Marine Science 2025 v1.0

General senior syllabus

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Queensland syllabuses for senior subjects

In Queensland, a syllabus for a senior subject is an official 'map' of a senior school subject. A syllabus's function is to support schools in delivering the Queensland Certificate of Education (QCE) system through high-quality and high-equity curriculum and assessment.

Syllabuses are based on design principles developed from independent international research about how excellence and equity are promoted in the documents teachers use to develop and enliven the curriculum.

Syllabuses for senior subjects build on student learning in the Prep to Year 10 Australian Curriculum and include General, General (Extension), Senior External Examination (SEE), Applied, Applied (Essential) and Short Course syllabuses.

More information about syllabuses for senior subjects is available at www.qcaa.qld.edu.au/senior/senior-subjects and in the 'Queensland curriculum' section of the *QCE and QCIA policy and procedures handbook*.

Teaching, learning and assessment resources will support the implementation of a syllabus for a senior subject. More information about professional resources for senior syllabuses is available on the QCAA website and via the QCAA Portal.

Course overview

Rationale

At the core of all scientific 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.

Syllabus objectives

The syllabus objectives outline what students have the opportunity to learn.

1. **Describe ideas and findings.**

   Students use scientific representations and language in appropriate genres to give a detailed account of scientific phenomena, concepts, theories, models and systems.

2. **Apply understanding.**

   Students use scientific concepts, theories, models and systems within their limitations. They use algebraic, visual and graphical representations of scientific relationships and data to determine unknown scientific quantities or features. They explain phenomena, concepts, theories, models, systems and modifications to methodologies.

3. **Analyse data.**

   Students consider scientific information from primary and secondary sources to identify trends, patterns, relationships, limitations and uncertainty. In qualitative data, they identify the essential elements, features or components. In quantitative data, they use mathematical processes and algorithms. They identify data to support ideas, conclusions or decisions.

4. **Interpret evidence.**

   Students use their understanding of scientific concepts, theories, models and systems and their limitations to draw conclusions and develop scientific arguments. They compare, deduce, extrapolate, infer, justify and make predictions based on their analysis of data.

5. **Evaluate conclusions, claims and processes.**

   Students critically reflect on the available evidence and make judgments about its application to research questions. They extrapolate findings to support or refute claims. They use the quality of the evidence to evaluate the validity and reliability of inquiry processes and suggest improvements and extensions for further investigation.

6. **Investigate phenomena.**

   Students develop rationales and research questions for experiments and investigations. They modify methodologies to collect primary data and select secondary sources. They manage risks, environmental and ethical issues and acknowledge sources of information.

Designing a course of study in Marine Science

Syllabuses are designed for teachers to make professional decisions to tailor curriculum and assessment design and delivery to suit their school context and the goals, aspirations and abilities of their students within the parameters of Queensland's senior phase of learning.

The syllabus is used by teachers to develop curriculum for their school context. The term *course of study* describes the unique curriculum and assessment that students engage with in each school context. A course of study is the product of a series of decisions made by a school to select, organise and contextualise subject matter, integrate complementary and important learning, and create assessment tasks in accordance with syllabus specifications.

It is encouraged that, where possible, a course of study is designed such that teaching, learning and assessment activities are integrated and enlivened in an authentic setting.

Course structure

Marine Science is a General senior syllabus. It contains four QCAA-developed units from which schools develop their course of study.

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

Students should complete Unit 1 and Unit 2 before beginning Units 3 and 4. Units 3 and 4 are studied as a pair.

More information about the requirements for administering senior syllabuses is available in the 'Queensland curriculum' section of the *QCE and QCIA policy and procedures handbook*.

Curriculum

Senior syllabuses set out only what is essential while being flexible so teachers can make curriculum decisions to suit their students, school context, resources and expertise.

Within the requirements set out in this syllabus and the *QCE and QCIA policy and procedures handbook*, schools have autonomy to decide:

- how and when subject matter is delivered
- how, when and why learning experiences are developed, and the context in which learning occurs
- how opportunities are provided in the course of study for explicit and integrated teaching and learning of complementary skills.

These decisions allow teachers to develop a course of study that is rich, engaging and relevant for their students.

Assessment

Senior syllabuses set out only what is essential while being flexible so teachers can make assessment decisions to suit their students, school context, resources and expertise.

General senior syllabuses contain assessment specifications and conditions for the assessment instruments that must be implemented with Units 3 and 4. These specifications and conditions ensure comparability, equity and validity in assessment.

Within the requirements set out in this syllabus and the *QCE and QCIA policy and procedures handbook*, schools have autonomy to decide:

- specific assessment task details
- assessment contexts to suit available resources
- how the assessment task will be integrated with teaching and learning activities
- how authentic the task will be.

In Unit 1 and Unit 2, schools:

- develop at least two but no more than four assessments
- complete at least one assessment for each unit
- ensure that each unit objective is assessed at least once.

In Units 3 and 4, schools develop three assessments using the assessment specifications and conditions provided in the syllabus.

More information about assessment in senior syllabuses is available in 'The assessment system' section of the *QCE and QCIA policy and procedures handbook*.

Subject matter

Each unit contains a unit description, unit objectives and 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 the subject. Subject matter itself is not the specification of learning experiences but provides the basis for the design of student learning experiences.

Subject matter has a direct relationship with the unit objectives and provides statements of learning that have been constructed in a similar way to objectives.

Aboriginal perspectives and Torres Strait Islander perspectives

The QCAA is committed to reconciliation. 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.

Complementary skills

Opportunities for the development of complementary skills have been embedded throughout subject matter. These skills, which overlap and interact with syllabus subject matter, 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.

These complementary skills are:

- literacy — the knowledge, skills, behaviours and dispositions about language and texts essential for understanding and conveying English language 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 skills include critical thinking, creative thinking, communication, collaboration and teamwork, personal and social skills, and digital literacy. The explanations of associated skills are available at www.qcaa.qld.edu.au/senior/senior-subjects/general-subjects/21st-century-skills.

It is expected that aspects of literacy, numeracy and 21st century skills will be developed by engaging in the learning outlined in this syllabus. Teachers may choose to create additional explicit and intentional opportunities for the development of these skills as they design the course of study.

Additional subject-specific information

Additional subject-specific information has been included to support and inform the development of a course of study.

Science understanding

The science understanding subject matter in each unit develops students' understanding of the key concepts, models and theories that underpin the subject, and of the strengths and limitations of different models and theories for explaining and predicting complex phenomena. It uses cognitions from Objectives 1–4.

The science understanding subject matter from Units 3 and 4 will be assessed by the external assessment.

