May 2015 subject reports

Marine Science

Overall grade boundaries

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0-12	13-23	24-32	33-47	48-59	60-70	71-100

Standard level internal assessment

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-8	9-16	17-22	23-27	28-33	34-38	39-48

General comments

Most schools used appropriate investigations of a good standard. Some schools set investigations for assessment that gave too much guidance or insufficient latitude, while others do not provide enough guidance.

For the 2016 IA submission, the Individual Investigation, the internally assessed component of the new program, will require an individual approach. Students cannot work in groups or work on the same investigation on this assignment. More details on the preparation for the new internal assessment criteria will be found at the end of the report.

In most schools the criteria were applied rigorously but in a few schools the teachers seem to be ignoring the descriptors of the different aspects.

Ethics

The Policy on Ethical Treatment of Animals, was appropriately applied in all schools offering Marine Science this year. However, it is important to reiterate the expectations for work in the

programme for 2016 onwards. Most of the following guidelines are more applicable to IB Biology than to Marine Science, but schools should nevertheless review the investigations carried out in light of this policy and ensure that all experiments are considered from an ethical point of view. Safety considerations should also be consistently considered in design and implementation of all experimental work. Both safety and ethical considerations should be included in the written report.

The IB does not wish to inhibit investigations but it does want to stimulate a responsible attitude towards experimentation on animals. Any proposed experimentation involving animals should result in a discussion between teacher and student based on its ethical implications and how to refine the experiment to alleviate any harm or distress to the animals. Exposing animals to conditions normally experienced in their natural environments is permissible. It is good practice to include a discussion with students on the tolerance limits of the animal and how these could be established. There are sites on the web that will help. Exposing animals to conditions outside their normal environmental tolerance limits is not appropriate. When animals are used, there should be discussion in the written introduction or in the procedure of a students work explaining how the standards have been handled in the practical work.

It goes without saying that wild animals should be returned to their natural environment soon after the investigation. Animals obtained from a supplier should be kept under safe and healthy conditions. Situations that deliberately demand the euthanizing of animals are not appropriate.

Fieldwork often involves the sampling of animal populations. This should take place with the minimum of disruption to the environment. The animals should be sampled using techniques that do not cause injury and which limit their stress. The animals should be returned, with due care and attention, to the places where they were collected.

Recommendations for IB procedures, instructions and forms

Clerical procedure

The latest versions of the 4/PSOW form should always be used – please check in the Forms section of the Handbook of Procedures for 2016. The 4/IA form and list of students was sometimes absent in the samples received. The new programme will continue to require teachers to produce a 4/PSOW indicating the practical programme undertaken by candidates as well as a coversheet for each student along with a reflection on the group 4 project.

The electronic version of the 4/PSOW was sometimes incorrectly filled in. The criteria for the sampled work was sometimes flagged using a cross or a tick, but the actual marks were not filled in.

Most teachers included the "complete", "partial" and "not at all" breakdown of their marks. When this was combined with comments and feedback to the candidates it made it very clear how the teachers were awarding marks. Unfortunately a growing trend has been observed of clean copies with no comments at all. It is a lot easier for a moderator to support a teacher's marks when there are clear, readable notes accompanying the sample. When errors of

science occur, it is reassuring to the moderator if a teacher has made a comment to the student to that effect.

There were some transcription errors between the marks indicated on the work and the mark on the 4/PSOW form. This should be verified before it is sent.

Some schools are sending photocopies of the student's work. Usually these are of good quality. The problem is that graphs and diagrams using colour can be confusing. The originals must be sent and a photocopy kept back.

The range and suitability of the work submitted

Trivial, simplistic investigations that do not generate sufficient data to permit adequate assessment of data processing were sometimes used for assessment. Students sometimes missed quite obvious conventional points (e.g. indicating uncertainties in their data) as well as limiting their processing to the calculation of a mean. Teachers also missed these points and marked over generously. Practical work and internal assessment should support understanding of Marine Science. So, bean germination experiments, for example, were not appropriate for a marine science practical programme.

