required. These properties include light availability, buoyancy, pressure, temperature, viscosity, sound, salinity and sediment loading. Students are not required to recall specific data (i.e. temperature values for thermal inversion layers). • Refer to Shelford's law when discussing tolerance limits and Leibig's law when discussing limiting factors. • Examples of organisms for tolerance-limit data could include distribution of intertidal organisms (e.g. sea cucumbers) or mangrove zonation. • For the concept of zonation, students should be able to show an understanding that the ocean is divided into different zones based on water depth, light availability and distance from the shore (i.e. in reference to a diagram). Students are not required to recall exact distances and depths. • Local ecosystem examples could include mangrove and estuarine systems, intertidal, seagrass fringing reef systems, rocky shore or rock platform environments.

Subject matter	Guidance
Adaptation • categorise different groups of animals using structural characteristics • identify and classify adaptations as anatomical (structural), physiological (functional) or behavioural • describe the role of adaptation in enhancing an organism's survival in a specific marine environment.	• **Notional time:** 3 hours • Examples of structural characteristics could include symmetry, modes of locomotion, life-cycle stages, coral shape, skeletal structure. • Examples of anatomical adaptations could include structures of locomotion (e.g. fins, jointed limbs) or patterns of camouflage (e.g. countershading). • Examples of physiological adaptations could include plant adaptations (e.g. mangrove exclusion, excretion and accumulation of salt) or animal adaptations (e.g. swim bladder, lateral line, osmoregulation). • Examples of behavioural adaptations could include diurnal migration of zooplankton or reproductive strategies. • **Suggested practical:** Identify physical structures of a specific marine organism (this could be virtual, practical or as a demonstration). • Case studies may be virtual or conducted in the field.

3.4 Topic 2: Marine environmental management

In this topic, students will:

Subject matter	Guidance
Marine conservation • recall the arguments for preserving species and habitats (i.e. ecological, economic, social, aesthetic, ethical) • describe the direct and indirect values of marine ecosystems of Australia • describe the role of stakeholders in the use and management of marine ecosystems • discuss the specific value systems that identified stakeholders use (i.e. ecocentric, technocentric and anthropogenic) • recognise the issues affecting a selected marine ecosystem • apply the terms ecosystem resilience, disturbance and recovery as indicators of 'health' of marine environments to a chosen case study.	• **Notional time:** 6 hours • The economic, ecological and social values of marine environments can differ depending on the perspectives of different groups holding those values (e.g. Aboriginal peoples and Torres Strait Islander peoples, international communities such as UNESCO, UNEP, governments and industry). • **Syllabus link:** Arguments for preserving species and habitats and direct and indirect values link to Unit 4 Topic 1: Oceans of the future, Sub-topic: Management and conservation. • Selected marine ecosystems could include – estuaries: catchment run-off, changing river flows, acid soil run-off – coastal lakes: urbanisation, eutrophication, sedimentation, saltwater encroachment – saltmarshes: urbanisation, sea level rise, introduced species – mangroves: urbanisation and contaminants – seagrass: sediment and nutrient run-off – rocky shores: over-harvesting – sandy beaches: coastal erosion (links to Unit 1 Topic 2: The dynamic shore). • Stakeholders in Australia include Aboriginal peoples, Torres Strait Islander peoples, general community, scientists, government and non-government agencies, fisheries and aquaculture, tourism, recreation, shipping and ports, offshore petroleum and land use (e.g. agriculture, forestry, mining, industry, transport, urban residential). • Refer to the glossary for definitions of ecocentric, technocentric and anthropogenic value systems.

Subject matter	Guidance
Resources and sustainable use • recall the precautionary principle of the marine environmental planning and management process as well as a requirement that any network of marine protected areas be comprehensive, adequate and representative • understand that criteria are used to inform decisions regarding the design of protected marine areas • compare the strategies and techniques used for marine environmental planning and management with reference to a specific case study • evaluate the marine environmental planning and management process using primary or secondary data of a specific case study (this may be linked to fieldwork).	• **Notional time:** 10 hours • Criteria used to inform decisions regarding the design of protected marine areas include relative naturalness, representativeness, biodiversity, vulnerability, fisheries value, tourism value, scientific importance, social acceptance, practicality of management and national/international significance. • Examples of the criteria against which decisions are made on the Great Barrier Reef could include the Representative Areas Program (RAP) mapping. • Strategies and techniques for marine environmental planning and management could include – plans: zoning plans or plans of management for Cairns, Hinchinbrook, Whitsundays, Great Sandy Strait, Moreton Bay, Shoalwater Bay – policies: *Reef 2050 long-term sustainability plan* – regulations: commercial and recreational fishing, permits for activities – legislation: *Great Barrier Reef Marine Park Act 1975* (Cwlth) • Examples of primary data could include rapid area assessment, abiotic testing, population counts, bio-indicator mapping. • Examples of secondary data could include zoning maps, bioregion maps. • **Syllabus link:** Unit 4 Topics 1 and 2 • **SHE:** Scientific evidence is used to inform the development of criteria that evaluate the success of regional zoning plans and plans of management. Assess one chosen plan based on the social, economic and cultural context on which it was considered.
Science as a Human Endeavour (SHE) • SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for a research investigation.	• Advances in remote sensing radar imagery, satellite tracking in real time and remotely piloted aircraft systems (RPAS) (i.e. drones) now enable scientists to measure and monitor populations in large or inaccessible ecosystems. This plays a significant role in surveying species such as dugongs. • Effective marine ecosystem management is informed by the development of complex models requiring a broad range of scientific knowledge in gathering data, identifying indicators and ensuring measurement is valid and reliable. • In areas where marine management decisions reflect scientific, social, cultural and ethical considerations, Aboriginal knowledge and practices and Torres Strait Islander knowledge and practices related to sea country are often used to complement conservation practices.

3.5 Assessment guidance

In constructing assessment instruments for Unit 2, schools should ensure that the objectives cover, or are chosen from, the unit objectives. If one assessment instrument is developed for a unit, it must assess all the unit objectives; if more than one assessment instrument is developed, the unit objectives must be covered across those instruments.

It is suggested that student performance on Unit 2 is assessed using techniques modelled on the techniques used in Unit 4:

- a research investigation
- an examination that includes some items modelled on the data test.

4 Unit 3: Marine systems — connections and change

4.1 Unit description

In Unit 3, students explore the ways marine science is used to describe and explain how marine ecosystems are formed and change due to a variety of natural and anthropogenic influences. Queensland's Great Barrier Reef and its associated marine protected areas are used as a focus for this exploration. An understanding of coral reef ecology and the connectivity between marine ecosystems allows students to appreciate the processes of reef development and change. Students conduct experiments and investigations into the factors affecting coral reef ecology. They examine trends, patterns and relationships between abiotic and biotic factors in order to analyse change.

Contexts that could be investigated in this unit cover a variety of temporal and spatial scales. Examples of temporal changes could include distribution of organisms over a tidal cycle and seasonal abiotic fluctuations over large spatial scales. Spatial scales could include zonation and micro to meso level marine biota distribution. This understanding could be developed through the use of case studies related to a reef ecosystem. Through investigation of these contexts, students may explore the ethical considerations that apply to sustainable use and management of coral reefs generally and the Great Barrier Reef in particular.

Participation in a range of experiments and investigations will allow students to progressively develop their suite of science inquiry skills while gaining an enhanced appreciation of the relationship between environmental change and the capacity of organisms to adapt. Collaborative experimental work also helps students to develop communication, interaction, and self-management skills.

Throughout the unit, students develop skills in conducting real or virtual laboratory work and carrying out spatial or temporal change investigations. They will construct and use models to describe and interpret data about the formation, change and resilience of the Great Barrier Reef and associated marine protected areas.

4.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

Unit objective	IA1	IA2	EA
1. describe and explain the reef and beyond, and changes on the reef			●
2. apply understanding of the reef and beyond, and changes on the reef	●	●	●
3. analyse evidence about the reef and beyond, and changes on the reef	●	●	●
4. interpret evidence about the reef and beyond, and changes on the reef	●	●	●
5. investigate phenomena associated with the reef and beyond, and changes on the reef		●	
6. evaluate processes, claims and conclusions about the reef and beyond, and changes on the reef		●	
7. communicate understandings, findings, arguments and conclusions about the reef and beyond, and changes on the reef.		●	

4.3 Topic 1: The reef and beyond

In this topic, students will:

Subject matter	Guidance
Coral reef distribution • identify the distribution of coral reefs globally and in Australia • identify abiotic factors that have affected the geographic distribution of corals over geological time including dissolved oxygen, light availability, salinity, temperature, substrate, aragonite and low levels of nitrates and phosphates • recall that corals first appeared within the geological record over 250 million years ago but not in Australian waters until approximately 500 000 years ago • recognise that the Great Barrier Reef of today has been shaped by changes in sea levels that began over 20 000 years before present (BP) and only stabilised 6500 years BP • recall the different types of reef structure (e.g. fringing, platform, ribbon, atolls, coral cays) • recognise the zonation within a reef cross-section (e.g. reef slope, reef crest/rim, lagoon/back reef).	• **Notional time:** 6 hours • Snorkelling skills may be used to expand marine scientific inquiry skills in this unit. • Opportunities exist to discuss sea level rise from Aboriginal perspectives and Torres Strait Islander perspectives. Sea level change in the Holocene resulted in an increase of approximately 125 metres in depth. • Factors that could influence the distribution patterns of reefs include changes moving down latitudinal gradients and across, from inshore to outer shelf reefs. • **SHE:** Analyse how the evidence from other disciplines, such as plate tectonics and shifts between glacial and interglacial periods, leads to improvements in the models used for the formation of reefs.
Coral reef development • recall the following groups of coral: Alcyonacea ‘soft corals’ and the two morphological groups within Scleractinia ‘hard corals’ — reef-forming/hermatypic and non-reef forming/ahermatypic • classify a specific coral to genus level only, using a relevant identification key • identify the anatomy of a typical reef-forming hard coral including skeleton, corallite, coelenteron, coral polyp, tentacles, nematocyst, mouth and zooxanthellae • recall that the limestone skeleton of a coral is built when calcium ions [Ca^{2+}] combine with carbonate ions [CO_3^{2-}] • describe the process of coral feeding (including night-feeding patterns and the function of nematocysts) • identify and describe the symbiotic relationships in a coral colony (including polyp interconnections and zooxanthellae)	• **Notional time:** 9 hours • In field investigations of reef communities, corals are often identified based on morphology (e.g. boulder, plate, branching, soft) rather than species or genus. • Opportunities to use a variety of biological classification keys should be provided, including pictorial keys. • It is recommended the genus species for the coral example is linked to a case study. • Case studies may be virtual or conducted in the field. • The process of building a coral skeleton is complex and influenced by a variety of factors notably the concentration of ions, temperature, light and pH changes. • Corals may need to overcome competition for space and light to establish at a particular site (e.g. defences in hard corals: sweeper tentacles; in soft corals: allelopathic chemicals).