Science as a human endeavour (SHE)

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 is not directly 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 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 and/or 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 subject matter in each unit. This highlights opportunities for teachers to contextualise the associated science understanding and science inquiry subject matter and provides stimulus for the development of claims and research questions for investigation.

Additional opportunities include:

- practicals provide opportunities 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
- the research investigation 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.

Science inquiry

Defining *inquiry* in science education

In order to support the school's task of aligning their chosen pedagogical framework with the curriculum and assessment expectations outlined in this syllabus, some guidance has been provided in the form of clarification of the use of the term *inquiry* and the articulation of 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** [emphasis added].

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.

Framework to describe the inquiry process

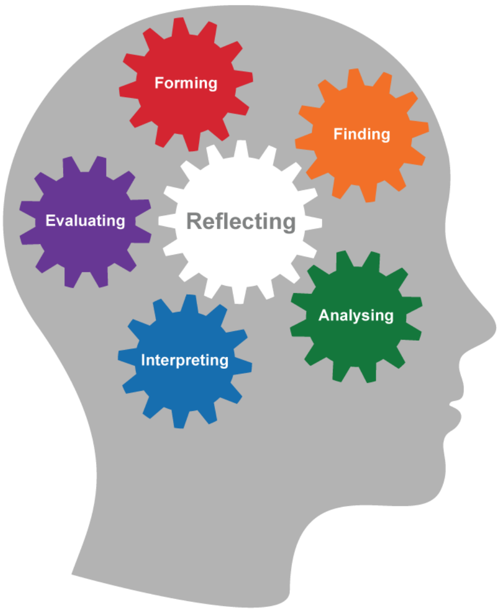
In order to support student engagement in activities involving inquiry, it is useful to establish a common language or framework to distinguish between stages of the process.

The stages involved in any inquiry are:

- forming and describing the inquiry activity
- finding valid and reliable evidence for the inquiry activity
- analysing the evidence collected
- 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 1: Stages of inquiry process



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 scientific inquiry (Tytler 2007). This expectation can be seen, for example, by the inclusion of practicals and investigations in the subject matter, and in the internal assessments for Units 3 and 4.

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 explicitly taught science inquiry skills (Krajcik et al 2000), a number of which are outlined throughout the syllabus. Some science inquiry skills will be used to complete the listed practicals and investigations. The selection, application and coordination of science inquiry skills will be required in the student experiment and research investigation.

It is the prerogative of the educator to determine how listed practicals and investigations 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.

Science inquiry skills

Throughout the course of study, students will:

- identify, research and construct questions for investigation
- propose hypotheses and/or predict possible outcomes
- design investigations, including the procedure/s to be followed, the materials required, and the type and amount of primary and/or secondary data required to obtain valid and reliable evidence, e.g.
  - distinguish between different types of investigations: descriptive, comparative, correlational, experimental, case studies
  - consider replicates, sample size, number of data points and quality of sources
  - identify the types of errors, extraneous variables or confounding factors that are likely to influence results and implement strategies to minimise systematic and random error
- identify and implement strategies to manage risks, ethics and environmental impact, e.g.
  - ethical guidelines
  - cultural guidelines, protocols for working with the knowledges of First Nations peoples
  - material safety data sheets
  - workplace health and safety guidelines
  - appropriate disposal methods
  - standard operating procedures
  - acknowledgment of sources and referencing

- use appropriate equipment, techniques, procedures and sources to systematically and safely collect primary and secondary data, e.g.
  - sampling methods: random, systematic, stratified
  - sampling techniques: quadrats, line transect, belt-transect, capture-recapture
  - laboratory and field techniques: measurement, equipment calibration, species identification
  - microscopy techniques: total magnification and field of view, scientific drawing
  - models and simulations
  - ICTs, scientific texts, databases, online sources
- use scientific language and representations to systematically record information, observations, data and measurement error, e.g.
  - symbols, units and prefixes
  - scale and magnification
  - indicators of measurement uncertainty
  - tables, graphs and diagrams
  - charts and maps
  - logbooks
- translate information between graphical, numerical and/or algebraic forms, e.g.
  - units and measurement conversions
  - ratios and percentages
  - symbols and notation
  - charts and maps
- use mathematical techniques to summarise data in a way that allows for identification of relevant trends, patterns, relationships, limitations and uncertainty, e.g.
  - comparative investigations: mean, standard deviation, standard error, Student's t-test
  - correlational investigations: regression analysis, Pearson's correlation coefficient, Spearman's rank
- select and construct appropriate representations to present data and communicate findings, e.g.
  - summary tables
  - column graphs (with error bars)
  - scatterplots (with trendline and R^2)
  - profile diagrams
  - scientific drawings
  - charts and maps
  - indexes and summary statistics
- analyse data to identify trends, patterns and relationships; recognising error, uncertainty and limitations of evidence
- select, synthesise and use evidence to construct scientific arguments and draw conclusions

- extrapolate findings to determine unknown values, predict outcomes and evaluate claims
- use data and reasoning to discuss and evaluate the validity and reliability of evidence, e.g.
  - discuss ways in which measurement error, instrumental uncertainty, the nature of the procedure, sample size or other factors influence uncertainty and limitations in the data
  - evaluate information sources and compare ideas, information and opinions presented within and between texts, considering aspects such as acceptance, bias, status, appropriateness and reasonableness
  - compare findings to theoretical models or expected values
- suggest improvements and extensions to minimise uncertainty, address limitations and improve the overall quality of evidence
- communicate to specific audiences and for specific purposes using appropriate language, nomenclature, genres and modes
- acknowledge sources of information and use standard scientific referencing conventions.
- appreciate the role of peer review in scientific research.

Science inquiry subject matter uses cognitions from across all objectives, and is primarily assessed through the internal assessments for Units 3 and 4. To support the development of these science inquiry skills, this syllabus identifies suggested practicals and investigations for each unit. These highlight opportunities for students to directly experience the associated Science understanding subject matter and provide stimulus for student experiments and research investigations.

It is expected that approximately five hours of fieldwork will be required to develop the associated science inquiry skills. Fieldwork can allow students to engage in science inquiry by offering authentic real-world learning. It offers students an opportunity to gather primary data to analyse and respond to questions they pose.

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* (https://ppr.qed.qld.gov.au) 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 National Health and Medical Research Council's publications website.

It should also be recognised that school personnel and students are not carrying out essential, ground-breaking 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, the *3Rs* principle of animal welfare should be applied (i.e. 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 have for choosing not to participate.

Strategies for retaining and recalling information for assessment

The following practices[1] can support preparation for senior assessment in Marine Science.

