May 2016 subject reports

Marine Science

Overall grade boundaries

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0-11	12-23	24-34	35-44	45-56	57-70	71-100

Standard level internal assessment

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-3	4-6	7-10	11-13	14-16	17-19	20-24

The range and suitability of the work submitted

It was clear that students were being encouraged to explore a topic of interest. The wide range of topics reflected student led inquiry, which was good to see. The student voice was evident in the wide variety of investigations undertaken. The bulk of the investigations were focused on traditional "wet labs" with few students using databases or alternate data sources, such as simulations. As these types of investigation represent a new opportunity to investigate topics, in subsequent examination sessions perhaps more students will explore topics that allow the use of databases or combinations of traditional labs and databases or simulations. All of the works submitted complied with the ethical guidelines for the treatment of animals. It was also clear the students were participating in a wide range of interesting Group 4 Projects and their reflections showed they were both enjoying and learning from the experience.

Candidate performance against each criterion

Personal Engagement: Most candidates included statements justifying the scientific interest of their investigation and some statement of personal interest. Stronger students also indicated how and why they had adapted the procedure to test their question.

This criterion assesses evidence of:

- independent thinking or creativity;
- personal significance;
- personal input into the design.

Exploration: Most candidates gave some background information to set the context of the investigation. Descriptions of the procedure varied in specificity. Safety and ethical considerations ranged in their depth of understanding. This criterion assesses evidence of:

- a clear and focused research question including identification of the independent variables, identification of the dependent variable and how it will be measured;
- background information to justify the research question, including the range selected for the independent variable, a description of controlled variables and their expected effect, as well as the means used to control or monitor their effect;
- methodology that is of sufficient detail that a reader could feasibly carry out the process to collect consistent data;
- methodology that is a fair test of the research question;
- methodology that leads to collection of enough data given the 10h of the project;
- attention to safety and ethical concerns such as safe handling of materials, ethical treatment of subjects, careful consumption and disposal of materials, the impacts of disturbance/sampling on natural systems.

Analysis: Most students neatly and clearly organized their raw data. The distinction in performance was usually at the processing level. For guidance on the mathematical expectations for a student in Marine Sciences please reference page 23 of the subject guide. Students often neglected to consider the effects of variance in the data and uncertainty in the measures on their results. This criterion assesses evidence of:

- collection and presentation of raw data, including appropriate relevant qualitative data;
- clear and appropriate data processing, with sample calculations provided;
- appropriate statistical analyses;
- data displayed for easy interpretation in graphs or tables;
- a clear, correct interpretation of the analyses, with an explanation of trends observed in data displays such as tables and graphs.

Evaluation: Students usually considered sources of experimental error as opposed to simple carelessness on their part in the execution of technique. Many neglected to link the source to its possible effect and then suggest a solution for that specific effect so their evaluation was too general. Many students failed to address the strengths of their data. This criterion assesses evidence of:

- A conclusion that addresses the ability of the data to answer the research question;
- The conclusion should be mathematically justified by the data and where appropriate, compared to the scientific literature for context;
- Assessment of the strengths and weaknesses of the data and the investigation;
- Suggestions to improve the investigation itself and to extend the investigation.

Communication: In general it was clear that students had been taught to use a format and they were adhering to the guidelines. They were usually consistent with a citation style. This criterion assesses evidence of:

- a clear communication that is sufficiently detailed, but not repetitive or filled with unnecessary detail;
- well organized and properly titled graphs and tables that are combined where possible to allow the best opportunity to compare measurements or processed data;
- the use of correct scientific conventions including reporting the uncertainty of measurements and instruments used in measuring, scientific names, and units;
- appropriate use of citations and references (all investigations that use a modification of a standard protocol should provide a reference to a source of that basic protocol);

Recommendations for the teaching of future candidates

In some cases, in future teaching it would be important for the students to be given a bit more direction in refining their topic as they had planned investigations that allowed them to collect little data or had no real research question to test. It is no longer necessary for all students to work from a single generic prompt. This widens the scope of permissible topics of investigation by individual students. In general, the command terms included in the subject guide are an excellent tool to help students understand the requirements of the different levels of performance reflected for each aspect of the criteria. For example, clear and focused research questions that are well justified not only state the relationship to be tested, they define the range of variables to be tested and predict some aspect of the expected outcome, justified with reference to proposed mechanisms, theoretical models or previous observations. The command terms organized according to the cognitive level of assessment objective they represent are provided on pages 92-93 of the subject guide.