Subject matter	Guidance
• recall the life cycle stages of a typical reef-forming hard coral (asexual: fragmentation, polyp detachment; sexual: gametes, zygotes, planulae, polyp/asexual budding) • explain the process of larval dispersal, site selection, settlement and recruitment • explain that growth of reefs is dependent on accretion processes being greater than destructive processes • assess data of abiotic factors (e.g. dissolved oxygen, salinity, substrate) that affect the distribution of coral reefs.	• The factors affecting larval dispersal, site selection, settlement and recruitment of coral species include currents, bathymetry, substrate, sediment, predation, competition. An understanding of the above factors underpins concepts related to connectivity, resilience (Unit 2 Topic 1: Marine ecology and biodiversity) and sustainability and management. • Accretion refers to the growth of coral substrate due to calcification rate. • **Suggested practical:** Identify coral genus (photo, online or field). • **Suggested practical**: Classify plankton using field work techniques such as collection/trawls. • **Suggested practical:** Investigate zooxanthellae (with flotsam jellyfish or aquarium coral) using a microscope.
Reef, habitats and connectivity • recognise that corals are habitat formers or ecosystem engineers • explain that habitat complexity (rugosity), established by corals, influences diversity of other species • explain connectivity between ecosystems and the role this plays in species replenishment • understand that fish life cycles are integrated within a variety habitats including reef and estuarine systems • describe how fish, particularly herbivore populations, benefit coral reefs • identify ecological tipping points and how this applies to coral reefs • describe hysteresis and how this applies to the concept of reef resilience • assess the diversity of a reef system using a measure that could include (but is not limited to) line intercept transects, quadrats and fish counts using underwater video survey techniques, benthic surveys, invertebrate counts and rugosity measurements • analyse reef diversity data, using an index, to determine rank abundance • interpret, with reference to regional trends, how coral cover has changed on a reef over time • recognise that some of the factors that reduce coral cover (e.g. crown-of-thorns) are directly linked to water quality • understand that the processes in this sub-topic interact to have an overall net	• **Notional time:** 12 hours • Refer to the glossary for definitions of habitat former and ecosystem engineer. • The process of building a coral skeleton is complex and influenced by a variety of factors, notably the concentration of ions, temperature, light and pH changes. • Habitat complexity should include not only species diversity but also rugosity and percentage coral cover. • Refer to the glossary for definitions of rugosity and (for *reef resilience*) ecosystem resilience. • Data can be primary or secondary (fieldwork, collected or virtual). • Diversity indices used to rank abundance could include Shannon–Wiener, Simpson’s, or similarity indices (Jaccard and Sorensen’s). • When interpreting coral cover change, recognise that reefs can and do recover from pulse events but this may take decades. • Examples of habitats for water quality testing could include estuarine, seagrass, inshore reefs. • **Suggested practical:** Examine coral diversity using a transect technique (using online or field data). • **SHE:** Investigate how complex models of marine ecosystems can be developed based on a wide range of evidence from multiple individuals and across disciplines.

Subject matter	Guidance
effect, i.e. they do not occur in isolation. • **Mandatory practical:** Examine the concept of connectivity within or between habitats by investigating the impact of water quality on reef health.	• Water quality data for the mandatory practical can be either online, virtual or field data. • Impacts on reef health should be considered as both qualitative and quantitative. • Evaluation of water quality data in the mandatory practical should be supported with data analysis (descriptive and inferential statistics). Examples of inferential statistical tests include student t-tests, standard error, Mann–Whitney U and confidence intervals. Examples of correlation tests include Pearson correlation coefficient, Spearman's rank and Cohen's *d* effect size.

4.4 Topic 2: Changes on the reef

In this topic, students will:

Subject matter	Guidance
Anthropogenic change • analyse results from models to determine potential reef futures under various scenarios • recall the global anthropogenic factors affecting the distribution of coral (i.e. coral mining, pollution: organic and non-organic, fishing practices, dredging, climate change, ocean acidification and shipping) • describe the specific pressures affecting coral reefs (i.e. surface run-off, salinity fluctuations, climate change, cyclic crown-of-thorns outbreaks, overfishing, spills and improper ballast) • recognise that during the Holocene no evidence of coral bleaching or ocean acidification can be found within coral cores dating back 6000 years • explain the concept of coral bleaching in terms of Shelford's law of tolerance • interpret thermal threshold data for reefs in the northern, central and southern sections of the Great Barrier Reef in relation to the likelihood of a bleaching event • use a specific case study to evaluate the ecological effects on other organisms (e.g. fish) after a bleaching event has occurred • describe the conditions necessary for recovery from bleaching events • compare the responses to bleaching events between two regions, while recognising that coral cover increases on resilient reefs once pressures are reduced or removed • interpret data, including qualitative graphical data of coral cores, that demonstrates that coral cores can act as a proxy for the climate record (i.e. they provide information on the changes in weather patterns and events affecting the composition of coral communities).	• **Notional time:** 7 hours • Models to determine potential reef futures could include those produced from the Australian Institute of Marine Science (AIMS). • **Syllabus link:** Shelford's law of tolerance is covered in Unit 2 Topic 1: Marine ecology and biodiversity. • When interpreting thermal thresholds, students should recognise the differences moving from the northern to central to southern Great Barrier Reef and the relationship between degree heating weeks (DHW). • Case studies of ecological effects could include the: – rate of recovery of reefs following bleaching events – relationship between depth and rugosity following bleaching events or – response rates of reefs in different areas/depths. • **SHE:** International collaboration is often required when addressing global issues. The Intergovernmental Panel on Climate Change (IPCC) is an objective, scientific, intergovernmental body that adopted the Representative Concentration Pathways (RCPs) in its 2014 *Fifth Assessment Report*. Recognise the ecological consequences of climate change for reefs with reference to each of the four RCPs (2.6–8.5). • **SHE:** Examine how decisions made on reef management and conservation are based on scientific knowledge, which relies on clear communication of findings, peer review and reproducibility. • An understanding of the technique of coral coring is not required.

<table>
<tr><th>Subject matter</th><th>Guidance</th></tr>
<tr><td>Ocean equilibria
explain the reason for differences between ocean pH and freshwater — presence of carbonate buffering system
explain that the carbonate system is linked to geological processes and operates on geological timescales
recognise that increases in atmospheric carbon dioxide influences both global temperature and ocean pH
describe sources of carbon dioxide in the atmosphere and how this influences ocean chemistry
describe the effect of ocean acidification on sea water in terms of increasing the concentration of hydrogen ions decreasing the concentration of carbonate ions
explain how the carbonate compensation depth (CCD) varies due to depth, location and oceanographic processes such as upwelling and coastal influences
understand that the ocean’s capacity to absorb carbon dioxide is changing and is linked to temperature (uptake) and changes in primary productivity (storage, e.g. biological pump).
</td><td>
Notional time: 5 hours
Refer to the glossary for the definition of ocean acidification.
With respect to ocean acidification students should understand that carbon dioxide (CO_2) is absorbed from the atmosphere and it bonds with sea water forming carbonic acid. This acid then releases a bicarbonate ion and a hydrogen ion. The hydrogen ion bonds with free carbonate ions in the water forming another bicarbonate ion. That carbonate would otherwise be available to marine animals for making calcium carbonate shells and skeletons. The more dissolved carbon dioxide in the ocean, the less free carbonate ions available for making calcium carbonate.
Students are not required to recall specific chemical equations.
</td></tr>
<tr><td>Implications for marine systems
recognise that the type of carbonate ions and concentration of ions have an implication for the development of shell-forming and skeletal-forming organisms including hard corals (Scleractinia), coralline algae, molluscs, plankton and crustaceans
interpret trends in data in relation to the carbonate system and changes in pH
distinguish between laboratory-scale and field-based experiments and what they demonstrate about ocean acidification
describe the potential consequences of ocean acidification for coral reef ecosystems
explain how resilience may partially offset ocean acidification responses in the short term.
Mandatory practical: Investigate the effects an altered ocean pH has on marine carbonate structures.
</td><td>
Notional time: 6 hours
Calcium carbonate can be precipitated into two main forms: calcite and aragonite.
Examples of data that could be interpreted include Bjerrum, hockey stick or Keeling curves.
The precipitation of aragonite is dependent on the concentration of both calcium and carbonate ions. It can be described using the following equation:
$\Omega = [Ca^{2+}] * [CO_3{}^{2-}]/K_{sp}$
$where:$
$\Omega = precipitation$
$K_{sp} = solubility\ product$
Suggested practical: Investigate how CO_2 lowers the pH of a solution.
Suggested practical: Investigate how changes in temperature and salinity affect the solubility of CO_2 in aqueous saline solutions.
</td></tr>
</table>

Subject matter	Guidance
	• **Suggested practical:** Investigate the effect of CO_2 on planktonic organisms. • Resilience of coral reefs is improved by minimising other impacts including coastal run-off (nitrogen inputs), and habitat destruction and fishing. The reef and catchment management processes of the Great Barrier Reef aim to reduce nutrient load in run-off.
Science as a Human Endeavour (SHE) • SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for a research investigation.	• The majority of scientists accept that anthropogenic atmospheric changes are linked to global temperature increases. Analysis of gas concentrations in the atmosphere and ice cores indicates that greenhouse gas levels have increased as a result of emissions from human activities. • Scientists agree that global predictions on climate change are accurate; however, at a regional scale, due to localised conditions, predictions are less reliable. • Decisions about actions to mitigate the effects of climate change depend on the perception of risk by individuals, communities, governments and international agencies and reflect their social, economic and cultural values.

4.5 Assessment

4.5.1 Summative internal assessment 1 (IA1): Data test (10%)

Description

This assessment focuses on the application of a range of cognitions to multiple provided items.

Student responses must be completed individually, under supervised conditions, and in a set timeframe.

Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

2. apply understanding of the reef and beyond or changes on the reef to given algebraic, visual or graphical representations of scientific relationships and data to determine unknown scientific quantities or features
3. analyse evidence about the reef and beyond or changes on the reef to identify trends, patterns, relationships, limitations or uncertainty in datasets
4. interpret evidence about the reef and beyond or changes on the reef to draw conclusions based on analysis of datasets.

Note: Objectives 1, 5, 6 and 7 are not assessed in this instrument.

Specifications

Description

Students respond to items using qualitative data and/or quantitative data derived from the mandatory or suggested practicals, activities or case studies from the unit being studied.

The data test contains two to four datasets and consists of a number of different types of items, which include:

- short response items requiring single-word, sentence or short paragraph responses
- calculating using algorithms
- interpreting datasets.

Mark allocations

Percentage of marks	Objective	Cognition and nature of response
~ 30%	2. apply understanding of the reef and beyond or changes on the reef to given algebraic, visual or graphical representations of scientific relationships and data to determine unknown scientific quantities or features	Students calculate, identify, recognise and use evidence to determine unknown scientific quantities or features.
~ 30%	3. analyse evidence about the reef and beyond or changes on the reef to identify trends, patterns, relationships, limitations or uncertainty in datasets	Students categorise, classify, contrast, distinguish, organise or sequence evidence to identify trends, patterns, relationships, limitations or uncertainty in datasets.
~ 40%	4. interpret evidence about the reef and beyond or changes on the reef to draw conclusions based on analysis of datasets.	Students compare, deduce extrapolate, infer, justify or predict using evidence to draw conclusions based on analysis of the datasets.

Conditions

- Time: 60 minutes plus 10 minutes perusal.
- Length: up to 500 words in total, consisting of
  - short responses, i.e. single words, sentences or short paragraphs (fewer than 50 words)
  - paragraphs, 50–250 words per item
  - other types of item responses (e.g. interpreting and calculating) should allow students to complete the response in the set time.
- Other:
  - QCAA-approved graphics calculator permitted
  - unseen stimulus.

Summary of the instrument-specific marking guide

The following table summarises the criteria, assessment objectives and mark allocation for the data test.

Criterion	Objectives	Marks
Data test	2, 3, 4	10
Total		**10**

Note: Unit objectives 1, 5, 6 and 7 are not assessed in this instrument.

Instrument-specific marking guide

Criterion: Data test

Assessment objectives

2. apply understanding of the reef and beyond or changes on the reef to given algebraic, visual or graphical representations of scientific relationships and data to determine unknown scientific quantities or features
3. analyse evidence about the reef and beyond or changes on the reef to identify trends, patterns, relationships, limitations or uncertainty in datasets
4. interpret evidence about the reef and beyond or changes on the reef to draw conclusions based on analysis of datasets

The student work has the following characteristics:	Cut-off	Marks
• consistent demonstration, across a range of scenarios about the reef and beyond or changes on the reef, of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct and appropriate use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions.	> 90%	10
	> 80%	9
• consistent demonstration, in scenarios about the reef and beyond or changes on the reef, of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions.	> 70%	8
	> 60%	7
• adequate demonstration, in the reef and beyond or changes on the reef, of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions.	> 50%	6
	> 40%	5
• demonstration, in scenarios about the reef and beyond or changes on the reef, of elements of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual or graphical representations of scientific relationships or data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations or uncertainty – correct interpretation of evidence to draw valid conclusions.	> 30%	4
	> 20%	3

The student work has the following characteristics:	Cut-off	Marks
• demonstration, in scenarios about the reef and beyond or changes on the reef, of elements of – application of scientific concepts, theories, models or systems to predict outcomes, behaviours or implications – calculation of quantities through the use of algebraic or graphical representations of scientific relationships and data – use of analytical techniques to identify trends, patterns, relationships, limitations or uncertainty – interpretation of evidence to draw conclusions.	> 10%	2
	> 1%	1
• does not satisfy any of the descriptors above.	≤ 1%	0

4.5.2 Summative internal assessment 2 (IA2): Student experiment (20%)

Description

This assessment requires students to research a question or hypothesis through collection, analysis and synthesis of primary data. A student experiment uses investigative practices to assess a range of cognitions in a particular context. Investigative practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

2. apply understanding of the reef and beyond or changes on the reef to modify experimental methodologies and process primary data
3. analyse experimental evidence about the reef and beyond or changes on the reef
4. interpret experimental evidence about the reef and beyond or changes on the reef
5. investigate phenomena associated with the reef and beyond or changes on the reef through an experiment
6. evaluate experimental processes and conclusions about the reef and beyond or changes on the reef
7. communicate understandings and experimental findings, arguments and conclusions about the reef and beyond or changes on the reef.