The spacing effect

The spacing effect draws on research about forgetting and learning curves. By recalling and revisiting information at intervals, rather than at the end of a study cycle, students remember a greater percentage of the information with a higher level of accuracy. Exposing students to information and materials numerous times over multiple spaced intervals solidifies long-term memory, positively affecting retention and recall.

Teachers should plan teaching and learning sequences that allow time to revisit previously taught information and skills at several intervals. These repeated learning opportunities also provide opportunities for teachers to provide formative feedback to students.

The retrieval effect

The retrieval effect helps students to practise remembering through quick, regular, low-stakes questioning or quizzes that exercise their memories and develop their ability to engage in the deliberate act of recalling information. This has been shown to be more effective at developing long-term memories than activities that require students to search through notes or other resources.

Students may see an inability to remember as an obstacle, but they should be encouraged to understand that this is an opportunity for learning to take place. By trying to recall information, students exercise or strengthen their memory and may also identify gaps in their learning. The more difficult the retrieval practice, the better it can be for long-term learning.

Interleaving

Interleaving involves interspersing the concepts, categories, skills or types of questions that students focus on in class or revision. This is in contrast to blocking, in which these elements are grouped together in a block of time. For example, for concepts A, B and C:

- Blocking A A A A A B B B B B C C C C C
- Interleaving A B C B C A B A C A C B C A B

Studies have found that interleaving in instruction or revision produces better long-term recall of subject matter. Interleaving also ensures that spacing occurs, as instances of practice are spread out over time.

Additionally, because exposure to one concept is interleaved with exposure to another, students have more opportunities to distinguish between related concepts. This highlighting of differences may explain why studies have found that interleaving enhances inductive learning, where participants use exemplars to develop an understanding of broader concepts or categories. Spacing without interleaving does not appear to benefit this type of learning.

Interleaving can seem counterintuitive — even in studies where interleaving enhanced learning, participants often felt that they had learnt more with blocked study. Despite this, their performance in testing indicated greater learning through the interleaving approach.

[1] Based on Agarwal, Roediger, McDaniel & McDermott (2020); Birnbaum, Kornell, Ligon Bjork & Bjork (2013); Carpenter & Agarwal (2020); Chen, Paas & Sweller (2021); Ebbinghaus (1885); Rohrer (2012); Taylor & Rohrer (2010).

Reporting

General information about determining and reporting results for senior syllabuses is provided in the 'Determining and reporting results' section of the *QCE and QCIA policy and procedures handbook*.

Reporting standards

Reporting standards are summary statements that describe typical performance at each of the five levels (A–E).

A
The student accurately describes 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 communicates effectively by using scientific representations and language accurately and concisely within appropriate genres. They efficiently collect, collate and process relevant evidence. 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 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 critically evaluates conclusions, claims and processes by insightfully scrutinising evidence, extrapolating credible findings, and discussing the reliability and validity of experiments. They investigate phenomena by carrying out effective experiments and research investigations.

B
The student accurately describes 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 communicates accurately by using scientific representations and language within appropriate genres to present information. They collect, collate and process relevant evidence. 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 effectively by 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 evaluate processes, claims and conclusions by scrutinising evidence, applying relevant findings and discussing the reliability and validity of experiments. They investigate phenomena by carrying out effective experiments and research investigations.

C
The student describes 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 communicates using scientific representations and language within appropriate genres to present information. They collect, collate and process evidence. 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 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 evaluates processes, claims and conclusions by describing the quality of evidence, applying findings, and describing the reliability and validity of experiments. They investigate phenomena by carrying out experiments and research investigations.
D
The student describes and gives accounts of aspects of concepts, theories, models and systems. The student uses scientific representations or language to present information. They use rudimentary representations of scientific relationships or data to determine unknown scientific quantities or variables. The student analyses 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 considers the quality of evidence and conclusions and discusses processes, claims or conclusions. They carry out aspects of experiments and research investigations.
E
The student describes scenarios and communicates by referring 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.

Determining and reporting results

Unit 1 and Unit 2

Schools make judgments on individual assessment instruments using a method determined by the school. They may use the reporting standards or develop an instrument-specific marking guide (ISMG). Marks are not required for determining a unit result for reporting to the QCAA.

The unit assessment program comprises the assessment instrument/s designed by the school to allow the students to demonstrate the unit objectives. The unit judgment of A–E is made using reporting standards.

Schools report student results for Unit 1 and Unit 2 to the QCAA as satisfactory (S) or unsatisfactory (U). Where appropriate, schools may also report a not rated (NR).

Units 3 and 4

Schools mark each of the three internal assessment instruments implemented in Units 3 and 4 using ISMGs.

Schools report a provisional mark by criterion to the QCAA for each internal assessment.

Once confirmed by the QCAA, these results will be combined with the result of the external assessment developed and marked by the QCAA.

The QCAA uses these results to determine each student’s subject result as a mark out of 100 and as an A–E.

Units

Unit 1: Oceanography

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.

Unit objectives

1. Describe ideas and findings about an ocean planet and the dynamic shore.
2. Apply understanding of an ocean planet and the dynamic shore.
3. Analyse data about an ocean planet and the dynamic shore.
4. Interpret evidence about an ocean planet and the dynamic shore.
5. Evaluate processes, claims and conclusions about an ocean planet and the dynamic shore.
6. Investigate phenomena associated with an ocean planet and the dynamic shore.

Subject matter

Topic 1: An ocean planet (13 hours)

Science understanding

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.

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.
- Describe the concept of ocean layers, including thermocline, halocline and pycnocline.
- Describe how thermoclines and nutrients produce the oxygen minimum zone within the open ocean.
- Explain how thermohaline circulation in the deep ocean is affected by salinity and water density.

Science as a human endeavour (SHE)

- Appreciate that 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.
- 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’.
- Understand that contemporary weather predictions are based on computer models but still 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.

- Appreciate that 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.
- Appreciate that knowledge of the oceans is limited and requires further investigation.
- Recognise that decisions relating to resource management are affected by the economic development of a nation and the value placed on marine environment.

Science inquiry

- Investigate convection.
- Investigate thermoclines (e.g. using ice and water, and hot and cold coloured water); salinity (e.g. using student-made straw hydrometers); stratification (e.g. using salt and fresh water).