Personal Engagement: Students should be encouraged to ensure that their report addresses why they undertook the investigation and why this investigation is of scientific interest. When they are doing preliminary trials, or pilot studies to refine their methodology they should also include brief descriptions or outlines of the trials as they are evidence of personal commitment and engagement.

Exploration: Students need to spend time refining their research question. The greater the specificity/focus of the question the better students performed in other aspects of the criterion. Students who included a photo or diagram of their investigation generally also did a better job of clearly describing the procedure. Students can be guided to elevate their addressing of safety and ethical considerations by applying the command terms to that aspect in the review of the draft, eg. identify/outline as compared to describe/explain as compared to discuss/evaluate.

Analysis: Students need to report the range or SD when means are calculated. The t-test is only applicable when there are only two levels of the independent variable. As soon as multiple t-tests are carried out within an investigation the P value of falsely rejecting the null increases for each comparison, so with more than two levels of the independent variable a different statistical tool must be used. Students need to choose carefully the best graph to display/discriminate among their data. Lines of best fit can often be determined/justified by the

mathematical relationship predicted by the theory or model described in the background information.

Evaluation: Students need to discuss the effects of the sources of experimental error in terms of their effects on results or on the ability to have a 'fair' test'. They also need to be encouraged to reflect on the strengths of their investigation/data. This criterion also requires both realistic improvements and extensions to the investigations.

Communication: This criterion is where students were penalized for poor communication in the use and titling of graphs and tables, and in the reporting of uncertainties of the measures, such as limitations in the precision of the instruments, and for inconsistencies in the reporting of the precision of the measurements. Any standard citation style is acceptable but students need to consistently conform to one of the standard styles. Other subjects within the Diploma programme are also teaching students to use suitable styles and so it might be helpful to students if one of the styles they are already learning is adopted as the class style so that they can learn to use it consistently and effectively.

Additionally, teachers are permitted to comment on one draft of the investigation prior to final submission and it might be reasonable in some cases for the student to then refine their ideas at that point, and perhaps refine their lab. Care must be taken to ensure that the student is not given too much direction, but some feedback is appropriate to guide them in their learning. Information and advice about giving suitable feedback on a draft is available in the information for supervisors of the Extended Essay, located on the OCC.

Further comments

These instructions are included to provide teachers with an understanding of the moderation process. In understanding the role of examiners moderatoring the IA, and the instructions they receive you might better be able to help a moderator understand your application of the criteria to the student work uploaded as a sample by providing comments that facilitate moderation.

- Read the whole report first to gain a general impression before attempting to establish marks. Evidence for particular criteria may appear in several parts of the investigation.
- Use a best-fit approach. The aim is to find the aspect within a criterion that most accurately conveys the level attained by the candidate. This approach means that compensation can be made when a piece of work matches different descriptors of a criterion at different levels.
- The overall mark per criterion is not an arithmetic mean, and only whole numbers should be awarded. Fractions or decimals cannot be entered.
- Teachers have been advised to read the aspects for each criterion starting with the lowest, but examiners may moderate using the teacher's marks as a starting point (i.e. looking for evidence, going up or down or accepting marks awarded as necessary). Examiners may mark by initially giving careful consideration to the teacher's mark and comments and then looking to see if there is clear evidence to adjust the mark upwards or downwards. If it is felt that the teacher has made a sensible interpretation of the criterion in question then the teacher's mark should be supported.
- Mark positively. Look for what is present in an investigation rather than minor omissions. Instead of questioning whether they have included everything, ask "have they said enough to meet the descriptor level?"