Note: Objective 1 is not assessed in this instrument.

Specifications

Description

In the student experiment, students modify (i.e. refine, extend or redirect) an experiment in order to address their own related hypothesis or question. It is sufficient that students use a practical performed in class or a simulation as the basis for their methodology and research question.

In order to complete the assessment task, students must:

- identify an experiment to modify*
- develop a research question to be investigated*
- research relevant background scientific information to inform the modification of the research question and methodology
- conduct a risk assessment and account for risks in the methodology*
- conduct the experiment*
- collect sufficient and relevant qualitative data and/or quantitative data to address the research question*
- process and present the data appropriately
- analyse the evidence to identify uncertainty and limitations

- interpret the evidence to draw conclusion/s to the research question
- evaluate the reliability and validity of the experimental process
- suggest possible improvements and extensions to the experiment
- communicate findings in an appropriate scientific genre (e.g. report, presentation poser, journal article, conference presentation).

*The steps indicated with an asterisk above may be completed in groups. All other elements must be completed individually.

Scientific inquiry is a non-linear, iterative process. Students will not necessarily complete these steps in the stated order; some steps may be repeated or revisited.

Conditions

- Time: 10 hours class time. This time will not necessarily be sequential. Students must perform the majority of the task during class time, including
  - performing background research and developing the methodology
  - conducting the experiment
  - processing and analysing evidence and evaluating the methodology
  - preparing and presenting the response (e.g. writing the scientific report, constructing and presenting the scientific poster).
- Length:
  - written (e.g. scientific report), 1500–2000 words

or

  - multimodal presentation (e.g. scientific poster presentation), 9–11 minutes
- Other:
  - students may work collaboratively with other students to develop the methodology and perform the experiment; all other stages (e.g. processing of data, analysis of evidence and evaluation of the experimental process) must be carried out individually
  - the response must be presented using an appropriate scientific genre (e.g. report, poster presentation, journal article, conference presentation) and contain
    - a research question
    - a rationale for the experiment
    - reference to the initial experiment and identification and justification of modifications to the methodology
    - raw and processed qualitative data and/or quantitative data
    - analysis of the evidence
    - conclusion/s based on the interpretation of the evidence
    - evaluation of the methodology and suggestions of improvements and extensions to the experiment
    - a reference list.

Summary of the instrument-specific marking guide

The following table summarises the criteria, assessment objectives and mark allocation for the student experiment.

Criterion	Objectives	Marks
Research and planning	2, 5	6
Analysis of evidence	2, 3, 5	6
Interpretation and evaluation	4, 6	6
Communication	7	2
Total		**20**

Note: Unit objective 1 is not assessed in this instrument.

Instrument-specific marking guide

Criterion: Research and planning

Assessment objectives

2. apply understanding of the reef and beyond or changes on the reef to modify experimental methodologies and process primary data
5. investigate phenomena associated with the reef and beyond or changes on the reef through an experiment

The student work has the following characteristics:	Marks
• informed application of understanding of the reef and beyond or changes on the reef to modify experimental methodologies demonstrated by – a considered rationale for the experiment – justified modifications to the methodology • effective and efficient investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by – a specific and relevant research question – a methodology that enables the collection of sufficient, relevant data – considered management of risks and ethical or environmental issues.	5–6
• adequate application of understanding of the reef and beyond or changes on the reef to modify experimental methodologies demonstrated by – a reasonable rationale for the experiment – feasible modifications to the methodology • effective investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by – a relevant research question – a methodology that enables the collection of relevant data – management of risks and ethical or environmental issues.	3–4
• rudimentary application of understanding of the reef and beyond or changes on the reef to modify experimental methodologies demonstrated by – a vague or irrelevant rationale for the experiment – inappropriate modifications to the methodology • ineffective investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by	1–2

The student work has the following characteristics:	Marks
– an inappropriate research question – a methodology that causes the collection of insufficient and irrelevant data – inadequate management of risks and ethical or environmental issues.	
• does not satisfy any of the descriptors above.	0

Criterion: Analysis of evidence

Assessment objectives

2. apply understanding of the reef and beyond or changes on the reef to modify experimental methodologies and process primary data
3. analyse experimental evidence about the reef and beyond or changes on the reef
5. investigate phenomena associated with the reef and beyond or changes on the reef through an experiment

The student work has the following characteristics:	Marks
• appropriate application of algorithms, visual and graphical representations of data about the reef and beyond or changes on the reef demonstrated by correct and relevant processing of data • systematic and effective analysis of experimental evidence about the reef and beyond or changes on the reef demonstrated by – thorough identification of relevant trends, patterns or relationships – thorough and appropriate identification of the uncertainty and limitations of evidence • effective and efficient investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by the collection of sufficient and relevant raw data.	5–6
• adequate application of algorithms, visual and graphical representations of data about the reef and beyond or changes on the reef demonstrated by basic processing of data • effective analysis of experimental evidence about the reef and beyond or changes on the reef demonstrated by – identification of obvious trends, patterns or relationships – basic identification of uncertainty and limitations of evidence • effective investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by the collection of relevant raw data.	3–4
• rudimentary application of algorithms, visual and graphical representations of data about the reef and beyond or changes on the reef demonstrated by incorrect or irrelevant processing of data • ineffective analysis of experimental evidence about the reef and beyond or changes on the reef demonstrated by – identification of incorrect or irrelevant trends, patterns or relationships – incorrect or insufficient identification of uncertainty and limitations of evidence • ineffective investigation of phenomena associated with the reef and beyond or changes on the reef demonstrated by the collection of insufficient and irrelevant raw data.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Interpretation and evaluation

Assessment objectives

4. interpret experimental evidence about the reef and beyond or changes on the reef
6. evaluate experimental processes and conclusions about the reef and beyond or changes on the reef

The student work has the following characteristics:	Marks
• insightful interpretation of experimental evidence about the reef and beyond or changes on the reef demonstrated by justified conclusion/s linked to the research question • critical evaluation of experimental processes about the reef and beyond or changes on the reef demonstrated by – justified discussion of the reliability and validity of the experimental process – suggested improvements and extensions to the experiment that are logically derived from the analysis of evidence.	5–6
• adequate interpretation of experimental evidence about the reef and beyond or changes on the reef demonstrated by reasonable conclusion/s relevant to the research question • basic evaluation of experimental processes about the reef and beyond or changes on the reef demonstrated by – reasonable description of the reliability and validity of the experimental process – suggested improvements and extensions to the experiment that are related to the analysis of evidence.	3–4
• invalid interpretation of experimental evidence about the reef and beyond or changes on the reef demonstrated by inappropriate or irrelevant conclusion/s • superficial evaluation of experimental processes about the reef and beyond or changes on the reef demonstrated by – cursory or simplistic statements about the reliability and validity of the experimental process – ineffective or irrelevant suggestions.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Communication

Assessment objective

7. communicate understandings and experimental findings, arguments and conclusions about the reef and beyond or changes on the reef

The student work has the following characteristics:	Marks
• effective communication of understandings and experimental findings, arguments and conclusions about the reef and beyond or changes on the reef demonstrated by – fluent and concise use of scientific language and representations – appropriate use of genre conventions – acknowledgment of sources of information through appropriate use of referencing conventions.	2
• adequate communication of understandings and experimental findings, arguments and conclusions about the reef and beyond or changes on the reef demonstrated by – competent use of scientific language and representations – use of basic genre conventions – use of basic referencing conventions.	1
• does not satisfy any of the descriptors above.	0

4.5.3 Summative external assessment (EA): Examination (50%)

General information

Summative external assessment is developed and marked by the QCAA. In Marine Science, it contributes 50% to a student's overall subject result.

Summative external assessment assesses learning from both Units 3 and 4.

The external assessment in Marine Science is common to all schools and administered under the same conditions, at the same time, on the same day.

See Section 5.5.2.

5 Unit 4: Ocean issues and resource management

5.1 Unit description

In Unit 4, students explore the ways marine science is used to describe and explain how changes due to climate and human use influence fisheries and other marine resources. An understanding of fish population dynamics and fishing activities is essential to appreciate the processes of fisheries management and the issues associated with the ‘blue revolution’. Students conduct experiments and investigations into factors affecting ocean productivity. They examine abiotic factors in order to analyse changes in fish populations.

Contexts that could be investigated in this unit cover a variety of temporal and spatial scales. Examples of temporal changes could include migratory patterns and the change from pre-industrial to industrial scale fishing. Spatial scales could include the location of fisheries and micro to meso level contexts, e.g. from aquaculture, to the Great Barrier Reef, and through to the high seas. This understanding could be developed through the appreciation of the influence of water quality change on fisheries and marine systems. Case studies related to these changes include management of estuaries and reefs, shifting pelagic populations (e.g. sharks and tuna), larval distributions and juvenile nurseries. Through the investigation of these contexts, students may explore the ethical considerations that apply to food security, connectivity, shifting baselines and impacts on other species.

Participation in a range of experiments and investigations will allow students to progressively develop their suite of science inquiry skills while gaining an enhanced appreciation of the relationship between ocean conservation and fisheries sustainability. Collaborative experimental work also helps students to develop communication, interaction, and self-management skills.

Throughout the unit, students develop skills in conducting real or virtual laboratory work and carrying out fish population and ocean acidification investigations. Students construct and use models to describe and interpret data about how climate change and human usage influence fisheries.

5.2 Unit objectives

Unit objectives are drawn from the syllabus objectives and are contextualised for the subject matter and requirements of the unit. Each unit objective must be assessed at least once.

Students will:

Unit objective	IA3	EA
1. describe and explain oceans of the future and managing fisheries		●
2. apply understanding of oceans of the future and managing fisheries	●	●
3. analyse evidence about oceans of the future and managing fisheries	●	●
4. interpret evidence about oceans of the future and managing fisheries	●	●
5. investigate phenomena associated with oceans of the future and managing fisheries	●	
6. evaluate processes, claims and conclusions about oceans of the future and managing fisheries	●	
7. communicate understandings, findings, arguments and conclusions about oceans of the future and managing fisheries.	●	

5.3 Topic 1: Oceans of the future

In this topic, students will:

Subject matter	Guidance
Management and conservation • recall and use the arguments for preserving species and habitats (i.e. ecological, economic, aesthetic, ethical) through identifying their associated direct and indirect values in a given case study • recall and explain the criteria (i.e. site selection, networking and connectivity, replication, spacing, size and coverage) used to design protected marine areas • identify management strategies used to support marine ecosystem health (e.g. managing threats, zoning, permits, plans, longitudinal monitoring) • evaluate the success of a named protected marine area • compare the roles of government and non-government organisations in the management and restoration of ecosystems and their relative abilities to respond (e.g. speed, diplomatic constraints, political influence, enforceability).	• **Notional time:** 6 hours • Direct values refer to those that can be calculated (i.e. goods that can be harvested). Indirect values generally cannot be easily measured (i.e. ecosystem services and processes). • Students should be able to use arguments for preservation in a given case study. Examples of each argument could include, but are not limited to - ecological — source of genetic diversity - economic — ecotourism, recreation, yield - ethical — bio rights and stewardship - aesthetic — source of beauty, spiritual connection. • Students should understand that the criteria used for marine areas is different to terrestrial situations. In order to be effective, these criteria must consider an extensive representation of marine biodiversity that takes into account connectivity and the mobility of the species being considered, in replicate habitats (to act as a buffer against change) and at a minimum size to support viable populations of the majority of species at a network level. • **SHE:** Evaluate efforts (i.e. global agreements, national frameworks, industry participation, community decisions, and individual actions) to reduce the effects of climate change and consider the complexity of these interactions.