In group 4 experimental science subjects, the expectation is that student work will be of a complexity that allows the candidate to demonstrate the skills required of the criteria. So, there needs to be sufficient data collected such that the student can demonstrate mathematical/quantitative skills described for the subject. (See “Processing & Presenting Data” in the old syllabus OR “Mathematical Requirements” in the new syllabus OR “Analysis" in the new IA criteria).

Literature sources are not consulted when they could provide valuable background information in determining the initial research question and in the discussion of the results.

Rules applied by the moderators

In the event of the teacher providing too much guidance to the students or ignoring the criteria the, following scale was applied by the moderators in 2015 (this will change for 2016).

(see overleaf for table)

Criterion	Problem	Teacher awards	Maximum moderator can award
Design	Teacher gives the problem or research question.	c; c; c = 6	p; c; c = 5 Students could have identified their own control variables
Design	It is clear that the students have been told precisely what apparatus and materials they require and have not modified it.	c; c; c = 6	c; c; n = 4
Data Collection & Processing	The students have used a photocopied data table with headings and units.	c; c; c = 6	p; c; c; = 5 Student could have added uncertainties or relevant qualitative observations
Data Collection & Processing	The students have been told, on the method sheet, to draw a graph from their raw data and which variables to plot or process the data in a particular way.	c; c; c = 6	c; n; c = 4
Conclusion and Evaluation	The student has only indicated as a criticism that they ran out of time and their only suggestion as an improvement is that they should repeat the investigation.	c; c; c = 6	c; n; p = 3

Although the programme for 2016 onward is designed to reduce the occurrence of these problems, when like problems persist, penalties will be applied.

The areas of the programme in which candidates appear well prepared

Most schools had interesting practical tasks for students that provided an opportunity for students to learn the basic tenets of good experimental work. In the new programme it will be important for the practical scheme of work to include the 6 required practicals and many additional skills which will be assessed on paper 2. However, no particular tasks have been established for these, nor is any particular write-up specified. The experience and imaginations of teachers can develop these practical experiences. As was done by most schools this year, the practical scheme will need to prepare students for the IA individual investigation before the student is immersed in it.

Candidate performance against each criterion

Design

The creative development of a focused question, with a demonstration of an understanding of variables and of how to develop a methodology that can control the confounding variables, was required of the Design component of the old criteria **and** will still be required by the new criteria: "Personal Engagement" and "Exploration".

The three categories of variables must be clearly identified. It is clear that students need to be taught what the different variables are and what their relationship is. There was sometimes confusion over what is a controlled variable, that ensures fair testing, and what is a control treatment that can establish the effect of a variable that is not controlled. There was a notable lack of control of temperature. Some students seem to think that temperature can be controlled by a thermometer. It was also noted that students who were varying the pH as the independent variable, rarely tried to measure the pH that the system was actually working at.

Research questions often stated that the aim was to investigate the influence of the independent variable on the rate of change of a dependent variable. Unfortunately the procedure did not explain how this rate was to be calculated. Often time was not measured and so a rate could not be calculated.

The investigations were sometimes too simplistic**.** The range of values of the independent variable was insufficient to establish a trend. The number of repeats was insufficient to permit a statistical analysis that allowed a firm conclusion to be drawn.

Standard protocols were used by the students when they designed their investigations. These are fine. However, these standard protocols must be duly referenced and significantly modified or applied to the student's own investigation.

Design with data logger was best presented when the link between what the sensor measures and the dependent variable was stated rather than left up to the reader. For example a pH sensor may be used to measure photosynthesis by phytoplankton. The fact that a gas (carbon dioxide) is absorbed during photosynthesis which raises the pH needs to be explained. For the dependent variable to be correctly identified this link needs to be made.

The word "amount" is often used by the students, but it is not always clear whether they are referring to volume, mass or concentration.