- Where there are two marks available within a descriptor level the upper marks should be awarded if the investigation demonstrates the qualities described to a greater extent (the work may be closer to achieving marks in the level above). The lower descriptor level would apply if the candidate's work demonstrates the qualities described to a lesser extent (the work may be closer to achieving marks in the level below).
- Examiner are asked "Does your final moderated mark look fair?". On samples where they support the overall mark, nonetheless small disagreements with the teacher's mark within a criterion may be seen. Examiners allow these random uncertainties to cancel out. However, if the marking of a criterion is consistently harsh or lenient, they will consider moderating the mark up or down respectively.
- Be open-minded and try to reward independent thinkers and risk takers. A candidate may have produced work that fulfills a criterion in a way these guidelines have not foreseen. Let the work in front of you define the outcome.
- If there is no achievement against one of the four descriptors within a criterion (with the occasional exceptions of the safety, ethical, environmental aspects of the Exploration criterion, when there is clearly no relevant issue to address), the overall mark for the criterion will most likely be impacted but this should not be over penalized.
- Double marking considerations might happen, especially regarding investigations that generated limited data; there may possibly be an impact on Exploration, Analysis and Evaluation.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-8	9-15	16-23	24-28	29-36	37-44	45-65

General comments

No G2 forms were received from teachers. Since this examination assesses a revised course, it is difficult to compare last year with this year. However, a greater number of candidates performed better when compared against the Grade Descriptors for Group 4 Subjects. Thus, it seems that candidates were better prepared this year than last.

The areas of the programme and examination which appeared difficult for the candidates

- Basic chemistry of water was seldom answered with any understanding of the properties or of the reasons for these properties. The role of density was seldom seen in answers.
- Most candidates demonstrated only superficial understanding of tectonics. They did

not show understanding of methods for studying tectonics or topography as separate dimensions of crustal geology.
- Generally speaking, most responses to the command terms “discuss” or “evaluate” were actually either outlines or descriptions. A structured argument with alternative points of view was rare.

The areas of the programme and examination in which candidates appeared well prepared

- Most candidates had accurate information about hydrothermal vents and about ecosystems and their inhabitants.
- Most were able to state the effects of upwelling on water qualities, and some were able to describe the mechanism that causes this phenomenon.
- While most candidates were able to outline the importance of phytoplankton, the subtler marking points about plankton were seen only on the strongest performing scripts.

The strengths and weaknesses of the candidates in the treatment of individual questions

When a candidate needs more space to write answers to this section of the examination, he/she should use the “additional pages” rather than the lined pages within the test booklet. Those line pages are for the answers to questions in Section B.

Question 1

Although most candidates were able to read the data with skill, only the strongest candidates were able to connect the three components of the data into a cohesive whole, as demonstrated with insightful answers to Q1e.

(a) Most candidates earned this mark.

(b) Those who missed a mark on this question failed to attach their observationson the effect on the population.

(c) There were many ways to answer this question correctly. Most candidates recognized that both a similarity and a difference were required, but stopped there without adding a third marking point which could have been either a similarity or a difference.

(d) Most candidates answered (i) correctly, but many became confused in (ii), confusing highest pH with greatest acidity.

(e) The most common misconception occurring in more than half of the answers was that climate change causes an increase in carbon dioxide in the atmosphere, whereas, the opposite is true. Most candidates who attempted to use the data were able to earn 2 marking points for this question. However, no candidate noticed that the experimental conditions and behavioural changes are far more acidic and used higher concentrations of carbon dioxide than currently exist. Answers seldom reflected a discussion.