Topic 2: The dynamic shore (32 hours)

Science understanding

Coastlines

- Describe how 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.
- Explain how gravitational pull, current strength and wave action cause tidal movement.
- Describe the concepts of sand budget and longshore drift.
- Contrast refraction, reflection and diffraction.
- Describe how wave action, wind and longshore drift influence the movement of water, nutrients, sand, sediment and pollutants, e.g. oil spills, debris.
- Compare accretion and erosion in the processes of coastal erosion.
- Explain how weather patterns and climate (e.g. temperature, wind speed and direction, rainfall, breezes, barometric pressure) are driven by atmosphere/ocean interactions.
- Describe the processes of wave formation, 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.

Coastal impacts

- Explain how coastal engineering regulates water or sediment flow, affects currents and impacts the coastline, including marine ecosystems.
- Analyse evidence from longitudinal studies showing changes that occur in marine environments, e.g. satellite imagery, aerial photography, field research.
- Identify how organisms populate areas following changes in habitats, e.g. succession.
- Identify types of pollution of coastal zones, including organic wastes, thermal, toxic compounds, heavy metals, oil, nutrients and pesticides.

Coastal conservation and monitoring impacts

- Describe the concept of sustainable management practices.
- Compare 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).
- Describe how biochemical oxygen demand (BOD) is used to indirectly assess water pollution levels.
- Explain the process of eutrophication.
- Describe land management practices that contribute to the health of marine ecosystems, including siltation, algal blooms and agricultural practices.
- Explain an indirect method of measuring pollution levels using a biotic index.
- Describe the concept of marine bio-indicators with an example, e.g. mussels (*Mytilus galloprovincialis*), mudskippers (*Scartelaos histophorus*), seagrass (*Zostera* spp.) and changes in concentration of pigments in certain corals.
- Interpret data from biotic and abiotic tests on a water sample to determine water quality.

Science as a human endeavour (SHE)

- Consider how historical local planning decisions on dynamic shorelines have influenced the selection of coastal management strategies.
- Recognise that impact levels from pulse events alter as populations increase and landscape dynamics change. This leads to increased pressure on infrastructure designed to mitigate risk.
- Appreciate that 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.
- Recognise that 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.
- Discuss that the education of stakeholders is essential to encouraging sustainable management practices.
- Consider that the use of data can inform the selection of coastal management strategies that may have beneficial, and/or harmful and/or unintended consequences.

Science inquiry

- Investigate water quality by conducting biotic and abiotic tests on a water sample.
- Investigate wave properties using a wave tank.
- Investigate sandy coastlines using beach profiles, dune transects and sand sifts.
- Interpret population density data of coastal areas to identify the impact on the health of coastal water.
- Interpret evidence used to inform the monitoring, assessment and evaluation of risk in relation to pulse events, i.e. cyclone, storm surge, tsunami and floods.
- 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.

Unit 2: Marine biology

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.

Unit objectives

1. Describe ideas and findings about marine ecology and biodiversity, and marine environmental management.
2. Apply understanding of marine ecology and biodiversity, and marine environmental management.
3. Analyse data about marine ecology and biodiversity, and marine environmental management.
4. Interpret evidence about marine ecology and biodiversity, and marine environmental management.
5. Evaluate processes, claims and conclusions about marine ecology and biodiversity, and marine environmental management.
6. Investigate phenomena associated with marine ecology and biodiversity, and marine environmental management.

Subject matter

Topic 1: Marine ecology and biodiversity (29 hours)

Science understanding

Biodiversity

- Describe the three main types of diversity, i.e. genetic, species and ecosystem.
- Explain 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, e.g. estuaries, mangroves, seagrass beds.
- 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), $SDI = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$

  where N = total number of organisms of all species and n = number of organisms of one species.
- Interpret data to determine the biodiversity of a marine ecosystem using diversity indices.
- Describe the concepts of ecosystem resilience, disturbance and recovery.

Biotic components of marine ecosystems

- Identify biotic components of marine ecosystems, i.e. trophic levels, food chains, food webs, interactions and population dynamics.
- Classify biotic interactions based on the following terms
  - *symbiosis* (i.e. parasitism, mutualism, commensalism and amensalism)
  - *competition* (i.e. intraspecific and interspecific)
  - *predation*.
- Identify and describe marine species, using field guides and identification keys.
- Identify 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, and the process of bioaccumulation (e.g. ciguatera and mackerel (*Scomberomorus* spp.); mercury and blacktip sharks (*Carcharhinus* spp.); and toxin accumulation on microplastics.
- Describe the concept of population dynamics using the terms *population size*, *density*, *abundance*, *distribution* (i.e. clumped, uniform, random), *carrying capacity*, *niche*, *K-strategists* and *r-strategists*, *keystone species*.

- Interpret population data to determine population size, density, abundance, distribution, carrying capacity.
- Calculate the rate of change of a population using $R = (B + I) - (D + E)$

  where *R* = the rate of change of a population, *B* = birth rate, *D* = death rate, *I* = immigration and *E* = emigration.

Abiotic components of the marine ecosystem

- Describe abiotic components of marine ecosystems: light availability, depth, stratification, temperature, currents (water and wind), tides, sediment type and nutrient availability.
- Explain how marine ecosystems are influenced and limited by abiotic factors differently than terrestrial ecosystems due to the different physical and chemical properties of water, e.g. light availability, buoyancy, pressure, temperature, viscosity, sound, salinity and sediment loading.
- Explain the concepts of limiting factors and tolerance limits and their importance in population distributions.
- Interpret data to identify an organism's tolerance limit, e.g. of intertidal organisms or mangrove zonation.
- Explain the concept of zonation using the following terms: *intertidal*, *pelagic* (neritic, oceanic), *benthic* and *abyss*.
- Interpret field data from a local ecosystem.

Adaptation

- Classify different groups of animals using structural characteristics.
- 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.

Science as a human endeavour (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.
- Discuss how scientists use the evidence from the monitoring and assessment of an ecosystem to inform scientific knowledge about ecosystem resilience and population recovery.
- Evaluate the role of biosecurity measures in preventing or responding to incursions of invasive marine species in Australian ports.

Science inquiry

- Investigate a local ecosystem to determine factors of population dynamics (e.g. density or distribution) and assess abiotic components, including
  - estimating populations, e.g. survey count, quadrats, species density, percentage coverage, indirect or direct observation, catch and release
  - using field guides to identify to a genus level
  - using a range of field equipment to measure biotic factors related to marine environments
  - conducting in-field mapping of food webs via gut analysis to determine food sources
  - identifying physical structures of a specific marine organism (this could be virtual, practical or as a demonstration).
- Assess the limitations of a chosen field technique, e.g. quadrat, transect.