Data Collection and Presentation (DCP)

Preparation for the investigation should include some time deciding whether or not any meaningful data will be collected. If no results (i.e.: results that are all zeros) are obtained, then the processing requirements cannot be demonstrated and no marks can be earned (under aspects 2 and 3 of DPP in the old criteria OR "Analysis" in the new criteria). There should be enough trials to calculate means or state ranges of data across the variables.

In order for student to demonstrate skills in data collection and presentation, they needed to

collect sufficient data. A student that had only one trial and only two conditions and collects only values of zero cannot process the data and so could only receive a "not at all" for those two aspects. The fault was in the design. Teachers should give guidance in these cases. A coaching approach with carefully chosen questions can often guide a student to more fruitful lines of inquiry. With the revised IA, students should have enough time to take some preliminary data to determine whether or not their plans will be fruitful.

It should be understood that the use of pooled data is inappropriate for the assessment of individual investigations assessed for the new IA, as these are supposed to be the student's own individual effort.

The following faults were seen in candidate work.

- Data tables that were inadequately presented (superficial titles, missing column or row headings) with "complete" awarded by the teacher.
- An indication of units with uncertainties in quantitative data was an expectation for the top marks. Units were often missing and their uncertainties were usually missing, yet "complete" was awarded. Uncertainties are expected for measurements including data logging sensors (literature for the sensor provides the uncertainty). More experienced students can be encouraged to understand the uncertainties of counts and other non-instrument measures. Only "partial" should have been awarded if uncertainties were missing. This aspect has been true as an expectation for a "complete" in DPP in the old criteria and will continue to be true in the new criteria, "Analysis"
- Treatment of uncertainty and/or experimental error should continue into the analysis and interpretation of the findings as seen in the description for "complete" in CE of the old criteria and in the highest markband for "Evaluation" in the new criteria
- Decimal places were sometimes inconsistent and more often they were not consistent with the precision of the instruments being used.
- In some schools, the recording of qualitative data was done by all students, whereas at other schools it was not seen at all. Whenever the candidate chooses to discuss in the conclusion something seen during the course of the experiment, it should be noted with the data.
- When calculations are performed, the procedure for getting the numbers should be clearly presented so that the reader can generate the same numbers. Usually a sample calculation or input information for the calculator/computer will suffice.
- Graphing of data should be done to illustrate a pattern, not to simply restate the raw data. In some cases candidates produced averages, but did not use them in the graph. Further, some candidates calculated percent changes or standard deviations, but then did not use them for analysis nor discussion of the results. "Complete" should not be given when these things are not carried out.

Conclusion and Evaluation (CE)

Investigations that lead to trivial amounts of data will lead to limited discussion of results, weak conclusions and poor evaluations. Insufficient data will not reveal uncertainties and this has an impact on evaluation. Although Design and DCP have been marked on their stand-

alone merits, there will be a knock-off effect on CE from an unfocussed research question to a poorly designed investigation that collects a limited amount of data, permitting limited processing, leading to a weak conclusion and evaluation.

Evaluations should evaluate the *procedure* and the *data*. They should seek weaknesses and strengths of both, explaining the consequences and impact upon the data. Only the most sophisticated candidates demonstrated evaluation skills at this level.

ICT coverage

Most candidates were exposed to the use of ICT. Use of databases was the component most frequently missing. There are good databases available on the internet for studying much of physical oceanography, climate, and geology. Seeking biological data from local coastal experiment stations can also be a source. Some schools develop their own databases from field experiences over several years and can use them in practical work and IA, where they should be cited.

The Group 4 Project

The Group 4 Project is to be 10 hours of group work and development of personal skills even though they are not included in the IA mark. A reflection on the experience is required in each portfolio of work. The Group 4 Project cannot be used for the individual project for IA. Group 4 Project and IA must be two separate experiences. Both are part of the Practical Scheme of Work.