Subject matter	Guidance
Future scenarios • evaluate future scenarios for a named marine system through the analysis of different atmospheric condition datasets • compare historical geological data (e.g. of coral cores) with changes in land use practices and global carbon dioxide and temperature levels • recognise that ocean acidification has indirect consequences on the ocean and its uses • identify the factors between the atmosphere and the oceans that drive weather patterns and climate (e.g. temperature, wind speed and direction, rainfall, breezes and barometric pressure) • understand that average global temperature increases impact on marine environments by altering thermal regimes and changing physical and chemical parameters of the ocean (e.g. aragonite saturation levels and rising sea levels).	• **Notional time:** 7 hours • Indirect consequences of ocean acidification could include changes in food webs, lowering of coral bleaching temperature thresholds, habitat destruction, coastal protection; and effects on fisheries, medicine, tourism and recreation. • The examination of coral cores to analyse changes in reef ecology over historic timeframes using paleoecological evidence should be based on secondary data. • **SHE:** Consider how scientific knowledge of the loss of coral reefs can be used to evaluate projected economic (e.g. fisheries, tourism), social (e.g. recreation) and environmental (e.g. food webs, habitat changes) impacts. • **SHE:** Examine scientific analysis of evidence that enables scientists to predict that when thermoclines and upwellings are disrupted the global ocean conveyor can be 'shut down'. It is estimated that the world's climate could be drastically altered in just a few years after this point, affecting global ocean productivity.

5.4 Topic 2: Managing fisheries

In this topic, students will:

Subject matter	Guidance
Fisheries and population dynamics • understand that the term *fishery* has a variety of meanings and that there are three main types (i.e. artisanal, recreational and commercial) • understand the significance of wild caught fish as the major source of protein globally • understand that the world's fisheries are in decline • explain how distribution of fish populations are determined by temperature, primary productivity and nutrient dispersal, and these are influenced by currents, upwelling and seasonal factors • assess rugosity data and link this to fish diversity • assess the impact of bioaccumulation through the food web into edible seafood • explain how the alteration of thermal regimes caused by climate change is affecting the distribution of fish populations • compare a case study of a fish population in decline with a case study of a fish population that is in recovery in relation to fisheries management practices • interpret fish population data using the Lincoln index (capture–recapture method) and identify the reliability of this data to inform fisheries management decision-making on quota and total allowable catch • identify the factors (e.g. sampling techniques, fish behaviour, temporal and spatial movement, life history) that determine the reliability of fisheries population data and consider the limitations of these factors • recognise an international agreement that is used to manage migratory pelagic species • appraise the use of maximum sustainable yields and maximum economic yields • recognise that fisheries management has shifted from single species maximum sustainable yield towards ecosystem-based fisheries management	• **Notional time:** 15 hours • Students are not required to explain or describe the three main types of fisheries in detail. Rather, they should have an awareness of these terms and be able to use them in context throughout this topic. • When interpreting evidence of management strategies students should consider the *Green paper on fisheries management reform in Queensland* from Department of Agriculture and Fisheries, Queensland Government. • The term *fishery* can include a – particular species fishery (e.g. mackerel fishery) – regional fishery (e.g. Queensland Coral Reef Fin Fish Fishery) – recreational or commercial fishery – fishing practice (e.g. northern trawl fishery) – global fishery (Pacific bluefin tuna fishery). • Examples of bioaccumulation of toxins in edible seafood could include ciguatera, heavy metals and microplastics. • **Syllabus link:** Bioaccumulation of toxins in edible seafood links to Unit 2 Topic 1: Marine ecology and biodiversity. • Students should understand that while wild caught fish provide a significant percentage of animal protein globally, this percentage can be higher in communities by the sea. • Examples of a fisheries species in decline could include Atlantic cod (*Gadus morhua*), Pacific bluefin tuna (*Thunnus orientalis*). Examples of fisheries in recovery could include coral trout (*Plectropomus leopardus*). • Examples of causes of fish population decline could include overfishing, destructive fishing practices, industrial fishing, illegal fishing, fishing down the food chain, pollution, climate change, habitat destruction and shifting baselines. • Students are not required to recall an exhaustive list of Australian or global fisheries. • Management measures could include total allowable catch, closing fishing areas,

Subject matter	Guidance
• understand the value of marine protected areas including estuarine and open-water environments to fisheries sustainability. • **Mandatory practical:** Apply the Lincoln index in a modelled capture–recapture scenario.	reducing boat numbers or banning the catch of a particular species. • **Formulas** – The formula for the population dynamics model BIDE (Birth, Immigration, Death, Emigration) is shown as: $N_1 = N_0 + B - D + I - E$ – The formula for estimation of population size by the capture–recapture measure is the Lincoln index, shown as: $N = \frac{M \, x \, n}{m}$ $where:$ $M = number\ of\ individuals\ caught, marked\ and\ released\ initially$ $n = number\ of\ individuals\ caught\ on\ second\ sampling$ $m = number\ of\ individuals\ recaptured\ that\ were\ marked.$ • In the modelled capture–recapture scenario, marine organisms can be represented by other physical representations (i.e. counters or buttons). Virtual programs are also available online. • Examples of issues associated with fisheries could include overfishing, bycatch, illegal fishing, discarded gear, destructive fishing techniques, impacts on ecosystems, trophic cascades, marine pests and impacts on endangered species. • Common commercial fishing techniques could include gill nets, beach seines, purse seines, trawl nets, scallop dredges, hook and line, traps, crab dillies and snares. • Examples of marine protected areas could include mangroves, seagrass and offshore reefs. • **Suggested practical:** Assess the life history of a fish by reviewing otoliths using a microscope. • **Suggested practical:** Analyse a water or sand sample to identify the presence of microplastics. • **SHE:** Examine the issue of overfishing, which — due to insufficient reliable data — continues to be a problem that requires a review of management policies.
Australia's fisheries management • identify the Australian Fishing Zone (AFZ) • infer that the status of Australian fisheries is due to science-based management, the rule of law and good governance • identify an example of a major Australian edible seafood export product and an import product	• **Notional time:** 8 hours • Students could appraise the practice of naming and identifying sources of seafood for consumption in Australia. • Opportunities exist to discuss Aboriginal peoples' and Torres Strait Islander peoples' voluntary management of traditional use activities on sea country

Subject matter	Guidance
• examine the factors that lead to a higher proportion of the seafood consumed in Australia being imported • recall that Australian Fisheries have an economic value • explain monitoring and control of total allowable catch and fixed quotas • describe dynamic spatial zoning fish management (including e-monitoring) as a fish management technique in terms of ecosystem-based management in relation to a case study • describe the use of the precautionary principle as applied to ecosystem management.	(e.g. Traditional Use of Marine Resources Agreements — TUMRA). • Examples of case studies could include southern bluefin tuna (*Thunnus maccoyii*). • Aspects of fisheries management that apply the precautionary principle could include bycatch reduction devices, closures, marine protected areas, licensing, gear restrictions, protected species, size limits, bag limits). • The Australian Fisheries Management Authority (AFMA) provides information on the authority's role in e-monitoring and enforcement. • **SHE:** Scientific knowledge can be used to design action for sustainability. Examine how enforcement logistics, identification of multiple uses of an area (e.g. fishing, recreation and tourism), Aboriginal peoples' and Torres Strait Islander peoples' usage rights, and area size required for biodiversity contribution are used to identify and classify a chosen marine reserve area.
Aquaculture • recognise why the current state of aquaculture in the world cannot address food security • analyse Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) fisheries reports to determine changes in fisheries practices over the past 10 years, including − economic contribution of aquaculture relative to wild catch − the top five aquaculture species in Australia by volume and value • identify attributes (e.g. resilience, fast growth rate, low-feed conversion ratio) of an aquaculture species detailing its life cycle, adaptations, requirements and marketability that would make a species desirable to farm • predict the maximum carrying capacity of an aquaculture system based on the size of ponds or tanks, the requirement of a species, and farming technique • contrast different aquaculture systems (e.g. open, closed or recirculating, intensive and extensive) • understand issues with output pollution, biosecurity and waste removal and production of feed for aquaculture.	• **Notional time:** 9 hours • The term *blue revolution* is used in literature in reference to the potential for aquaculture to address food security. • Examples of aquaculture fisheries could include − bluefin tuna (*Thunnus maccoyii*) − salmon (*Oncorhynchus* spp.) − barramundi (*Lates calcarifer*) − freshwater fish including eels (*Anguilla* spp.) − abalone (*Haliotidae*) − oysters (mainly *Crassostreas gigas, Saccostrea glomerata*) − prawns (*Penaeus* spp., *Fenneropenaeus merguiensis*) − yabbies (*Cherax destructor*) − redclaw crayfish (*Cherax quadricarinatus*) − silver perch (*Bidyanus bidyanus*) or Murray cod (*Maccullochella peelii peelii*). • **Suggested practical:** Investigate factors that affect the growth rate of an aquaculture species. • Factors that affect growth rates could include − biotic (crowding, territorial or dominant behaviour, stress, waste production, metabolic rate), − abiotic (dissolved oxygen, nitrites, ammonia, temperature, pH)

Subject matter	Guidance
	– systemic (volume, exchange rates, dead spots). • **Formula:** The formula for food conversion rate is shown as: $FCR = \frac{mass\ of\ feed\ fed}{increase\ in\ mass\ of\ organisms}$ • Issues with pollution and feed production could include bacterial growth and infection in handlers and natural ecosystems, high nitrate wastes, disposal of effluent, production of fish food in South America or bottom trawling for prawn farm feed in South-East Asia. • Biosecurity issues could include escape of non-endemic or genetically modified species into surrounding ecosystems, potential of disease released from intensive practices and in fish-based foods. • **SHE:** Examine the scientific evidence for intensive aquaculture farming practice impacts (e.g. water quality) that can be used to inform the monitoring, assessment and evaluation of risk for local fisheries and tourism.
Science as a Human Endeavour (SHE) • SHE subject matter will not be assessed on the external examination but could be used in the development of claims and research questions for the research investigation.	• Some scientists predict that regional increases in primary production, due to increased global carbon dioxide concentrations, may be offset by large predicted losses in productivity around the polar regions due to ice cap contraction. • As a model, maximum sustainable yield (MSY) has been one of the most influential concepts to inform fish stock management. It has been criticised as a fisheries management tool as it ignores the size and age of the animal being harvested, its reproductive status and the effects of fishing on the ecosystem more broadly. • Aquaculture productivity is seen as essential to achieving food security. However, it has implications for health, sustainable economic development, environmental protection and trade. It can lead to a focus on farming high yield species, which may in itself lead to a decrease in the genetic diversity of global food species.

5.5 Assessment

5.5.1 Summative internal assessment 3 (IA3): Research investigation (20%)

Description

This assessment requires students to evaluate a claim. They will do this by researching, analysing and interpreting secondary evidence from scientific texts to form the basis for a justified conclusion about the claim. A research investigation uses research practices to assess a range of cognitions in a particular context. Research practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

2. apply understanding of oceans of the future or managing fisheries to develop research questions
3. analyse research evidence about oceans of the future or managing fisheries
4. interpret research evidence about oceans of the future or managing fisheries
5. investigate phenomena associated with oceans of the future or managing fisheries through research
6. evaluate research processes, claims and conclusions about oceans of the future or managing fisheries
7. communicate understandings and research findings, arguments and conclusions about oceans of the future or managing fisheries.

Note: Objective 1 is not assessed in this instrument.

Specifications

Description

In the research investigation, students gather secondary evidence related to a research question in order to evaluate the claim. The students develop their research question based on a number of possible claims provided by their teacher. Students work individually throughout this task.

Evidence must be obtained by researching scientifically credible sources, such as scientific journals, books by well-credentialed scientists and websites of governments, universities, independent research bodies or science and technology manufacturers.

In order to complete the assessment task, students must:

- select a claim to be evaluated
- identify the relevant scientific concepts associated with the claim
- pose a research question addressing an aspect of the claim
- conduct research to gather scientific evidence that may be used to address the research question and subsequently evaluate the claim

- analyse the data to identify sufficient and relevant evidence
- identify the trends, patterns or relationships in the evidence
- analyse the evidence to identify limitations
- interpret the evidence to construct justified scientific arguments
- interpret the evidence to form a justified conclusion to the research question
- discuss the quality of the evidence
- evaluate the claim by extrapolating the findings of the research question to the claim
- suggest improvements and extensions to the investigation
- communicate findings in an appropriate scientific genre (e.g. report, journal article, essay, conference presentation).

Scientific inquiry is a non-linear, iterative process. Students will not necessarily complete these steps in the stated order; some steps may be repeated or revisited.