Topic 2: Marine environmental management (16 hours)

Science understanding

Marine conservation

- Classify the arguments for preserving species and habitats as ecological, economic, social, aesthetic or 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.
- Identify issues affecting selected marine ecosystem, including erosion, eutrophication, overharvesting, runoff, sedimentation, urbanisation.
- Apply the terms *ecosystem resilience*, *disturbance* and *recovery* as indicators of 'health' of marine environments to a chosen case study.

Resources and sustainable use

- Explain the precautionary principle of the marine environmental planning and management process, and the requirements that marine protected area networks are comprehensive, adequate and representative.
- Describe criteria 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.
- Interpret data related to the marine environmental planning and management process.

Science as a human endeavour (SHE)

- Evaluate the success of a regional zoning plans or plan management, based on the social, economic and cultural context on which it was considered.
- Assess the use of remote sensing radar imagery, satellite tracking in real time and remotely piloted aircraft systems (RPAS) (i.e. drones) to enable scientists to measure and monitor populations in large or inaccessible ecosystems such as dugongs.
- Appreciate that 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.
- Recognise that in areas where marine management decisions reflect scientific, social, cultural and ethical considerations, Aboriginal knowledges and practices and Torres Strait Islander knowledges and practices related to sea country are often used to complement conservation practices.

Unit 3: Marine systems — connections and change

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.

Unit objectives

1. Describe ideas and findings about the reef and beyond, and changes on the reef.
2. Apply understanding of the reef and beyond, and changes on the reef.
3. Analyse data about the reef and beyond, and changes on the reef.
4. Interpret evidence about the reef and beyond, and changes on the reef.
5. Evaluate processes, claims and conclusions about the reef and beyond, and changes on the reef.
6. Investigate phenomena associated with the reef and beyond, and changes on the reef.

Subject matter

Topic 1: The reef and beyond (27 hours)

Science understanding

The following subject matter can be assessed in the external assessment.

Coral reef distribution

- Identify the distribution of coral reefs globally and in Australia.
- Describe the distribution patterns of reefs, including changes moving down latitudinal gradients and across, from inshore to outer shelf reefs.
- Explain how abiotic factors 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.
- State that corals first appeared within the geological record over 250 million years ago but not in Australian waters until approximately 500 000 years ago.
- Describe how 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.
- Describe the different types of reef structure, e.g. fringing, platform, ribbon, atolls, coral cays.
- Describe the zonation within a reef cross-section, e.g. reef slope, reef crest/rim, lagoon/back reef.

Coral reef development

- Discriminate between 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.
- Describe the anatomy of a typical reef-forming hard coral, including skeleton, corallite, coelenteron, coral polyp, tentacles, nematocyst, mouth and zooxanthellae.
- Describe how the limestone skeleton of coral is built (i.e. when calcium ions [Ca^{2+}] combine with carbonate ions [CO_3^{2-}]) and is influenced by a variety of factors, e.g. concentration of ions, temperature, light and pH.
- 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.
- Describe the life cycle stages of a typical reef-forming hard coral, i.e. asexual: fragmentation, polyp detachment; sexual: gametes, zygotes, planulae, polyp/asexual budding.
- Explain the process of larval dispersal, site selection, settlement and recruitment of coral species and describe how factors (e.g. currents, bathymetry, substrate, sediment, predation, competition) affect this process.
- Explain that growth of reefs is dependent on accretion processes being greater than destructive processes.
- Analyse abiotic factors (e.g. dissolved oxygen, salinity, substrate) that affect the distribution of coral reefs.

Reef, habitats and connectivity

- Explain that corals are habitat formers and ecosystem engineers.
- Explain that the habitat complexity (including species diversity, rugosity and percentage coral cover) established by corals influences the diversity of other species.
- Explain connectivity between ecosystems (including reef, estuaries, seagrass meadows and mangroves) and the role this plays in species replenishment.
- Describe how fish life cycles are integrated within a variety of habitats including reef and estuarine systems.
- Describe how fish, particularly herbivore populations, benefit coral reefs.
- Explain the concept of an ecological tipping point and how this applies to coral reef ecosystems.
- Describe hysteresis and how this applies to the concept of reef resilience.
- Interpret primary and secondary reef diversity data including abundance, species richness, Simpsons diversity Index, evenness and rank abundance, e.g. Whittaker plot.
- Interpret regional and temporal trends in coral cover.
- Identify the relationship between water quality and some of the factors that affect coral cover, e.g. crown-of-thorns.
- Discuss how the processes in this sub-topic interact to have an overall net effect, i.e. they do not occur in isolation.
- Interpret data relating to the impact of water quality on reef health.

Science as a human endeavour (SHE)

The following subject matter may be assessed in the internal assessments.

- Investigate how complex models of marine ecosystems can be developed based on a wide range of evidence from multiple individuals and across disciplines.
- 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.
- Consider Aboriginal perspectives and Torres Strait Islander perspectives on rising sea levels. Sea level change in the Holocene resulted in an increase of approximately 125 metres in depth.

Science inquiry

The following subject matter may be assessed in the internal assessments.

- Investigate the impact of water quality on reef health to infer connectivity within or between habitats. Consider the impacts qualitatively and quantitatively, using online, virtual or field data.
- Examine coral to determine genus (photo, online or field).
- Explore and classify plankton using field work techniques such as collection/trawls.
- Investigate zooxanthellae (e.g. with flotsam jellyfish or aquarium coral) using a microscope.
- Examine coral diversity using a transect technique (using online or field data).
- Assess the diversity of a reef system, e.g. using line intercept transects, quadrats, fish counts using underwater video survey techniques, benthic surveys, invertebrate counts and rugosity measurements.

Topic 2: Changes on the reef (18 hours)

Science understanding

The following subject matter can be assessed in the external assessment.

Anthropogenic change

- Interpret data from models to determine potential reef futures under various scenarios.
- Describe the global anthropogenic factors affecting the distribution of coral (i.e. coral mining, organic and non-organic pollution, 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.
- Explain how coral cores provide a historical record of coral growth rates and environmental conditions.
- Explain the concept of coral bleaching in terms of Shelford’s law of tolerance.
- Interpret degree heating weeks, sea surface temperature and thermal threshold data for reefs in the northern, central and southern sections of the Great Barrier Reef to predict the likelihood of a bleaching event.
- Discuss the ecological effects of a bleaching event on other reef organisms, e.g. fish.
- Describe the conditions necessary for recovery from bleaching events.
- Compare the responses to bleaching events between two regions, 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.