Recommendations for the teaching of future candidates

- Read the feedback on your IA samples from this (2015) session. This form is available from your IB Coordinator.
- Share the new criteria with students and explain them.
- Give the students experience in identifying independent, dependent and controlled variables.
- Provide experiences for students using mathematical tools for processing their data and have them practice choosing the appropriate style of graph for a variety of types of data.
- Teach them about uncertainty of measurements and impact of calculations on uncertainty. Help them to understand the use of range/spread of data and standard deviation on the analysis of data. Teach them how to determine the proper number of significant figures based upon the precision of the instruments being used.
- Be sure that investigations used for assessment produce sufficient quantitative data. Encourage the students to make additional qualitative observations about their experiment. Some teachers have their students keep a log book, an excellent practice.
- Counsel the students on the safety issues, ethics and feasibility of the investigations they design.
- Guide students away from repeating classic investigations or working on the same research question when they design their own individual investigations.
- Take time to teach students how to do a literature search and how to cite sources.
- Recognize the difference between IA and an extended essay. The IA stresses inquiry-based practical skills and uses 10 hours, whereas the extended essay is a piece of

scholarly research and uses 40 hours. Although some aspects seem similar, the difference is substantive.

New features of the Internal Assessment that need to be considered:

From now on the new criteria need to be applied. These can be found in the latest subject guide. The nature of the science investigations has not changed, so teachers should recognize many of the same skills being expected of the candidates. Nevertheless the mode of application has changed significantly. There are no separate aspects to the criteria and the mark range for some criteria has been extended. The marking is arranged by bands, which may take a little getting used to.

There are a number of new features that teachers should be aware of:

- The purpose of the investigation needs to be expressed clearly in the report an d there needs to be clear evidence of personal engagement (see next point).
- The investigation cannot be a simple repeat of a classic investigation or one tha t
  is listed as part of the skills. However, it is possible to adapt and extend from a prescribed investigation.
- Given that 10 hours are allocated to the Individual Investigation, a significant amount of data should be collected. This will impact on Personal Engagement, Exploration, Analysis and Evaluation.
- Citations as footnotes are preferable for specific facts such as literature values. Correct format of citations/bibliography is necessary. URLs alone are insufficient. This will contribute to the Communication criterion.
- Page length is limited to 6–12 pages. In addition format, e.g. font size and sizes of images and graphs will contribute to the Communication criterion. Text and graphs should be large enough to read clearly.
- As well as suggested improvements to modify the investigation, suggested extensions to the study are expected for the Evaluation criterion. As with the improvements they need to be realistic and precise.
- Assessment means that students have been trained through the practical programme to meet the criteria when the time comes for assessment. They will do their work individually. This means that no two students will have identical design-development, nor will they have the same data tables, processing or graphs. If a class or school has established a data bank, there may be some of the same numbers from one candidate to another. Such data must be credited as is any other data source.
- The teacher may not provide the focused question, nor the procedure, nor tell the candidate how to process his/her data. However, *IN ADVANCE* of the assessment tasks, a teacher will need to train students in relevant protocols, design techniques, data collection and display as well as mathematical processes and statistical tests. The new curriculum suggests skills and practical work that can be used to prepare students for their individual investigation (IA).

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-4	5-8	9-12	13-18	19-21	22-27	28-40

General comments

No G2 reports were submitted, and in reflecting on the need to shift grade boundaries significantly this year, it would appear this paper was more difficult than the last year's.

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

- use of turbines to generate electricity from tides
- how to test pH
- mechanism of echolocation
- characteristics of salt wedge estuaries

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

- chemosynthesis
- hunting adaptations

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

Question 1

(a) While most candidates were able to identify the time of the first high and low tide for the date requested, most did not notice that there were two high tides and two low tides, and thus did not earn the two marks.

(b) Many candidates were able to suggest that turbines could be used to transform tidal energy into a usable form, but few specifically stated that turbines generate electricity, or identified the flow of water out of the lagoon between high and low tide as the source of energy.