Question 2

This application question proved quite difficult. The candidate needed to know that new and full moons result in larger than normal daily tidal ranges and that quarter moons have smaller ranges for the day. With the two full moons provided in the stem, it then defaults to the new moon being the large range in the middle of the month. It was not intended that candidates would have to distinguish first and third quarter moons as occurring at the two smallest ranges. Therefore, the mark for Q2.(a) could be earned by indicating either of the two quarter moons in the graph. A range of dates was accepted for both parts of the question as there is a drag effect due to friction that causes these tidal extremes to occur slightly after the phase of the moon occurs. This concept was not expected. For weaker candidates, it was clear that they had an erroneous definition of spring and neap tide as they labelled the lowest water level as quarter moon and the highest water level as the new moon. Often these were labelled as being on the same day. Annotations require a label especially since there were two annotations on the same graph.

Question 3

(a) While many candidates were able to list satellite altimetry and sonar/boat-based collection, and several added accurate descriptions, some did not know what topography is and described any oceanographic technology that collects geological data.

(b) Most candidates chose to describe the techniques rather than evaluate them. Those who evaluated often said that one was more expensive but failed to qualify what was meant by that assessment, ie: more expensive for the amount of data gained. The format of the question implied that an evaluative statement about the first technique was to be made and an evaluative statement about the second. However, the question asked that the techniques be evaluated relative to each other. The two numbers were meant to encourage candidates to write two relatively evaluative statements.

Question 4

(a) Many candidates did not recognize that pressure on the Y-axis is an indicator of ocean depth. A few did not read the two profiles correctly, assuming that there was a halocline on each of them. The most common label was upon the salinity profile but placed between 100 and 300 decibars of pressure rather than between 0 and 100 decibars.

(b) Vertical stability was to be deduced by seeing that the more dense water was at the bottom of the column. Only a few strong scripts made any reference to density.

Question 5

Most candidates correctly listed abiotic qualities of hydrothermal vent ecosystems. Only a few weaker scripts showed a combination of abiotic and biotic qualities. *Riftia* could win a popularity contest for the hydrothermal vent system! A few other vent organisms were given, with most of them being verifiable. Only a few candidates actually got all three marks for this question because, while adaptations were described, they were not explicitly tied to conditions in the hydrothermal vent.

Question 6

In this question where candidates were asked to discuss reasons and consequences, the answers ranged from excellent balanced arguments to regurgitations of disconnected errors about the polar ecosystems. For example penguins do not live in the Arctic nor do polar bears live in the Antarctic! Further, global warming is not a human activity; it could have been discussed as a consequence of some human activities.

Section B

Questions 8 and 9 were more often answered than Q7. Of those who answered Q7, they often also answered Q9. Candidates should be instructed to number and letter the answers that they write so that these numbers and letters correspond to the sections of the questions. Answers should be placed in the test booklet rather than on additional pages.

Question 7

(a) Many candidates answered this question in a reasonable way. Those who did not provided types of evidence rather than techniques.

(b) It was expected that the description would contain evidence of movement with a description of how (direction and timing) the plate is moving. Instead, it seemed that candidates were trying to justify that the plate is moving rather than the nature of its movement. Many described the coasts of the continents as fitting against each other. This may be true in the Atlantic Ocean but is not true in the Pacific. Most did not mention the hotspot creating Hawaii which was specified in the syllabus. Some candidates made reference to the Cascadia subduction zone. This does not involve the Pacific Plate, but rather the Juan de Fuca plate subducting under the North American plate.

(c) Only a few papers went beyond the fact that waves and currents cause erosion. Seasonal deposition, scouring, long-shore currents, etc. were only mentioned a few times.

Question 8

(a) This question was answered fairly well. The strongest answers defined euryhaline somewhere in the answer. While many outlined the effects of evaporation, only a few outlined the effects of precipitation. Some candidates wrote about temperature variation rather than salinity.

(b) Those who knew that all estuaries are not alike generally earned all of the marks for this question. Those who knew something about estuaries earned a couple of marks for knowing some things that are true of most estuaries.

(c) This was most often given as a list with a consequence for each item in the list. There was seldom any trace of a discussion. Many who dealt with fishing treated it as a bad thing rather than discussing it as an activity that can be regulated, or acknowledging that in some, but not all, circumstances fishing may lead to over-fishing. A nuanced discussion was expected.