Ocean equilibria

- Explain that the reason for differences between ocean pH and freshwater is the presence of carbonate buffering system.
- Explain that the carbonate system is linked to geological processes and operates on geological timescales.
- Interpret data to determine how increases in atmospheric carbon dioxide influences both global temperature and ocean pH.
- Describe sources of carbon dioxide in the atmosphere.
- Describe the effect of ocean acidification on sea water, including that
  - carbon dioxide (CO_2) is absorbed from the atmosphere and bonds with sea water, forming carbonic acid (H_2CO_3)
  - the acid releases a bicarbonate ion (HCO_3^{-}) and a hydrogen ion (H^{+})
  - the hydrogen ion bonds with free carbonate ions (CO_3^{2-}) in the water, forming another bicarbonate ion
  - the more dissolved carbon dioxide in the ocean, the fewer free carbonate ions are available to marine organisms for making calcium carbonate shells and skeletons.
- Explain how the carbonate compensation depth (CCD) varies due to depth, location and oceanographic processes such as upwelling and coastal influences.
- Determine the effect of temperature (uptake) and changes in primary productivity (storage, e.g. biological pump) on the ocean's capacity to absorb carbon dioxide.

Implications for marine systems

- State that calcium carbonate ($CaCO_3$) can be precipitated into two main forms: calcite and aragonite.
- Determine whether aragonite will precipitate, using the equation: $\Omega = \frac{[Ca^{2+}]\times[CO_3^{2-}]}{K_{sp}}$

  where Ω = precipitation of aragonite and K_{sp} = solubility product
- Explain 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.
- Discuss how resilience of coral reefs is improved by minimising other impacts including coastal run-off (nitrogen inputs), and habitat destruction and fishing.
- Interpret data relating to the effects of altered ocean pH on marine carbonate structures.

Science as a human endeavour (SHE)

The following subject matter may be assessed in the internal assessments.

- Appreciate that international collaboration is often required when addressing global issues.
- Recognise the ecological consequences of climate change for reefs with reference to each of the four RCPs (2.6–8.5) identified in the IPCC's 2014 *Fifth Assessment Report*.
- 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.
- Recognise that the majority of scientists accept that anthropogenic atmospheric changes are linked to global temperature increases.
- Appreciate that scientists agree that global predictions on climate change are accurate; however, at a regional scale, due to localised conditions, predictions are less reliable.
- Understand that 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.

Science inquiry

The following subject matter may be assessed in the internal assessments.

- Evaluate the ecological effects of bleaching on other reef organisms (e.g. fish) using a case study.
- Investigate the effects an altered ocean pH has on marine carbonate structures.
- Investigate how increasing the concentration of dissolved CO_2 lowers the pH of a solution.
- Investigate how changes in temperature and salinity affect the solubility of CO_2 in aqueous saline solutions.
- Investigate the effect of CO_2 on planktonic organisms.

Unit 4: Ocean issues and resource management

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.

Unit objectives

1. Describe ideas and findings about oceans of the future and managing fisheries.
2. Apply understanding of oceans of the future and managing fisheries.
3. Analyse data about oceans of the future and managing fisheries.
4. Interpret evidence about oceans of the future and managing fisheries.
5. Evaluate processes, claims and conclusions about oceans of the future and managing fisheries.
6. Investigate phenomena associated with oceans of the future and managing fisheries.

Subject matter

Topic 1: Oceans of the future (13 hours)

Science understanding

The following subject matter can be assessed in the external assessment.

Management and conservation

- Apply the arguments for preserving species and habitats to a given case study by identifying their associated direct and indirect values, including
  - ecological, e.g. source of genetic diversity
  - economic, e.g. ecotourism, recreation, yield
  - ethical, e.g. bio rights and stewardship
  - aesthetic, e.g. source of beauty, spiritual connection.
- 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.
- Interpret data to determine the success of a 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.

Future scenarios

- Interpret datasets about atmospheric conditions to predict future scenarios for a given marine system.
- Compare historical geological evidence (e.g. of coral cores) with changes in land use practices and global carbon dioxide and temperature levels.
- Explain the indirect consequences that ocean acidification has on the ocean and its uses, including
  - changes in food webs
  - lowering of coral bleaching temperature thresholds
  - habitat destruction
  - coastal protection
  - effects on fisheries, medicine, tourism and recreation.
- Identify the interactions between the atmosphere and the oceans that drive weather patterns and climate, e.g. temperature, wind speed and direction, rainfall, breezes and barometric pressure.
- Explain the impact of average temperature increases on the marine environment, including
  - altering thermal regimes
  - changing physical and chemical parameters of the ocean, e.g. aragonite saturation levels and rising sea levels.

Science as a human endeavour (SHE)

The following subject matter may be assessed in the internal assessments.

- 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.
- 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.
- Consider the evidence that enables scientists to predict that when thermoclines and upwellings are disrupted to shut down the 'global ocean conveyor' and the effect of this on global ocean productivity.

Science inquiry

The following subject matter may be assessed in the internal assessments.

- Evaluate the success of a named protected marine area.

Topic 2: Managing fisheries (32 hours)

Science understanding

The following subject matter can be assessed in the external assessment.

Fisheries and population dynamics

- Discriminate between the three main types of fishery (i.e. artisanal, recreational and commercial) and describe the variety of meanings of the term *fishery*.
- Explain the global significance of wild caught fish as a source of protein.
- Describe causes for the decline in world fisheries, including overfishing, destructive fishing practices, industrial fishing, illegal fishing, fishing down the food chain, pollution, climate change, habitat destruction and shifting baselines.
- Explain how the distributions of fish populations are determined by temperature, primary productivity and nutrient dispersal, and how these factors are influenced by currents, upwelling and seasonal factors.
- Analyse rugosity data and link this to fish diversity.
- Determine the impact of bioaccumulation and biomagnification through the food web into edible seafood, e.g. ciguatera, heavy metals and microplastics.
- 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 (e.g. Atlantic cod (*Gadus morhua*), Pacific bluefin tuna (*Thunnus orientalis*)) with a case study of a fish population that is in recovery (e.g. coral trout (*Plectropomus leopardus*)) in relation to fisheries management practices.
- Calculate fish population size using the BIDE model of population dynamics.
- Apply the Lincoln index to a capture-recapture scenario, using $N = \frac{M \times n}{m}$

  where M = number of individuals caught, marked and released initially, n = number of individuals caught on second sampling and m = number of individuals recaptured that were marked

- Describe how factors (including sampling techniques, fish behaviour, temporal and spatial movement, life history) affect the reliability of fisheries population data and how this informs fisheries management decision-making on quota and total allowable catch.
- Identify an international agreement that is used to manage migratory pelagic species.
- Compare the use of maximum sustainable yields and maximum economic yields.
- Contrast ecosystem-based fisheries management and traditional single species maximum sustainable yield.
- Explain the benefits of marine protected areas to fisheries, e.g. spill-over effect, fisheries replenishment, bycatch reduction, insurance.
- Justify the use of estuarine and open-water marine protected areas for fishery sustainability.