Question 2

(a) The majority of candidates were able to identify a method of testing pH, but in order to earn the full three marks, they also needed to outline the general procedure, and the way that results are interpreted. These second two points did not occur as frequently. An answer of litmus paper was not accepted, as this method does not

measure pH. Quite a few candidates identified CTD probes as a method, but were very vague about how this tool related to pH, and were apt to discuss salinity as a direct indicator of pH.

(b) It appeared that many candidates were unfamiliar with this concept, and did not realize the underlying connection to pH that grouped these questions together.

Question 3

(a) Many candidates correctly identified plankton as organisms that drift in ocean currents. The second mark, which asked candidates to explain that plankton cannot swim/move faster/against ocean currents, was seen less often.

(b) Most candidates demonstrated an understanding of this vocabulary.

Question 4

(a) Candidates were able to identify countershading as a method of camouflage, but did not as often name the coloration pattern—dark upper side and pale lower side—or mention that this camouflage blends in with both the light sky when seen from below, or with the dark ground when seen from above.

(b) Many candidates described echolocation as a method of communication, rather than outlining its use for locating prey, navigation, etc. Similarly to question 4 a), candidates rarely explained the mechanism of echolocation.

Question 5

(a) Candidates were mostly aware that hydrothermal vents have high salinity and low light, although some provided strange reasoning for these conditions. As long as their reasoning did not contradict their statement, marks were awarded.

(b) (i) Many students correctly identified chemosynthetic bacteria as the autotrophs in hydrothermal vent ecosystems, and more than half of those were able to describe the process of chemosynthesis. Some candidates described *Riftia* species instead, and while these organisms come to rely on symbiotic chemosynthetic bacteria, their larval forms do not, and the bacteria are thought to be acquired from the environment, rather than being present in gametes.

- (ii) A surprising number of candidates named invertebrates here. For the candidates that were able to name fish and shark species, only about half were able to provide a description.

Question 6

(a) Most candidates were able to name an animal and a relevant adaptation. Blubber in marine mammals was the most common response, followed by the behavioral adaptation of huddling in penguins.

(b) Many of the explanations here were vague, and/or did not identify the condition of the environment to which the adaptation provided a benefit.

Question 7

(a) The markscheme for this question focused entirely on the second part, which asked why coral atolls form only in shallow water. Many candidates focused on describing the diagram, or explaining the subsidence of volcanoes, rather than discussing the fact that coral growth depends on symbiotic algae that require particular light and

temperature conditions.

(b) While the question asked for threats to coral **other than** tourism, pollution, and overfishing, many candidates provided answers that fit into these categories. For example, 'blast fishing' or 'scuba-divers accidentally breaking off pieces of coral' were not accepted.

Question 8

(a) This question proved difficult for many candidates, who were unable to describe the characteristics of salt wedge estuaries, or the conditions that produce them. About half of all candidates were able to name two other estuary types.

(b) Many candidates knew that euryhaline organisms could survive in a range of salinities, although only about half were able to describe or name particular adaptations that enable this survival.

Question 9

(a) Most candidates were able to correctly define the term, although some omitted a named example.

(b) Candidates were mostly successful here, although there continued to be some confusion about in/vertebrates, and some candidates provided second and third organisms in their responses that contradicted their initial answer, resulting in no marks.

(c) Candidates did a good job here connecting named species with their hunting adaptations.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0-6	7-12	13-16	17-26	27-35	36-40	41-60

General comments

It was refreshing to see candidates respond to this test with fewer regurgitated answers and more real thinking than sometimes occurs in more established subjects. Teachers are to be commended for providing brilliant and original courses for their students. It will be a challenge to teachers to keep the freshness and vitality of the courses they are currently teaching as more support is provided. Strangely a desire from students, parents and teachers to improve scores sometimes begins to out-weight the desire to provide an interesting and meaningful course.

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

Section A

Since many candidates did not understand carbon fixation as photosynthesis, they had difficulty with some of the questions related to the flow chart in question 1. Others did not try to tease out some rather obvious answers - perhaps they were unfamiliar with examination of a labelled carbon cycle. Distinction of phytoplankton as producers was missed by weaker candidates.