Question 9

(a) Most candidates correctly identified phytoplankton as producers, many also acknowledged zooplankton as being consumers. Only a few candidates included any information about detritus or “planktonic snow”. It is an error to state that phytoplankton create energy.

(b) Most candidates described the effects of upwelling upon surface waters. Many described a mechanism for this to occur and some even correctly connected it with La Niña. Some candidates confused upwelling with thermohaline circulation.

(c) Coral reef bleaching was very well explained by many candidates. Others had no idea what they were explaining. As a note, some candidates referred to the relationship of zooxanthellae with corals as endosymbiosis. This terminology is reserved for the inclusion of organelles during the evolution of cells and does not apply to internally housed symbionts.

Recommendations and guidance for the teaching of future candidates

Candidates should

- Develop the skill of reading and interpreting questions properly. This should be practised throughout the course, so that the exam is a natural extension of classwork.
- Work to become a critical thinker who can write a balanced argument giving multiple perspectives and/or the advantages and limitations of ideas or data. It is useful to be able to discuss the reasons why people do what they do.
- Practise writing responses that are appropriate to the command terms. Since command terms are not used in the new syllabus content as assessment statements, the understandings will be open to various command terms. This can add richness to learning the material as students practise applying more than one command term to an understanding or skill.
- Give units for calculated/mathematical answers; show working—it may be worth a mark!
- Bring a ruler and a calculator to the exam.

Teachers should

- Expose candidates to a variety of graphs, flow charts and models for interpretation.
- Help students understand spatial directions so that they can express horizontal dimensions (north-south, east-west) as well as vertical ones (deep to surface). One way of doing this is to have students physically use a ball or globe to make the appropriate distinctions.
- Have candidates practise writing long response questions and then look at an answer key/markscheme to see the level of detail and what is missing; emphasize question-answering techniques e.g. avoiding contradiction, irrelevance and, where possible, help candidates to create connections within their answers. Candidates could then mark another classmate's answers using a markscheme. This type of activity is bound to activate student critical thinking skills about the content they should be learning.
- Teach clear expectations for calculations, including number of decimal points and use of units. When doing calculations insist that students show workings. Guidance can be found in the Mathematical Expectations of the new syllabus for what calculations and statistical tools are expected.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-3	4-7	8-9	10-14	15-18	19-24	25-35

General comments

The majority of candidates responded to Option A of section B, and these candidates demonstrated the greatest depth of understanding of the optional course material. Option B was the next most selected option, and candidates struggled with this option to demonstrate an understanding of concepts beyond what is covered in the core material. Option C was the least selected option, and again candidates had difficulty with questions that required them to use appropriate terminology related to this material. In general, candidates had difficulty with questions from assessment objective 3 across both sections of paper 2.

The strengths and weaknesses of the candidates in the treatment of individual questions Section A

Question 1

a) Many candidates were able to predict the height of the next tide, though were much less successful in predicting the time of the next tide. In part, the use of a 24-hour timing scheme on the x-axis may have been partly responsible for this difficulty.

b) Candidates were generally successful with this question. The markscheme emphasized the factors that set tides into regular patterns, or that enable the prediction of tides, while some candidates interpreted the question to include any possible variable that might influence tidal conditions. In addition, some candidates provided answers like “the moon”/ “the sun” without additional explanation, ie, “moon phase” or “relative positions of the sun, Earth, and moon.”

c) Candidates were generally successful in identifying meteorological conditions as the factor most likely to cause tidal observations to vary from predictions.

Question 2

a) The majority of candidates were able to identify the property of water that accounts for its lower variation in heating and cooling.

b) While many candidates demonstrated a basic understanding of the impact of specific heat on the heating and cooling of different substances, relatively few were able to explain the relationship between this property and the generation of differential pressures and convection currents that lead to land and sea breezes.