Australia's fisheries management

- Identify the Australian Fishing Zone (AFZ).
- Explain 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.
- Discuss the factors that lead to a higher proportion of the seafood consumed in Australia being imported.
- Identify the economic value of Australian Fisheries.
- 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, e.g. southern bluefin tuna (*Thunnus maccoyii*).
- Describe the use of the precautionary principle as applied to ecosystem management, e.g. through by-catch reduction devices, closures, marine protected areas, licensing, gear restrictions, protected species, size limits, bag limits.

Aquaculture

- Explain the importance of aquaculture in addressing global food security.
- Interpret evidence from 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.
- Describe attributes (e.g. resilience, growth rate, feed conversion ratio) of an aquaculture species detailing its life cycle, adaptations, requirements and marketability that would make a species desirable to farm.
- Predict how the size of ponds or tanks, the requirement of a species and farming technique influence the maximum carrying capacity of an aquaculture system.

- Contrast different aquaculture systems, e.g. open, closed or recirculating, intensive and extensive.
- Identify and explain issues associated with aquaculture production, including output pollution, biosecurity, waste removal and feed production.

Science as a human endeavour (SHE)

The following subject matter may be assessed in the internal assessments.

- Consider Aboriginal peoples' and Torres Strait Islander peoples' voluntary management of traditional use activities on sea country, e.g. Traditional Use of Marine Resources Agreements — TUMRA.
- Examine the issue of overfishing, which — due to insufficient reliable data — continues to be a problem that requires a review of management policies.
- 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.
- 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.
- 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.
- Recognise that maximum sustainable yield (MSY) has been one of the most influential concepts to inform fish stock management, although 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.
- Appreciate that 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.

Science inquiry

The following subject matter may be assessed in the internal assessments.

- Investigate fisheries populations by applying the Lincoln index to a capture-recapture scenario.
- Explore the life history of a fish by reviewing otoliths using a microscope.
- Examine a water or sand sample to identify the presence of microplastics.
- Investigate factors that affect the growth rate of an aquaculture species.

Assessment

Internal assessment 1: Data test (10%)

Students respond to items using qualitative data and/or quantitative data derived from practicals, activities or case studies from Unit 3.

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 data 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.

Specifications

The teacher provides an examination that may ask students to respond using:

- single words
- sentences (up to 150 words per question)
- calculations.

Question specifications

The examination must be aligned to the specifications provided in the table below.

Focus of question	Mark allocation (±2%)	Objective	In these questions, students:
Unknown scientific quantities or features of datasets	~ 30%	2	calculate using algorithms, determine, identify, use
Trends, patterns, relationships, limitations or uncertainty in datasets	~ 30%	3	categorise, classify, compare, contrast, identify, organise, sequence
Conclusions based on analysis of datasets	~ 40%	4	deduce, determine, draw (a conclusion), extrapolate, infer, interpolate, justify, predict

Stimulus specifications

The teacher provides unseen stimulus that:

- uses qualitative data and/or quantitative data from the listed practicals, activities or case studies from Unit 3
- contains between two and four datasets.

Conditions

- Time allowed
  - Perusal time: 5 minutes
  - Working time: 60 minutes
- This is an individual supervised task.
- Students are permitted a QCAA-approved graphics or scientific calculator.

Mark allocation

Criterion	Assessment objectives	Marks
Data test	2, 3, 4	10
	Total marks:	10

Instrument-specific marking guide

Data test	Cut-off	Marks
The student response has the following characteristics:		
• consistent demonstration, across a range of scenarios, 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 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 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 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
• demonstration 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
The student response does not match any of the descriptors above.	≤ 1%	0

Internal assessment 2: Student experiment (20%)

Students modify (i.e. refine, extend or redirect) an experiment relevant to Unit 3 subject matter to address their own related hypothesis or question. This assessment provides opportunities to assess science inquiry skills.

Assessment objectives

1. Describe ideas and experimental findings about the reef and beyond or changes on the reef.
2. Apply understanding of the reef and beyond or changes on the reef to modify experimental methodologies and process data.
3. Analyse experimental data 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. Evaluate experimental processes and conclusions about the reef and beyond or changes on the reef.
6. Investigate phenomena associated with the reef and beyond or changes on the reef through an experiment.

Specifications

This task requires students to:

- 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 relevant qualitative data and/or quantitative data to address the research question
- process and present the data appropriately
- analyse the evidence to identify trends, patterns or relationships
- 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/or extensions to the experiment
- communicate findings in an appropriate scientific genre, e.g. report, poster presentation, journal article, 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.

It is recommended that this task is designed so that students can develop a response in approximately 10 hours of class time.

Conditions

- Students can develop their responses in class time and their own time.
- This is an individual task.
- The following aspects of the task may be completed as a group
  - identifying an experiment
  - developing a research question
  - conducting a risk assessment
  - conducting the experiment
  - collecting data.
- Students use a practical or simulation performed in class as the basis for their methodology and research question.

Response requirements

One of the following:

- Multimodal (at least two modes delivered at the same time): up to 11 minutes
- Written: up to 2000 words

Mark allocation

Criterion	Assessment objectives	Marks
Forming	1, 2, 6	5
Finding	6	5
Analysing	2, 3	5
Interpreting and Evaluating	4, 5	5
	Total marks:	20

Instrument-specific marking guide

Forming	Marks
The student response has the following characteristics:	
• a considered rationale for the experiment • justified modifications to the methodology • a specific and relevant research question • appropriate use of genre and referencing conventions • fluent and concise use of scientific language and representations	4–5
• a reasonable rationale for the experiment • feasible modifications to the methodology • a relevant research question • use of basic genre and referencing conventions • competent use of scientific language and representations	2–3
• a vague or irrelevant rationale for the experiment • inappropriate modifications to the methodology • an inappropriate research question • inadequate use of genre and referencing conventions • simplistic use of language and representations.	1
The student response does not match any of the descriptors above.	0

Finding	Marks
The student response has the following characteristics:	
• a methodology that enables the collection of sufficient, relevant data • considered management of risks/ethical issues/environmental issues • collection of sufficient and relevant raw data	4–5
• a methodology that enables the collection of relevant data • management of risks/ethical issues/environmental issues • collection of relevant raw data	2–3
• a methodology that causes the collection of insufficient and irrelevant data • inadequate management of risks/ethical issues/environmental issues • collection of insufficient and irrelevant raw data.	1
The student response does not match any of the descriptors above.	0