Conditions

- Time: 10 hours class time. This time will not necessarily be sequential. Students must perform the majority of the task during class time, including
  - performing background research
  - developing the research question
  - collecting scientific evidence
  - analysing and interpreting evidence and evaluating the claim
  - preparing and presenting the response (e.g. writing the scientific essay).
- Length:
  - written (e.g. scientific essay), 1500–2000 words

  or

  - multimodal presentation (e.g. scientific conference presentation), 9–11 minutes.
- Other:
  - students are to work individually throughout this task
  - the response must be presented using an appropriate scientific genre (e.g. report, journal article, essay, conference presentation) and contain
    - a claim
    - a research question
    - a rationale for the investigation
    - justified scientific arguments using evidence
    - a conclusion to the research question based on the interpretation of the evidence
    - evaluation of the claim and suggestions of improvements and extensions to the investigation
    - a reference list.

Summary of the instrument-specific marking guide

The following table summarises the criteria, assessment objectives and mark allocation for the research investigation.

Criterion	Objectives	Marks
Research and planning	2, 5	6
Analysis and interpretation	3, 4	6
Conclusion and evaluation	4, 6	6
Communication	7	2
Total		**20**

Note: Unit objective 1 is not assessed in this instrument.

Instrument-specific marking guide

Criterion: Research and planning

Assessment objectives

2. apply understanding of oceans of the future or managing fisheries to develop research questions
5. investigate phenomena associated with oceans of the future or managing fisheries through research

The student work has the following characteristics:	Marks
• informed application of understanding of oceans of the future or managing fisheries demonstrated by a considered rationale identifying clear development of the research question from the claim • effective and efficient investigation of phenomena associated with oceans of the future or managing fisheries demonstrated by – a specific and relevant research question – selection of sufficient and relevant sources.	5–6
• adequate application of understanding of oceans of the future or managing fisheries demonstrated by a reasonable rationale that links the research question and the claim • effective investigation of phenomena associated with oceans of the future or managing fisheries demonstrated by – a relevant research question – selection of relevant sources.	3–4
• rudimentary application of understanding of oceans of the future or managing fisheries demonstrated by a vague or irrelevant rationale for the investigation • ineffective investigation of phenomena associated with oceans of the future or managing fisheries demonstrated by – an inappropriate research question – selection of insufficient and irrelevant sources.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Analysis and interpretation

Assessment objectives

3. analyse research evidence about oceans of the future or managing fisheries
4. interpret research evidence about oceans of the future or managing fisheries

The student work has the following characteristics:	Marks
• systematic and effective analysis of qualitative data and/or quantitative data within the sources about oceans of the future or managing fisheries demonstrated by – the identification of sufficient and relevant evidence – thorough identification of relevant trends, patterns or relationships – thorough and appropriate identification of limitations of evidence • insightful interpretation of research evidence about oceans of the future or managing fisheries demonstrated by justified scientific argument/s.	5–6
• effective analysis of qualitative data and/or quantitative data within the sources about oceans of the future or managing fisheries demonstrated by – the identification of relevant evidence – identification of obvious trends, patterns or relationships – basic identification of limitations of evidence • adequate interpretation of research evidence about oceans of the future or managing fisheries demonstrated by reasonable scientific argument/s.	3–4
• rudimentary analysis of qualitative data and/or quantitative data within the sources about oceans of the future or managing fisheries demonstrated by – the identification of insufficient and irrelevant evidence – identification of incorrect or irrelevant trends, patterns or relationships – incorrect or insufficient identification of limitations of evidence • invalid interpretation of research evidence about oceans of the future or managing fisheries demonstrated by inappropriate or irrelevant argument/s.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Conclusion and evaluation

Assessment objectives

4. interpret research evidence about oceans of the future or managing fisheries
6. evaluate research processes, claims and conclusions about oceans of the future or managing fisheries

The student work has the following characteristics:	Marks
• insightful interpretation of research evidence about oceans of the future or managing fisheries demonstrated by justified conclusion/s linked to the research question • critical evaluation of the research processes, claims and conclusions about oceans of the future or managing fisheries demonstrated by – insightful discussion of the quality of evidence – extrapolation of credible findings of the research to the claim – suggested improvements and extensions to the investigation that are considered and relevant to the claim.	5–6
• adequate interpretation of research evidence about oceans of the future or managing fisheries demonstrated by reasonable conclusion/s relevant to the research question • basic evaluation of the research processes, claims and conclusions about oceans of the future or managing fisheries demonstrated by – reasonable description of the quality of evidence – application of relevant findings of the research to the claim – suggested improvements and extensions to the investigation that are relevant to the claim.	3–4
• invalid interpretation of research evidence about oceans of the future or managing fisheries demonstrated by inappropriate or irrelevant conclusion/s • superficial evaluation of the research processes, claims and conclusions about oceans of the future or managing fisheries demonstrated by – cursory or simplistic statements about the quality of evidence – application of insufficient or inappropriate findings of the research to the claim – ineffective or irrelevant suggestions.	1–2
• does not satisfy any of the descriptors above.	0

Criterion: Communication

Assessment objective

7. communicate understandings and research findings, arguments and conclusions about oceans of the future or managing fisheries

The student work has the following characteristics:	Marks
• effective communication of understandings and research findings, arguments and conclusions about oceans of the future or managing fisheries demonstrated by – fluent and concise use of scientific language and representations – appropriate use of genre conventions – acknowledgment of sources of information through appropriate use of referencing conventions.	2
• adequate communication of understandings and research findings, arguments and conclusions about the oceans of the future or managing fisheries demonstrated by – competent use of scientific language and representations – use of basic genre conventions – use of basic referencing conventions.	1
• does not satisfy any of the descriptors above.	0

5.5.2 Summative external assessment (EA): Examination (50%)

General information

Summative external assessment is developed and marked by the QCAA. In Marine Science, it contributes 50% to a student's overall subject result.

Summative external assessment assesses learning from both Units 3 and 4.

The external assessment in Marine Science is common to all schools and administered under the same conditions, at the same time, on the same day.

Description

The examination assesses the application of a range of cognitions to multiple provided items — questions, scenarios and problems.

Student responses must be completed individually, under supervised conditions and in a set timeframe.

Assessment objectives

This assessment technique is used to determine student achievement in the following objectives:

1. describe and explain the reef and beyond, changes on the reef, oceans of the future and managing fisheries
2. apply understanding of the reef and beyond, changes on the reef, oceans of the future and managing fisheries
3. analyse evidence about the reef and beyond, changes on the reef, oceans of the future and managing fisheries to identify trends, patterns, relationships, limitations or uncertainty
4. interpret evidence about the reef and beyond, changes on the reef, oceans of the future and managing fisheries to draw conclusions based on analysis.

Note: Objectives 5, 6 and 7 are not assessed in this instrument.

Specifications

Description

This examination will include two papers. Each paper consists of a number of different types of possible items:

- multiple choice
- short response items requiring single-word, sentence or paragraph responses
- calculating using algorithms
- interpreting graphs, tables or diagrams
- responding to unseen data and/or stimulus
- extended response (300–350 words or equivalent).

Conditions

Paper 1

- Time: 90 minutes plus 10 minutes perusal.
- Other: QCAA-approved graphics calculator permitted.

Paper 2

- Time: 90 minutes plus 10 minutes perusal.
- Other: QCAA-approved graphics calculator permitted.

Instrument-specific marking guide

No ISMG is provided for the external assessment.

6 Glossary

Term	Explanation
A	
accomplished	highly trained or skilled in a particular activity; perfected in knowledge or training; expert
accuracy	the condition or quality of being true, correct or exact; freedom from error or defect; precision or exactness; correctness; in science, the extent to which a measurement result represents the quantity it purports to measure; an accurate measurement result includes an estimate of the true value and an estimate of the uncertainty
accurate	precise and exact; to the point; consistent with or exactly conforming to a truth, standard, rule, model, convention or known facts; free from error or defect; meticulous; correct in all details
acknowledgment	recognition of the authority or validity of something
adept	very/highly skilled or proficient at something; expert
adequate	satisfactory or acceptable in quality or quantity equal to the requirement or occasion
algebraic representation	a set of symbols linked by mathematical operations; the set of symbols summarises relationships between variables (ACARA 2015c)
algorithm	an effective procedure for solving a particular mathematical problem in a finite number of steps
analyse	dissect to ascertain and examine constituent parts and/or their relationships; break down or examine in order to identify the essential elements, features, components or structure; determine the logic and reasonableness of information; examine or consider something in order to explain and interpret it, for the purpose of finding meaning or relationships and identifying patterns, similarities and differences
analysis	examination of evidence to identify the essential features, components, elements or structure; identification of patterns, similarities and differences
analytical technique	a procedure or method for analysing data
anomaly	something that deviates from what is standard, normal, or expected (Taylor 1982)
anthropogenic	changes in nature caused or influenced by human activity; a value system that encourages sustainable management of resources through taxes, regulations and legislation as a means for solving environmental problems

Term	Explanation
applied learning	the acquisition and application of knowledge, understanding and skills in real-world or lifelike contexts that may encompass workplace, industry and community situations; it emphasises learning through doing and includes both theory and the application of theory, connecting subject knowledge and understanding with the development of practical skills
Applied subject	a subject whose primary pathway is work and vocational education; it emphasises applied learning and community connections; a subject for which a syllabus has been developed by the QCAA with the following characteristics: results from courses developed from Applied syllabuses contribute to the QCE; results may contribute to ATAR calculations
apply	use knowledge and understanding in response to a given situation or circumstance; carry out or use a procedure in a given or particular situation
appraise	evaluate the worth, significance or status of something; judge or consider a text or piece of work
appreciate	recognise or make a judgment about the value or worth of something; understand fully; grasp the full implications of
appropriate	acceptable; suitable or fitting for a particular purpose, circumstance, context, etc.
apt	suitable to the purpose or occasion; fitting, appropriate
area of study	a division of, or a section within a unit
argue	give reasons for or against something; challenge or debate an issue or idea; persuade, prove or try to prove by giving reasons
argument	process of reasoning; series of reasons; a statement or fact tending to support a point
aspect	a particular part of a feature of something; a facet, phase or part of a whole
assess	measure, determine, evaluate, estimate or make a judgment about the value, quality, outcomes, results, size, significance, nature or extent of something
assessment	purposeful and systematic collection of information about students' achievements
assessment instrument	a tool or device used to gather information about student achievement
assessment objectives	drawn from the unit objectives and contextualised for the requirements of the assessment instrument (see also 'syllabus objectives', 'unit objectives')
assessment technique	the method used to gather evidence about student achievement (e.g. examination, project, investigation)
astute	showing an ability to accurately assess situations or people; of keen discernment

Term	Explanation
ATAR	Australian Tertiary Admission Rank
authoritative	able to be trusted as being accurate or true; reliable; commanding and self-confident; likely to be respected and obeyed
B	
balanced	keeping or showing a balance; not biased; fairly judged or presented; taking everything into account in a fair, well-judged way
basic	fundamental
behaviour	in science, the action of any material; the action or activity of an individual
biochemical oxygen demand	a measure of the amount of dissolved oxygen required to decompose the organic material in a given volume of water through aerobic biological activity; used as an index of the degree of organic pollution in water
C	
calculate	determine or find (e.g. a number, answer) by using mathematical processes; obtain a numerical answer showing the relevant stages in the working; ascertain/determine from given facts, figures or information
categorise	place in or assign to a particular class or group; arrange or order by classes or categories; classify, sort out, sort, separate
challenging	difficult but interesting; testing one's abilities; demanding and thought-provoking; usually involving unfamiliar or less familiar elements
characteristic	a typical feature or quality
claim	an assertion made without any accompanying evidence to support it
clarify	make clear or intelligible; explain; make a statement or situation less confused and more comprehensible
clarity	clearness of thought or expression; the quality of being coherent and intelligible; free from obscurity of sense; without ambiguity; explicit; easy to perceive, understand or interpret
classify	arrange, distribute or order in classes or categories according to shared qualities or characteristics
clear	free from confusion, uncertainty, or doubt; easily seen, heard or understood
clearly	in a clear manner; plainly and openly, without ambiguity
coherent	having a natural or due agreement of parts; connected; consistent; logical, orderly; well-structured and makes sense; rational, with parts that are harmonious; having an internally consistent relation of parts
cohesive	characterised by being united, bound together or having integrated meaning; forming a united whole