Section B

Understanding of chemical and physical components of marine ecosystems was lacking including water qualities of ecosystems (Q7a), dynamic equilibrium of a sandy beach (Q9a).

A concept of thermohaline circulation (dense surface waters sink and less dense waters rise—the opposite of upwelling) was not demonstrated by any candidates. Therefore, the idea of atmospheric conditions and latitude having an effect on thermohaline circulation was too difficult. However, many did connect the phenomena with the ocean conveyor belt successfully.

Directions posed a problem for some candidates. Vertical as deep and "down" was poorly expressed and some referred to the equator as "down" from the arctic, which it is not.

Although most candidates who wrote about adaptations of organisms showed a rudimentary understanding, most answers were vague or incomplete.

The relationship between the abiotic conditions set up by tides and their connection to organism distribution within the intertidal zone was not always understood.

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

Section A

Those who understood how to read a flow chart did very well with the initial parts of the data based question. Interpretation of the data on El Niño was well done by many candidates.

Section B

Most candidates chose questions 8 and 10, where they were able to demonstrate good understanding of origins of oceans (Q8a) and sources of salt in oceans (Q10a). Throughout the paper, there was an adequate understanding of what upwelling is and its importance.

Candidates were able to write with good understanding of subduction and its relationship to tsunami waves (albeit without the subtle understanding that there must be subsidence to generate tsunamis)

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

Section A

Question 1

(a) The phrase "fixed carbon" seems not to have been familiar to most candidates. However, several candidates identified this correctly, probably from the idea of "uptake" stated in the chart or from the clue provided in question 3(a). A few failed to record the amount as requested in the question.

(b) Many candidates were able to identify the processes and explain them, showing a good connection between theory and the processes shown on the table.

Question 2

Surprisingly, only a few candidates showed an understanding that the energy source that drives a community within an ecosystem is the sun! Hence, the central importance of phytoplankton.

Question 3

(a) This question provided information needed about "fixing carbon" for those who did not recognize it in question 1. Although a simple calculation, only the strongest candidates calculated it correctly. One candidate wrote that not all candidates at the testing centre were provided with a calculator. It is expected that all candidates will have equal access to the required materials.

(b) Many candidates were able to provide this answer with its units.

Question 4

Most candidates recognized phytoflagellates and heteroflagellates, but had more difficulty understanding the arrows that showed bacteria and detritis as the other two sources.

Question 5

(a) Most candidates scored both marks on this question, but few actually reported on the temperature profile.

(b) Several students scored all five marks, and most scored 2-3 marks on this question. A few weaker candidates misunderstood upwelling.

Question 6

Some exceptional evaluations were given to this case study. However, many gave information from the graph and nothing more. Others noted the predator-prey relationship between the birds and the anchovies. Evaluation of a hypothesis requires discussion of multiple possibilities as well as strengths and weaknesses of the evidence/data.

Section B

Question 7

Few candidates chose this question. Furthermore, it seems to have been the most difficult for those who did choose it.

(a) Each ecosystem studied in the syllabus requires a description of temperature, salinity, light, nutrients, oxygen, substrate, and energy. However, few candidates were able to provide descriptive quality answers for these physical aspects of these two ecosystems. There were a couple of outstanding treatments of the question.

(b) Adequate descriptions of mangrove tree adaptations were given, but only a listing of organisms that are typical of mangrove ecosystems was given. Without the adaptation, few points were earned. Again, some candidates provided thorough treatment of the question.

(c) This question proved to be confusing, so the question was generously marked when candidates discussed two human impacts on named ecosystems. The greatest fault with the answers given was that they were not discussions as defined in the command terms. A discussion should contain reasons that the human activities exist, the specific effects of their impact on both ecosystems and people, with possible solutions.

Question 8

(a) Most candidates who answered this question scored well frequently including outgassing from the mantle, condensation, precipitation, and sometimes comets. Few included the concept of stratification. The most frequent errors were a description of Pangaea.