Analysing	Marks
The student response has the following characteristics:	
• correct and relevant processing of data • thorough identification of relevant trends/patterns/relationships • thorough and appropriate identification of the uncertainty and limitations of evidence	4–5
• basic processing of data • identification of obvious trends/patterns/relationships • basic identification of uncertainty/limitations of evidence	2–3
• incorrect or irrelevant processing of data • identification of incorrect or irrelevant trends/patterns/relationships • incorrect or insufficient identification of uncertainty/limitations of evidence.	1
The student response does not match any of the descriptors above.	0

Interpreting and Evaluating	Marks
The student response has the following characteristics:	
• justified conclusion/s linked to the research question • 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	4–5
• reasonable conclusion/s relevant to the research question • reasonable description of the reliability and validity of the experimental process • suggested improvements and/or extensions to the experiment that are related to the analysis of evidence	2–3
• inappropriate or irrelevant conclusion/s • cursory or simplistic statements about the reliability and validity of the experimental process • ineffective or irrelevant suggestions.	1
The student response does not match any of the descriptors above.	0

Internal assessment 3: Research investigation (20%)

Students gather evidence related to a research question to evaluate a claim relevant to Unit 4 subject matter. This assessment provides opportunities to assess science inquiry skills and science as a human endeavour (SHE) subject matter.

Assessment objectives

1. Describe ideas and findings about oceans of the future or managing fisheries.
2. Apply understanding of oceans of the future or managing fisheries to develop research questions.
3. Analyse research data about oceans of the future or managing fisheries.
4. Interpret research evidence about oceans of the future or managing fisheries.
5. Evaluate research processes, claims and conclusions about oceans of the future or managing fisheries.
6. Investigate phenomena associated with oceans of the future or managing fisheries through research.

Specifications

This task requires students to:

- select a claim to be evaluated, from a list provided by the teacher
- identify the relevant scientific concepts associated with the claim
- conduct research to gather evidence from scientifically credible sources to evaluate the claim
- pose a research question that addresses an aspect of the claim
- identify relevant evidence to answer the research question
- identify the trends, patterns or relationships in the evidence
- analyse the evidence to identify limitations
- interpret the evidence to construct scientific arguments
- interpret the evidence to form a conclusion to the research question
- discuss the quality of the evidence
- evaluate the claim by applying the findings of the research to the claim
- suggest improvements and/or 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.

Evidence must be obtained by researching scientifically credible sources, such as:

- books and podcasts by well-credentialed scientists
- ‘popular’ science websites or magazines
- websites of governments, universities, independent research bodies or science and technology manufacturers
- scientific journals.

It is recommended that this task is designed so that students can develop a response in approximately 10 hours of class time.

Conditions

- Students can develop their responses in class time and their own time.
- This is an individual task.
- The following aspects of the task may be completed as a group
  - selecting a claim
  - identifying the relevant scientific concepts associated with the claim
  - conducting research.

Response requirements

One of the following:

- Multimodal (at least two modes delivered at the same time): up to 11 minutes
- Written: up to 2000 words

Mark allocation

Criterion	Assessment objectives	Marks
Forming and Finding	1, 2, 6	5
Analysing	3	5
Interpreting	4, 5	5
Evaluating	5, 1	5
	Total marks:	20

Instrument-specific marking guide

Forming and Finding	Marks
The student response has the following characteristics:	
• a considered rationale identifying clear development of the research question from the claim • a specific and relevant research question • selection of sufficient and relevant sources • acknowledgment of sources of information through appropriate use of referencing conventions • fluent and concise use of scientific language/representations	4–5
• a reasonable rationale that links the research question and the claim • a relevant research question • selection of relevant sources • use of basic referencing conventions • competent use of scientific language/representations	2–3
• a vague or irrelevant rationale for the investigation • an inappropriate research question • selection of insufficient or irrelevant sources • inadequate acknowledgment of sources • incorrect use of language/representations.	1
The student response does not match any of the descriptors above.	0

Analysing	Marks
The student response has the following characteristics:	
• the identification of sufficient and relevant evidence • thorough identification of relevant trends/patterns/relationships in evidence • thorough and appropriate identification of limitations of evidence	4–5
• the identification of relevant evidence • identification of obvious trends/patterns/relationships in evidence • basic identification of limitations of evidence	2–3
• the identification of insufficient and irrelevant evidence • identification of incorrect or irrelevant trends/patterns/relationships in evidence • incorrect or insufficient identification of limitations of evidence.	1
The student response does not match any of the descriptors above.	0

Interpreting	Marks
The student response has the following characteristics:	
• justified scientific argument/s • justified conclusion linked to the research question • justified discussion of the quality of evidence	4–5
• reasonable scientific argument/s • reasonable conclusion relevant to the research question • reasonable description of the quality of evidence	2–3
• inappropriate or irrelevant argument/s • inappropriate or irrelevant conclusion • cursory or simplistic statements about the quality of evidence.	1
The student response does not match any of the descriptors above.	0

Evaluating	Marks
The student response has the following characteristics:	
• 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 • appropriate use of genre conventions	4–5
• application of relevant findings of the research to the claim • suggested improvements and/or extensions to the investigation that are relevant to the claim • use of basic genre conventions	2–3
• application of insufficient or inappropriate findings of the research to the claim • ineffective or irrelevant suggestions • inadequate use of genre conventions.	1
The student response does not match any of the descriptors above.	0

External assessment: Examination — combination response (50%)

External assessment is developed and marked by the QCAA. 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.

Assessment objectives

1. Describe ideas and findings about 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 data 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.

Specifications

This examination:

- includes two papers. Each paper consists of a number of different types of questions relating to Units 3 and 4
- may ask students to respond using
  - multiple choice
  - single words
  - sentences or paragraphs
- may ask students to
  - calculate using algorithms
  - interpret unseen stimulus, including graphs, tables or diagrams.

Conditions

Paper 1

- Time allowed
  - Perusal time: 5 minutes
  - Working time: 90 minutes
- Students may use a QCAA-approved graphics or scientific calculator.

Paper 2

- Time allowed
  - Perusal time: 5 minutes
  - Working time: 90 minutes
- Students may use a QCAA-approved graphics or scientific calculator.

Glossary

The syllabus glossary is available at www.qcaa.qld.edu.au/downloads/senior-qce/common/snr_glossary_cognitive_verbs.pdf.

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Version history

Version	Date of change	Information
1.0	January 2024	Released for familiarisation and planning (with implementation starting in 2025)