Question 3

a) Many candidates correctly interpreted the Simpson's Inverse Diversity Index, and recognized that the diversity of the subtidal zone was higher than of the intertidal zone. Some candidates ignored the data altogether, and responded in vague terms about the importance of protecting diversity without specifically addressing the question.

b) Candidate responses to this question were highly variable. Some described basic observational techniques, such as "count the number of crabs that can be seen" without providing a method appropriate for a scientific investigation. Further, few candidates provided a description of how raw data could be transformed or manipulated graphically or statistically to address the question of distribution.

Section B

Option A

Question 4

a) i) The majority of candidates were successful at reading the graph and identifying the highest proportion of biomass for the two different time periods. ii) Many candidates identified increased fishing activities as a reason for the observed shift towards a younger population, while others proposed reasons for population decreases that were less likely to cause the demographic shift observed, such as disease and pollution.

b) Some candidates continued to describe mechanisms that could cause the observed population shift, rather than addressing the consequences of the shift. While many candidates recognized that the demographic shift could result in a general population decline, fewer explicitly addressed the relationship between fish age and fertility.

c) Many candidates listed methods, rather than evaluating them.

Question 5

Candidates were largely successful in comparing zooplankton and phytoplankton, though were less accurate in their ability to contrast the two. Some candidates made t-charts and listed characteristics of the two groups without explicitly comparing and contrasting the two.

Question 6

While many candidates demonstrated an understanding of the environmental impact of fish farms, some candidates discussed the impacts of over-fishing in general, rather than recognizing the distinct impacts of coastal fish farms.

Question 7

a) The majority of candidates correctly identified the differences in diversity between the two states, and the general pattern of diversity increasing from low to middle to high marsh sites.

b) Because this is an “explain” question, candidates were required to draw connections between the characteristics of salt marshes, and the adaptations of the plants found in these ecosystems, and many listed characteristics and adaptations without relating the two. Some candidates offered descriptions of ecosystems that more closely resembled mangroves, rather than the specifics of salt marshes. Candidates were generally familiar with the adaptations of plants in high salinity environments, and were less familiar with the characteristics related to water movement and lower oxygen levels.

Option B

Question 8

a) The majority of candidates successfully used the figure to answer this question.

b) Many candidates correctly identified high surface temperatures as a cause, though fewer identified the Coriolis effect and the impact of conditions in the upper atmosphere.

c) Most candidates described efforts to respond to coastal disasters, and a few described long term efforts related to the construction of levees and seawalls, etc. Very few candidates engaged in a discussion of these efforts, and instead treated this question as a “describe” or “outline” one.

Question 9

a) Most candidates were able to correctly define the pattern.

b) While candidate responses demonstrated a basic understanding of upwelling, few responses made connections between sea surface temperatures, the process of upwelling, and its impact on fishing.

c) Candidates were largely unfamiliar with these terms, and consequently unable to compare and contrast them.

Question 10

Candidates were generally aware of the role of currents in distributing warm equatorial water towards the poles, there was little mention of the role of vertical circulation in driving the global ocean conveyor belt. In addition, candidates did not discuss the impact of the global ocean conveyor belt on previous climate events, nor did they extend the discussion to include contemporary issues related to climate change and ocean currents.

Question 11

While some candidates were able to list various types of evidence used to infer climatic conditions of the past, very few were able to explain how various types of evidence provided support for different aspects of historical climate change.

Option C

Question 12

a) Most candidates were familiar with the concept of range.

b) Candidates demonstrated an understanding of technological advances in tsunami monitoring, but were less able to describe specifics.

Question 13

a) Some candidates were familiar with seismic profiling, while others discussed mapping the topography of the ocean floor, rather than its composition.

b) Candidates were able to list basic costs and benefits of ocean mining, but answers did not offer explanations.

Question 14

a) Candidates were not familiar with the Wentworth scale.

b) Candidates did not use appropriate vocabulary for discussing the origins of sediments.

Question 15

a) Candidates were able to identify basic changes to the coastal profile, although did not often recognize that negative elevations referred to regions below sea level.

b) Candidates were unable to describe the impact of human activity on sediment transport.

Recommendations and guidance for the teaching of future candidates

As for paper 1.