Term	Explanation
collate	to put together; to compare
collection	in science, a systematic approach to gathering and measuring evidence from a variety of sources in order to evaluate outcomes and make predictions
comment	express an opinion, observation or reaction in speech or writing; give a judgment based on a given statement or result of a calculation
communicate	convey knowledge and/or understandings to others; make known; transmit
compare	display recognition of similarities and differences and recognise the significance of these similarities and differences
competent	having suitable or sufficient skills, knowledge, experience, etc. for some purpose; adequate but not exceptional; capable; suitable or sufficient for the purpose; having the necessary ability, knowledge or skill to do something successfully; efficient and capable (of a person); acceptable and satisfactory, though not outstanding
competently	in an efficient and capable way; in an acceptable and satisfactory, though not outstanding, way
complex	composed or consisting of many different and interconnected parts or factors; compound; composite; characterised by an involved combination of parts; complicated; intricate; a complex whole or system; a complicated assembly of particulars
comprehend	understand the meaning or nature of; grasp mentally
comprehensive	inclusive; of large content or scope; including or dealing with all or nearly all elements or aspects of something; wide-ranging; detailed and thorough, including all that is relevant
concept	in science, an idea or model explaining some natural phenomenon; a theoretical construct; a thought, idea or notion
concise	expressing much in few words; giving a lot of information clearly and in a few words; brief, comprehensive and to the point; succinct, clear, without repetition of information
concisely	in a way that is brief but comprehensive; expressing much in few words; clearly and succinctly
conclusion	a judgment based on evidence (ACARA 2015c)
conduct	direct in action or course; manage; organise; carry out
consider	think deliberately or carefully about something, typically before making a decision; take something into account when making a judgment; view attentively or scrutinise; reflect on
considerable	fairly large or great; thought about deliberately and with a purpose
considered	formed after careful and deliberate thought

Term	Explanation
consistent	agreeing or accordant; compatible; not self-opposed or self-contradictory, constantly adhering to the same principles; acting in the same way over time, especially so as to be fair or accurate; unchanging in nature, standard, or effect over time; not containing any logical contradictions (of an argument); constant in achievement or effect over a period of time
construct	create or put together (e.g. an argument) by arranging ideas or items; display information in a diagrammatic or logical form; make; build
contrast	display recognition of differences by deliberate juxtaposition of contrary elements; show how things are different or opposite; give an account of the differences between two or more items or situations, referring to both or all of them throughout
controlled	shows the exercise of restraint or direction over; held in check; restrained, managed or kept within certain bounds
convincing	persuaded by argument or proof; leaving no margin of doubt; clear; capable of causing someone to believe that something is true or real; persuading or assuring by argument or evidence; appearing worthy of belief; credible or plausible
correct	conforming to fact or truth; accurate
course	a defined amount of learning developed from a subject syllabus
create	bring something into being or existence; produce or evolve from one's own thought or imagination; reorganise or put elements together into a new pattern or structure or to form a coherent or functional whole
creative	resulting from originality of thought or expression; relating to or involving the use of the imagination or original ideas to create something; having good imagination or original ideas
credible	capable or worthy of being believed; believable; convincing
criterion	the property or characteristic by which something is judged or appraised
critical	involving skilful judgment as to truth, merit, etc.; involving the objective analysis and evaluation of an issue in order to form a judgment; expressing or involving an analysis of the merits and faults of a work of literature, music, or art; incorporating a detailed and scholarly analysis and commentary (of a text); rationally appraising for logical consistency and merit
critique	review (e.g. a theory, practice, performance) in a detailed, analytical and critical way
cursory	hasty, and therefore not thorough or detailed; performed with little attention to detail; going rapidly over something, without noticing details; hasty; superficial

Term	Explanation
D	
data	in science, measurements of an attribute or attributes; data may be quantitative or qualitative and be from primary or secondary sources (ACARA 2015c)
dataset	qualitative data and/or quantitative data (e.g. diagram, graph, image, map, photograph, table) derived from a practical, activity or case study
decide	reach a resolution as a result of consideration; make a choice from a number of alternatives
deduce	reach a conclusion that is necessarily true, provided a given set of assumptions is true; arrive at, reach or draw a logical conclusion from reasoning and the information given
defensible	justifiable by argument; capable of being defended in argument
define	give the meaning of a word, phrase, concept or physical quantity; state meaning and identify or describe qualities
demonstrate	prove or make clear by argument, reasoning or evidence, illustrating with practical example; show by example; give a practical exhibition
derive	arrive at by reasoning; manipulate a mathematical relationship to give a new equation or relationship; in mathematics, obtain the derivative of a function
describe	give an account (written or spoken) of a situation, event, pattern or process, or of the characteristics or features of something
design	produce a plan, simulation, model or similar; plan, form or conceive in the mind; in English, select, organise and use particular elements in the process of text construction for particular purposes; these elements may be linguistic (words), visual (images), audio (sounds), gestural (body language), spatial (arrangement on the page or screen) and multimodal (a combination of more than one)
detailed	executed with great attention to the fine points; meticulous; including many of the parts or facts
determine	establish, conclude or ascertain after consideration, observation, investigation or calculation; decide or come to a resolution
develop	elaborate, expand or enlarge in detail; add detail and fullness to; cause to become more complex or intricate
devise	think out; plan; contrive; invent
differentiate	identify the difference/s in or between two or more things; distinguish, discriminate; recognise or ascertain what makes something distinct from similar things; in mathematics, obtain the derivative of a function
diffraction	a property of wave interference whereby the wave changes direction after passing through an opening or around a barrier

Term	Explanation
discerning	discriminating; showing intellectual perception; showing good judgment; making thoughtful and astute choices; selected for value or relevance
discriminate	note, observe or recognise a difference; make or constitute a distinction in or between; differentiate; note or distinguish as different
discriminating	differentiating; distinctive; perceiving differences or distinctions with nicety; possessing discrimination; perceptive and judicious; making judgments about quality; having or showing refined taste or good judgment
discuss	examine by argument; sift the considerations for and against; debate; talk or write about a topic, including a range of arguments, factors or hypotheses; consider, taking into account different issues and ideas, points for and/or against, and supporting opinions or conclusions with evidence
disjointed	disconnected; incoherent; lacking a coherent order/sequence or connection
distinguish	recognise as distinct or different; note points of difference between; discriminate; discern; make clear a difference/s between two or more concepts or items
diverse	of various kinds or forms; different from each other
document	support (e.g. an assertion, claim, statement) with evidence (e.g. decisive information, written references, citations)
draw conclusions	make a judgment based on reasoning and evidence
E	
ecocentric	a value system that integrates social, spiritual and environmental dimensions; places nature as central to humanity; encourages self-restraint in human behaviour as a means for solving environmental problems; prioritises ‘bio rights’, i.e. the rights of endangered species or unique landscapes to remain untouched
ecosystem disturbance	a temporary change in environmental conditions that alters physical structures or arrangements of biotic and abiotic elements within an ecosystem; can also occur over larger temporal scales and affect diversity; can be natural or anthropogenic
ecosystem diversity	the variety per unit area of ecosystems, comprising the variety of habitats, number of ecological niches, trophic levels, ecological processes and the associated communities (per unit area); the largest scale of biodiversity
ecosystem engineer	organism that directly or indirectly control the availability of resources to other species by causing physical state changes in biotic or abiotic material; they modify, maintain and create habitats (Jones, Lawton & Shachak 1994)
ecosystem recovery	the return of a damaged ecological system and associated ecosystem services to a stable state

Term	Explanation
ecosystem resilience	the capacity of an ecosystem to recover from a disturbance or withstand ongoing pressures
effective	successful in producing the intended, desired or expected result; meeting the assigned purpose
efficient	working in a well-organised and competent way; maximum productivity with minimal expenditure of effort; acting or producing effectively with a minimum of waste, expense or unnecessary effort
element	a component or constituent part of a complex whole; a fundamental, essential or irreducible part of a composite entity
elementary	simple or uncompounded; relating to or dealing with elements, rudiments or first principles (of a subject); of the most basic kind; straightforward and uncomplicated
erroneous	based on or containing error; mistaken; incorrect
essential	absolutely necessary; indispensable; of critical importance for achieving something
eutrophication	the natural or artificial enrichment of a body of water, particularly with respect to nitrates and phosphates, that results in depletion of the oxygen content of the water
evaluate	make an appraisal by weighing up or assessing strengths, implications and limitations; make judgments about ideas, works, solutions or methods in relation to selected criteria; examine and determine the merit, value or significance of something, based on criteria
evidence	in science, evidence is data that has been selected as it is considered reliable and valid and can be used to support a particular idea, conclusion or decision; evidence gives weight or value to data by considering its credibility, acceptance, bias, status, appropriateness and reasonableness (ACARA 2015c)
examination	a supervised test that assesses the application of a range of cognitions to one or more provided items such as questions, scenarios and/or problems; student responses are completed individually, under supervised conditions, and in a set timeframe
examine	investigate, inspect or scrutinise; inquire or search into; consider or discuss an argument or concept in a way that uncovers the assumptions and interrelationships of the issue
experiment	try out or test new ideas or methods, especially in order to discover or prove something; undertake or perform a scientific procedure to test a hypothesis, make a discovery or demonstrate a known fact in science, an investigation that involves carrying out a practical activity
experimental	relating to, derived from, or founded on experiment
explain	make an idea or situation plain or clear by describing it in more detail or revealing relevant facts; give an account; provide additional information

Term	Explanation
explicit	clearly and distinctly expressing all that is meant; unequivocal; clearly developed or formulated; leaving nothing merely implied or suggested
explore	look into both closely and broadly; scrutinise; inquire into or discuss something in detail
express	convey, show or communicate (e.g. a thought, opinion, feeling, emotion, idea or viewpoint); in words, art, music or movement, convey or suggest a representation of; depict
extend	in science, to extend an experiment is to modify the methodology to overcome limitations of the scope or applicability of the data
extended response	an open-ended assessment technique that focuses on the interpretation, analysis, examination and/or evaluation of ideas and information in response to a particular situation or stimulus; while students may undertake some research when writing the extended response, it is not the focus of this technique; an extended response occurs over an extended and defined period of time; an item on an examination may also require an extended response, either written or oral
Extension subject	a two-unit subject for which a syllabus has been developed by QCAA; it is an extension of one or more general or alternative sequence subject/s; studied concurrently with the final two units of that subject/s or after completion of, the final two units of that subject/s
extensions	in science, modifications to an investigation that could be used to further examine a claim
extensive	of great extent; wide; broad; far-reaching; comprehensive; lengthy; detailed; large in amount or scale
external assessment	summative assessment that occurs towards the end of a course of study and is common to all schools; developed and marked by the QCAA according to a commonly applied marking scheme
external examination	a supervised test, developed and marked by the QCAA, that assesses the application of a range of cognitions to multiple provided items such as questions, scenarios and/or problems; student responses are completed individually, under supervised conditions, and in a set timeframe
extrapolate	infer or estimate by extending or projecting known information; conjecture; infer from what is known; extend the application of something (e.g. a method or conclusion) to an unknown situation by assuming that existing trends will continue or similar methods will be applicable
extrapolation	extension of a conclusion to a new situation with the assumption that existing trends will continue

Term	Explanation
F	
factual	relating to or based on facts; concerned with what is actually the case; actually occurring; having verified existence
familiar	well-acquainted; thoroughly conversant with; well known from long or close association; often encountered or experienced; common; (of materials, texts, skills or circumstances) having been the focus of learning experiences or previously encountered in prior learning activities
feasible	capable of being achieved, accomplished or put into effect; reasonable enough to be believed or accepted; probable; likely
feature	distinctive attribute, characteristic, property or quality of evidence
fieldwork	research carried out in the field (i.e. beyond the classroom) which includes data collection
findings	in science, the outcomes of research, investigation or experimentation, including facts or principles established in these ways
fluent	spoken or written with ease; able to speak or write smoothly, easily or readily; articulate; eloquent; in artistic performance, characteristic of a highly developed and excellently controlled technique; flowing; polished; flowing smoothly, easily and effortlessly
fluently	in a graceful and seemingly effortless manner; in a way that progresses smoothly and readily
formative assessment	assessment whose major purpose is to improve teaching and student achievement
fragmented	disorganised; broken down; disjointed or isolated
frequent	happening or occurring often at short intervals; constant, habitual, or regular
fundamental	forming a necessary base or core; of central importance; affecting or relating to the essential nature of something; part of a foundation or basis
G	
General subject	a subject for which a syllabus has been developed by the QCAA with the following characteristics: results from courses developed from General syllabuses contribute to the QCE; General subjects have an external assessment component; results may contribute to ATAR calculations
generate	produce; create; bring into existence
genetic diversity	the variety of genetic material present in a gene pool or population of a species
genre conventions	agreed and acceptable conditions; a style or category