(b) This questions was used by candidates to demonstrate excellent understanding of the anatomy of waves and the interplay of wind and circular movement of water. Some even described how waves change as they enter shallow water. The diagrams were, for the most part, of good quality. Some dimensions were missing. Speed/celerity, steepness, and period were seldom included.

(c) Candidates were able to write with good understanding on the subject of subduction, its characteristic landforms and its relationship to tsunami waves (albeit without the subtle understanding for there to be subsidence to generate them). Most responses were more descriptive than explanatory. However, the best marks were earned by those candidates who could explain the mechanisms.

Question 9

(a) This question was not often chosen by candidates. However, those who chose it described the beach dynamics as seasonal, results of erosion and described changes of beach profile. Few added the additional details of what transports sand, longshore currents (as a result of wave action) nor where new sediments originate. Some weaker candidates interpreted "beach dynamics" as changes in organisms living on the beaches between high and low water.

(b) This part of the question was not well answered. To earn the marks, candidates needed to state names of specific organisms and explain how they are adapted to a

condition of the sandy beach ecosystem. Answers tended to be vague and/or incomplete.

(c) This question required candidates to connect what was learned in topic 1 about tides and apply their understandings about tide changes to the environment of the rocky shore ecosystem. Some candidates wrote well about the changing conditions, but did not know how to write about the distribution of organisms across the zones of the intertidal region. Successful responses often included a diagram.

Question 10

(a) This question was very well answered with many students including a diagram of a halocline to illustrate their narratives. For weaker candidates, it was apparent that they had little understanding of a vertical profile/halocline. Nevertheless, good descriptions of sources of salts, which salts came from where, and how they get to the ocean. A few strong answers even included the extrusion of salt when sea ice forms increasing salinity.

(b) This question was most often answered with an explanation of the ocean conveyor belt and some variations in atmosphere that occur with latitude. Most commonly mentioned were differences in temperature and occasionally the tri-cell model of air circulation. There was little recognition that it is the water that absorbs the light and changes it to heat setting up a dynamic by which the water transports heat to the northern regions where it heats the atmosphere. The idea of prevailing wind and Coriolis Effect was occasionally mentioned as the way that currents move poleward. The wind shear effect of polar winds evaporating the waters and cooling in the Polar Regions creating water with greater density that then sinks was not mentioned by any candidate. It is this sinking primarily in the North Atlantic that drives the ocean conveyor belt. Although the idea of density driven circulation was not included in any of the explanations, many candidates scored marks for their partial understanding. Poor responses thought that density driven circulation is upwelling. This was a response that often revealed a misunderstanding of depth/vertical dimensions and the word "down" which was often confused. The concept of "down" was used to mean in the direction of the equator.

(c) Most candidates scored at least 4 marks on this response because there was excellent understanding of upwelling, its causes and its benefits to organisms.

Recommendations and guidance for the teaching of future candidates

Candidates should

- work to figure out what they think looks difficult. This skill of reading and interpreting questions properly should be practised throughout the course so that the exam is not alarming.
- 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

- familiarize themselves with the changes in the syllabus for 2016 onwards. In particular, they should note the following:
- Instead of assessment statements, in the new course there are understandings, skills and applications. As such, the command terms seem to have disappeared. This makes it reasonable for classes to discuss how answers would vary in response to specific command terms on any particular topic. Paper 2, Section A will assess practical work and problem-solving using the listed skills. It is important to note that practical work and IA are not synonymous. IA is a subset of practical work. It is assessment, the test, for practical work, just as course exams are assessment of theoretical work.
- There are more topics concerning physical, chemical, and geological marine science and less of the core is devoted to marine biology/ecology than in the past syllabus.
- There are three options, of which one captures the remaining marine biology/ecology, Option A. The other two options are further explorations of atmosphere, ocean and climate, Option B and geology of ocean basins, Option C. Options will be assessed in Section B of paper 2.
- A description of the exam adjustments can be found in the course guide.

Teachers should also

- 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 practice 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, creating connections in 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 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.