Term	Explanation
graphical representation	in science, a visual representation of the relationships between quantities plotted with reference to a set of axes; also known as a graph (ACARA 2015c)
H	
habitat former	any organism that forms a habitat; can be primary, secondary or focal; a least three habitat formers are required to create a habitat cascade
halocline	a cline (layer) caused by a strong, vertical salinity gradient in the ocean or a body of saline water in which the salinity changes significantly with depth (relative to the layers above and below)
hypothesis	in science, a tentative explanation for an observed phenomenon, expressed as a precise and unambiguous statement that can be supported or refuted by experiment (ACARA 2015c)
hypothesise	formulate a supposition to account for known facts or observed occurrences; conjecture, theorise, speculate; especially on uncertain or tentative grounds
I	
identify	distinguish; locate, recognise and name; establish or indicate who or what someone or something is; provide an answer from a number of possibilities; recognise and state a distinguishing factor or feature
illogical	lacking sense or sound reasoning; contrary to or disregardful of the rules of logic; unreasonable
implement	put something into effect, e.g. a plan or proposal
implication	a likely consequence of something; a conclusion that may be drawn though it is implied rather than explicit
implicit	implied, rather than expressly stated; not plainly expressed; capable of being inferred from something else
improbable	not probable; unlikely to be true or to happen; not easy to believe
improvements	in science, modifications to an investigation that mitigate the limitations of the evidence, method or design
inaccurate	not accurate
inadequate	not satisfactory or acceptable in quality and/or quantity to the requirements of the situation
inappropriate	not suitable or proper in the circumstances
inconsistent	lacking agreement, as one thing with another, or two or more things in relation to each other; at variance; not consistent; not in keeping; not in accordance; incompatible, incongruous
incorrect	not conforming to fact or truth
independent	thinking or acting for oneself, not influenced by others

Term	Explanation
in-depth	comprehensive and with thorough coverage; extensive or profound; well-balanced or fully developed
ineffective	not producing a result, or not producing any significant result; not producing the intended, desired or expected result
infer	derive or conclude something from evidence and reasoning, rather than from explicit statements; listen or read beyond what has been literally expressed; imply or hint at
informed	knowledgeable; learned; having relevant knowledge; being conversant with the topic; based on an understanding of the facts of the situation (of a decision or judgment)
innovative	new and original; introducing new ideas; original and creative in thinking
insightful	showing understanding of a situation or process; understanding relationships in complex situations; informed by observation and deduction
instrument-specific marking guide	ISMG; a tool for marking that describes the characteristics evident in student responses and aligns with the identified objectives for the assessment (see 'assessment objectives')
insufficient	not enough; inadequate for purpose
integral	*adjective* necessary for the completeness of the whole; essential or fundamental; *noun* in mathematics, the result of integration; an expression from which a given function, equation, or system of equations is derived by differentiation
intended	designed; meant; done on purpose; intentional
internal assessment	assessments that are developed by schools; summative internal assessments are endorsed by the QCAA before use in schools and results externally confirmed; contributes towards a student's final result
interpret	use knowledge and understanding to recognise trends and draw conclusions from given information; make clear or explicit; elucidate or understand in a particular way; bring out the meaning of, e.g. a dramatic or musical work, by performance or execution; bring out the meaning of an artwork by artistic representation or performance; give one's own interpretation of; identify or draw meaning from, or give meaning to, information presented in various forms, such as words, symbols, pictures or graphs
invalid	not sound, just or well-founded; not having a sound basis in logic or fact (or an argument or point); not reasonable or cogent; not able to be supported; not legitimate or defensible; not applicable

Term	Explanation
investigate	carry out an examination or formal inquiry in order to establish or obtain facts and reach new conclusions; search, inquire into, interpret and draw conclusions about data and information
investigation	an assessment technique that requires students to research a specific problem, question, issue, design challenge or hypothesis through the collection, analysis and synthesis of primary and/or secondary data; it uses research or investigative practices to assess a range of cognitions in a particular context; an investigation occurs over an extended and defined period of time in science, a scientific process of answering a question, exploring an idea or solving a problem that requires activities such as planning a course of action, collecting data, interpreting data, reaching a conclusion and communicating these activities (ACARA 2015c)
irrelevant	not relevant; not applicable or pertinent; not connected with or relevant to something
ISMG	instrument-specific marking guide; a tool for marking that describes the characteristics evident in student responses and aligns with the identified objectives for the assessment (see 'assessment objectives')
isolated	detached, separate, or unconnected with other things; one-off; something set apart or characterised as different in some way
J	
judge	form an opinion or conclusion about; apply both procedural and deliberative operations to make a determination
justified	sound reasons or evidence are provided to support an argument, statement or conclusion
justify	give reasons or evidence to support an answer, response or conclusion; show or prove how an argument, statement or conclusion is right or reasonable
L	
learning area	a grouping of subjects, with related characteristics, within a broad field of learning, e.g. the Arts, sciences, languages
limitation	a weak point or disadvantage that makes evidence less effective
link	anything serving to connect one part or thing with another
logical	rational and valid; internally consistent; reasonable; reasoning in accordance with the principles/rules of logic or formal argument; characterised by or capable of clear, sound reasoning; (of an action, decision, etc.) expected or sensible under the circumstances
logically	according to the rules of logic or formal argument; in a way that shows clear, sound reasoning; in a way that is expected or sensible
longshore drift	a geological sediment transport process along a coastline parallel to the shore

Term	Explanation
M	
make decisions	select from available options; weigh up positives and negatives of each option and consider all the alternatives to arrive at a position
management	handling, direction or control
manipulate	adapt or change to suit one's purpose
mental procedures	a domain of knowledge in Marzano's taxonomy, and acted upon by the cognitive, metacognitive and self-systems; sometimes referred to as 'procedural knowledge' there are three distinct phases to the acquisition of mental procedures — the cognitive stage, the associative stage, and the autonomous stage; the two categories of mental procedures are skills (single rules, algorithms and tactics) and processes (macroprocedures)
methodical	performed, disposed or acting in a systematic way; orderly; characterised by method or order; performed or carried out systematically
methodology	a systematic, ordered approach to gathering data in a scientific experiment or investigation
minimal	least possible; small, the least amount; negligible
model	in science, a representation that describes, simplifies, clarifies or provides an explanation of the workings, structure or relationships within an object, system or idea (ACARA 2015c)
modifications	in science, changes to methodology to extend, refine or redirect the research focus
modify	change the form or qualities of; make partial or minor changes to something
multimodal	uses a combination of at least two modes (e.g. spoken, written), delivered at the same time, to communicate ideas and information to a live or virtual audience, for a particular purpose; the selected modes are integrated so that each mode contributes significantly to the response
N	
narrow	limited in range or scope; lacking breadth of view; limited in amount; barely sufficient or adequate; restricted
nuanced	showing a subtle difference or distinction in expression, meaning, response, etc.; finely differentiated; characterised by subtle shades of meaning or expression; a subtle distinction, variation or quality; sensibility to, awareness of, or ability to express delicate shadings, as of meaning, feeling, or value

Term	Explanation
O	
objectives	see ‘syllabus objectives’, ‘unit objectives’, ‘assessment objectives’
obvious	clearly perceptible or evident; easily seen, recognised or understood
ocean acidification	global decrease of ocean pH caused by the absorption of carbon dioxide by seawater
optimal	best, most favourable, under a particular set of circumstances
organise	arrange, order; form as or into a whole consisting of interdependent or coordinated parts, especially for harmonious or united action
organised	systematically ordered and arranged; having a formal organisational structure to arrange, coordinate and carry out activities
outcome	results of something; a consequence
outlier	a value that ‘lies outside’ (is much smaller or larger than) most of the other values in a set of data
outstanding	exceptionally good; clearly noticeable; prominent; conspicuous; striking
P	
partial	not total or general; existing only in part; attempted, but incomplete
particular	distinguished or different from others or from the ordinary; noteworthy
pattern	a repeated occurrence or sequence (ACARA 2015c)
perceptive	having or showing insight and the ability to perceive or understand; discerning (see also ‘discriminating’)
performance	an assessment technique that requires students to demonstrate a range of cognitive, technical, creative and/or expressive skills and to apply theoretical and conceptual understandings, through the psychomotor domain; it involves student application of identified skills when responding to a task that involves solving a problem, providing a solution or conveying meaning or intent; performance is developed over an extended and defined period of time
persuasive	capable of changing someone’s ideas, opinions or beliefs; appearing worthy of approval or acceptance; (of an argument or statement) communicating reasonably or credibly (see also ‘convincing’)
perusal time	time allocated in an assessment to reading items and tasks and associated assessment materials; no writing is allowed; students may not make notes and may not commence responding to the assessment in the response space/book
phenomena	events that are not artificial and can be observed through the senses or can be scientifically described or explained

Term	Explanation
planning time	time allocated in an assessment to planning how to respond to items and tasks and associated assessment materials; students may make notes but may not commence responding to the assessment in the response space/book; notes made during planning are not collected, nor are they graded or used as evidence of achievement
polished	flawless or excellent; performed with skilful ease
practical	in science, an activity that produces primary data
precise	definite or exact; definitely or strictly stated, defined or fixed; characterised by definite or exact expression or execution
precision	accuracy; exactness; exact observance of forms in conduct or actions in science, exactness; how close two or more measurements of the same object or phenomena are to each other
predict	give an expected result of an upcoming action or event; suggest what may happen based on available information
primary data	data collected directly by a person or group (ACARA 2015c)
process	in science, to collect and manipulate data to produce meaningful information; operate on a set of data to extract the required information in an appropriate form such as tables or graphs
product	an assessment technique that focuses on the output or result of a process requiring the application of a range of cognitive, physical, technical, creative and/or expressive skills, and theoretical and conceptual understandings; a product is developed over an extended and defined period of time
proficient	well advanced or expert in any art, science or subject; competent, skilled or adept in doing or using something
project	an assessment technique that focuses on a problem-solving process requiring the application of a range of cognitive, technical and creative skills and theoretical understandings; the response is a coherent work that documents the iterative process undertaken to develop a solution and includes written paragraphs and annotations, diagrams, sketches, drawings, photographs, video, spoken presentations, physical prototypes and/or models; a project is developed over an extended and defined period of time
propose	put forward (e.g. a point of view, idea, argument, suggestion) for consideration or action
prove	use a sequence of steps to obtain the required result in a formal way
psychomotor procedures	a domain of knowledge in Marzano's taxonomy, and acted upon by the cognitive, metacognitive and self-systems; these are physical procedures used to negotiate daily life and to engage in complex physical activities; the two categories of psychomotor procedures are skills (foundational procedures and simple combination procedures) and processes (complex combination procedures)

Term	Explanation
purposeful	having an intended or desired result; having a useful purpose; determined; resolute; full of meaning; significant; intentional
pycnocline	a cline (layer) with the greatest density gradient in the ocean or a body of water
Q	
QCE	Queensland Certificate of Education
qualitative data	information that is not numerical in nature
quality of evidence	the standard of evidence, as measured against relevant criteria
quantitative data	numerical information (Taylor 1982)
quantity	in science, having magnitude, size, extent, amount or the like
R	
rationale	in science, a set of reasons, or logical basis for a course of action or decision
raw data	unprocessed and/or unanalysed data; data that has been collected without any additional processing (Taylor 1982)
realise	create or make (e.g. a musical, artistic or dramatic work); actualise; make real or concrete; give reality or substance to
reasonable	endowed with reason; having sound judgment; fair and sensible; based on good sense; average; appropriate, moderate
reasoned	logical and sound; based on logic or good sense; logically thought out and presented with justification; guided by reason; well-grounded; considered
recall	remember; present remembered ideas, facts or experiences; bring something back into thought, attention or into one's mind
recognise	identify or recall particular features of information from knowledge; identify that an item, characteristic or quality exists; perceive as existing or true; be aware of or acknowledge
redirect	in science, to redirect an experiment is to modify the methodology to gain further insight into the phenomena observed in the original experiment
referencing conventions	agreed, consistent ways of referencing a source of information
refine	in science, to refine an experiment is to modify the methodology to obtain more accurate or precise data
refined	developed or improved so as to be precise, exact or subtle
reflection	a property of wave interference whereby the wave changes direction after bouncing off a barrier
refraction	a property of wave interference whereby the wave changes direction after passing from one medium to another (i.e. deep to shallow water)

Term	Explanation
reflect on	think about deeply and carefully
rehearsed	practised; previously experienced; practised extensively
related	associated with or linked to
relationship	scientific relationships are a connection or association between ideas or between components of systems and structures (ACARA 2015c)
relevance	being related to the matter at hand
relevant	bearing upon or connected with the matter in hand; to the purpose; applicable and pertinent; having a direct bearing on
reliable	constant and dependable or consistent and repeatable
reliability	in science, the likelihood that another experimenter will obtain the same results (or very similar results) if they perform exactly the same experiment under the same conditions (ACARA 2015c, Taylor 1982)
repetitive	containing or characterised by repetition, especially when unnecessary or tiresome
reporting	providing information that succinctly describes student performance at different junctures throughout a course of study
representation	in science, verbal, physical or mathematical demonstrations of understanding of a science concept or concepts; a concept can be represented in a range of ways and using multiple models (ACARA 2015c)
research	to locate, gather, record and analyse information in order to develop understanding (ACARA 2015c)
research ethics	norms of conduct that determine ethical research behaviour; research ethics are governed by principles such as honesty, objectivity, integrity, openness, and respect for intellectual property and include consideration of animal ethics (ACARA 2015c)
research question	a question that directs the scientific inquiry activity; it focuses the research investigation or student experiment, informing the direction of the research, and guiding all stages of inquiry, analysis, interpretation and evaluation
resolve	in the Arts, consolidate and communicate intent through a synthesis of ideas and application of media to express meaning
risk assessment	evaluations performed to identify, assess and control hazards in a systematic way that is consistent, relevant and applicable to all school activities; requirements for risk assessments related to particular activities will be determined by jurisdictions, schools or teachers as appropriate (ACARA 2015c)
routine	often encountered, previously experienced; commonplace; customary and regular; well-practised; performed as part of a regular procedure, rather than for a special reason

Term	Explanation
rudimentary	relating to rudiments or first principles; elementary; undeveloped; involving or limited to basic principles; relating to an immature, undeveloped or basic form
rugosity	a measure of reef structural complexity (surface roughness) that is used as an indicator of habitat availability for coral colonisation
S	
safe	secure; not risky
sand budget	the volume of sand entering, leaving or contained within a system; a coastal assessment technique used to analyse the movement of sand in a study area (littoral cell)
scientific language	terminology that has specific meaning in a scientific context
scrutinise	to examine closely or critically
secure	sure; certain; able to be counted on; self-confident; poised; dependable; confident; assured; not liable to fail
secondary data	data collected by a person or group other than the person or group using the data (ACARA 2015c)
select	choose in preference to another or others; pick out
sensitive	capable of perceiving with a sense or senses; aware of the attitudes, feelings or circumstances of others; having acute mental or emotional sensibility; relating to or connected with the senses or sensation
sequence	place in a continuous or connected series; arrange in a particular order
show	provide the relevant reasoning to support a response
significant	important; of consequence; expressing a meaning; indicative; includes all that is important; sufficiently great or important to be worthy of attention; noteworthy; having a particular meaning; indicative of something
simple	easy to understand, deal with and use; not complex or complicated; plain; not elaborate or artificial; may concern a single or basic aspect; involving few elements, components or steps
simplistic	characterised by extreme simplification, especially if misleading; oversimplified
simulation	a representation of a process, event or system which imitates a real or idealised situation (ACARA 2015c)
sketch	execute a drawing or painting in simple form, giving essential features but not necessarily with detail or accuracy; in mathematics, represent by means of a diagram or graph; the sketch should give a general idea of the required shape or relationship and should include features

Term	Explanation
skilful	having technical facility or practical ability; possessing, showing, involving or requiring skill; expert, dexterous; demonstrating the knowledge, ability or training to perform a certain activity or task well; trained, practised or experienced
skilled	having or showing the knowledge, ability or training to perform a certain activity or task well; having skill; trained or experienced; showing, involving or requiring skill
solve	find an answer to, explanation for, or means of dealing with (e.g. a problem); work out the answer or solution to (e.g. a mathematical problem); obtain the answer/s using algebraic, numerical and/or graphical methods
sophisticated	of intellectual complexity; reflecting a high degree of skill, intelligence, etc.; employing advanced or refined methods or concepts; highly developed or complicated
source	any piece of scientific literature or text from which scientific evidence is drawn
species diversity	the variety of species per unit area (e.g. habitat or a region) that includes both the number of species present and their relative abundance
specific	clearly defined or identified; precise and clear in making statements or issuing instructions; having a special application or reference; explicit, or definite; peculiar or proper to something, as qualities, characteristics, effects, etc.
sporadic	happening now and again or at intervals; irregular or occasional; appearing in scattered or isolated instances
statement	a communication or declaration setting forth facts, particulars; an expression
straightforward	without difficulty; uncomplicated; direct; easy to do or understand
structure	*verb* give a pattern, organisation or arrangement to; construct or arrange according to a plan; *noun* in languages, arrangement of words into larger units, e.g. phrases, clauses, sentences, paragraphs and whole texts, in line with cultural, intercultural and textual conventions
structured	organised or arranged so as to produce a desired result
subject	a branch or area of knowledge or learning defined by a syllabus; school subjects are usually based in a discipline or field of study (see also ‘course’)
subject matter	the subject-specific body of information, mental procedures and psychomotor procedures that are necessary for students’ learning and engagement within that subject

Term	Explanation
substantial	of ample or considerable amount, quantity, size, etc.; of real worth or value; firmly or solidly established; of real significance; reliable; important, worthwhile
substantiated	established by proof or competent evidence
subtle	fine or delicate in meaning or intent; making use of indirect methods; not straightforward or obvious
successful	achieving or having achieved success; accomplishing a desired aim or result
succinct	expressed in few words; concise; terse; characterised by conciseness or brevity; brief and clear
sufficient	enough or adequate for the purpose
suitable	appropriate; fitting; conforming or agreeing in nature, condition, or action
summarise	give a brief statement of a general theme or major point/s; present ideas and information in fewer words and in sequence
summative assessment	assessment whose major purpose is to indicate student achievement; summative assessments contribute towards a student's subject result
superficial	concerned with or comprehending only what is on the surface or obvious; shallow; not profound, thorough, deep or complete; existing or occurring at or on the surface; cursory; lacking depth of character or understanding; apparent and sometimes trivial
supported	corroborated; given greater credibility by providing evidence
sustainability	in science, the quality of not being harmful to the environment or depleting natural resources, and therefore supporting long-term ecological balance
sustainable management practice	application and monitoring of practices and/or policies that are informed by the concept of sustainability
sustained	carried on continuously, without interruption, or without any diminishing of intensity or extent
syllabus	a document that prescribes the curriculum for a course of study
syllabus objectives	outline what the school is required to teach and what students have the opportunity to learn; described in terms of actions that operate on the subject matter; the overarching objectives for a course of study (see also 'unit objectives', 'assessment objectives')
symbolise	represent or identify by a symbol or symbols
synthesise	combine different parts or elements (e.g. information, ideas, components) into a whole, in order to create new understanding
system	a group of interacting objects, materials or processes that form an integrated whole; systems can be open or closed (ACARA 2015c)

Term	Explanation
systematic	done or acting according to a fixed plan or system; methodical; organised and logical; having, showing, or involving a system, method, or plan; characterised by system or method; methodical; arranged in, or comprising an ordered system
T	
technocentric	a value system that encourages the use of technological developments as a means for solving environmental problems
test	take measures to check the quality, performance or reliability of something
theory	in science, a set of concepts, claims and/or laws that can be used to explain and predict a wide range of related observed or observable phenomena; theories are typically founded on clearly identified assumptions, are testable, produce reproducible results and have explanatory power (ACARA 2015c)
thermocline	a cline (layer) caused by a strong thermal gradient of rapid temperature change in the ocean or a body of water; separates the mixed layer and the deep ocean
thorough	carried out through, or applied to the whole of something; carried out completely and carefully; including all that is required; complete with attention to every detail; not superficial or partial; performed or written with care and completeness; taking pains to do something carefully and completely
thoughtful	occupied with, or given to thought; contemplative; meditative; reflective; characterised by or manifesting thought
topic	a division of, or sub-section within a unit; all topics/sub-topics within a unit are interrelated
trend	general direction in which something is changing (ACARA 2015c)
U	
uncertainty	range of values for a measurement result, taking account of the likely values that could be attributed to the measurement result given the measurement equipment, procedure and environment (ACARA 2015c); indicators of uncertainty may include percentage, and/or absolute measurement uncertainty, confidence intervals, inferential statistics, statistical measure of spread, e.g. range, standard deviation
unclear	not clear or distinct; not easy to understand; obscure
understand	perceive what is meant by something; grasp; be familiar with (e.g. an idea); construct meaning from messages, including oral, written and graphic communication
understanding	perception of what is meant by something
uneven	unequal; not properly corresponding or agreeing; irregular; varying; not uniform; not equally balanced

Term	Explanation
unfamiliar	not previously encountered; situations or materials that have not been the focus of prior learning experiences or activities
unit	a defined amount of subject matter delivered in a specific context or with a particular focus; it includes unit objectives particular to the unit, subject matter and assessment direction
unit objectives	drawn from the syllabus objectives and contextualised for the subject matter and requirements of a particular unit; they are assessed at least once in the unit (see also ‘syllabus objectives’, ‘assessment objectives’)
unrelated	having no relationship; unconnected
use	operate or put into effect; apply knowledge or rules to put theory into practice
V	
vague	not definite in statement or meaning; not explicit or precise; not definitely fixed, determined or known; of uncertain, indefinite or unclear character or meaning; not clear in thought or understanding; couched in general or indefinite terms; not definitely or precisely expressed; deficient in details or particulars; thinking or communicating in an unfocused or imprecise way
valid	sound, just or well-founded; authoritative; having a sound basis in logic or fact (of an argument or point); reasonable or cogent; able to be supported; legitimate and defensible; applicable
validity	in science, the extent to which tests measure what was intended; the extent to which data, inferences and actions produced from tests and other processes are accurate (ACARA 2015c)
variable	*adjective* apt or liable to vary or change; changeable; inconsistent; (readily) susceptible or capable of variation; fluctuating, uncertain; *noun* in mathematics, a symbol, or the quantity it signifies, that may represent any one of a given set of number and other objects in science, a factor that can be changed, kept the same or measured in an investigation, e.g. time, distance, light, temperature
variety	a number or range of things of different kinds, or the same general class, that are distinct in character or quality; (of sources) a number of different modes or references
visual representation	in science, an image that shows relationships within scientific evidence

Term	Explanation
W	
wide	of great range or scope; embracing a great number or variety of subjects, cases, etc.; of full extent
with expression	in words, art, music or movement, conveying or indicating feeling, spirit, character, etc.; a way of expressing or representing something; vivid, effective or persuasive communication

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8 Version history

Version	Date of change	Update
1.1	December 2017	Editorial changes
		Syllabus objective 2: Amendment to explanatory paragraph
		IA1: Data test • Minor amendments to Assessment objectives 2,3 & 4 • Percentage of marks modified – objective 3 — 40% changed to 30% – objective 4 — 30% changed to 40% • Condition amendment (Length) — 400 words changed to 'up to 500 words'
		IA2: Student experiment • Minor amendment to Assessment objective 5
		IA3: Research investigation • Minor amendment to Assessment objective 5
		Amendments to ISMGs to reflect modifications to objectives
		Glossary update
1.2	June 2018	Editorial changes
		Minor amendment to subject matter in Unit 3
		IA1: Data test • Minor amendments to Assessment objective 2 • Minor amendments to description and conditions • Addition of information about cognition and nature of response for each objective
		IA2: Student experiment • Minor editorial changes to ISMG
		IA3: Research investigation • Minor editorial changes to ISMG
		EA: Examination • Minor amendments to Assessment objectives 3 and 4 • Minor amendments to description and conditions
		Glossary update
1.3	July 2022	Amendments to Unit 1 and Unit 2 Assessment guidance

ISBN: 978-1-74378-038-1

Marine Science General Senior Syllabus 2019

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