

# A COURSE PORTFOLIO OF TEACHING IN INTRODUCTORY OCEANOGRAPHY

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## A. THE PURPOSE OF THE PORTFOLIO

### 1. Participation in the portfolio project

My interest in this project arose from recognition that the principal means for assessment of teaching was student evaluations, which stand in stark contrast to the principles used to appraise research through the well-established structure and process of peer review of manuscripts and grant proposals. Moreover, reviewers may offer suggestions for improvements in papers and changes to proposals that enhance their effectiveness or scope. No comparable structure exists for the evaluation of teaching. Hence, I hope that efforts to describe teaching practices, learning objectives and course outcomes can provide a faculty voice in the evaluation process. Course portfolios permit faculty reflection, investigation and documentation of teaching, and contribution to meaningful student learning, in a manner amenable to critical review by peers.

### 2. Goals of the portfolio

This course portfolio documents my teaching activities in the introductory science class G131 "Oceans and our Global Environment" (<http://www.indiana.edu/~g131/home.html>\*) over the past eight years. Throughout this time I have continually modified instructional materials and assignments in my classes with the tacit assumption that these developments provided enhanced learning experiences for my students simply because these changes improved the quality of the course materials and the sophistication of class assignments. Any further justification of the perceived benefits resides solely in anecdotal, rather than substantive, evidence of enhancements student learning. Thus, a major aim of this portfolio is to provide evidence of student learning that complement discussions of improvements in materials and assignments. Hence, the objectives of this portfolio includes creation of:

- A document that enables external, independent assessment of my teaching in oceanography via the peer review process.
- A comprehensive description and evaluation of innovative measures taken in this course.
- A record of scholarly evidence for teaching excellence and innovation and reflection on pedagogy and approaches to teaching in this specific class.

All of these aspects are considered in the context of evidence for class activities that enhance student success and learning outcomes. Moreover, this portfolio encompasses several iterations of this course and therefore presents longitudinal studies of the effectiveness of changes in teaching methods and practices. A separate focused aim of the portfolio is therefore to document selected pedagogical changes in the course and examine evidence of their effect on student learning

or accomplishment. The questions addressed by this aspect of this portfolio include:

- Are there specific measures of performance within class assessments that assess critical learning objectives, such as students' abilities to comprehend complex oceanographic concepts?
- Is there any evidence of systematic differences in student accomplishments that reflect the impact of class size on student learning?
- What is the benefit, if any, of awarding partial credit for partially correct answers in multiple-choice questions and who are the beneficiaries?
- Can the impact of class attendance on student accomplishment be assessed without explicit monitoring?

## B. CLASS SYNOPSIS:

### 1. Course Description

G131 is a three-credit-hour, introductory science course for non-science majors focused on exploration of the marine realm, which incorporates aspects of geology, geography, physics, chemistry and biology in an interdisciplinary approach to the fundamentals of oceanography, emphasizing the climatic and environmental importance of the oceans. It is one of eleven different courses offered in geological sciences, among many other classes campus-wide, which fulfills the 'Natural and Mathematical Sciences' distribution requirement.

### 2. Class Demographics:

Through the Fall semester of 2003, a total of 1309 students have taken G131 in 18 separate class sections, with 982 receiving passing letter grades. One benefit of this large statistical sample is the possibility of assessing aspects of the comparative performance of students of at different stages of their degree programs, within different fields of study and of different gender. A summary of student performance according to student status (Table 1) shows a balance of students according to class, and only minor systematic discrepancies in student accomplishments among the statistically significant data, which excludes continuing and masters students. The range of average class grades is 2.39 to 3.01 (ave. 2.73).

### 3. Student attitudes

One of the major issues in any course that meets distribution requirements is recognition of student attitudes toward the class. I perceive that undergraduate science education is more likely to be more effective when students are willing volunteers rather than grudging conscripts in the learning process. Unfortunately, the element of compulsion in requiring students to take prescribed options to meet distribution requirements inevitably leads a few of them to perceive all aspects (lectures, discussion sessions and assignments) of such a course as an unwelcome burden, rather than an opportunity to learn. Moreover, it encourages some students to commit only the minimal effort necessary to obtain a passing grade. The

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\*References to other web pages on the [www.indiana.edu](http://www.indiana.edu) website are abbreviated for simplicity following the principle whereby .../home.html represents <http://www.indiana.edu/~g131/home.html>.

**Table 1. Student Profile**

Status	No. Students		% Individual Grades				% Other			Ave. GPA
	Total	A-D	A	B	C	D	F	W	I	
Freshman	312	238	20.8	22.8	18.6	14.1	7.7	15.4	0.6	2.62
(completing*)			24.8	27.1	22.1	16.8				
Sophomore	342	260	16.4	28.1	21.6	9.9	8.2	15.2	0.6	2.65
(completing)			19.4	33.3	25.7	11.8				
Junior	290	224	23.8	24.8	21.7	6.9	5.9	14.8	2.1	2.80
(completing)			28.6	29.9	26.1	8.3				
Senior	340	241	21.5	21.2	20.6	7.6	8.2	17.4	2.4	2.74
(completing)			27.1	26.8	26.0	9.7				
Continuing	17	11	17.6	11.8	5.9	29.4	23.5	11.8	0	2.19
Masters	8	8	50.0	37.5	12.5	0	0	0	0	3.30
All	1309	982	20.6	24.1	20.4	9.9	7.7	15.6	1.4	2.70
(completing)			24.9	29.2	24.7	11.9				

\* % of students completing the course (i.e. excluding W and I grades)

undeniable, and perhaps sometimes unobtainable, challenge is to overcome these inherent prejudices that inhibit individual learning because the value, importance or utility of the subject is not recognized. The role of instructor therefore becomes that of a salesperson to cajole and persuade students that the enterprise of learning the class material is worthwhile, and that of a facilitator to accept, albeit reluctantly, a sometimes casual approach toward class responsibilities if it accommodates rather than alienates students with negative attitudes toward the class.

## C. COURSE DESIGN

### 1. Approach

I consider that the practice of teaching follows many of the same principles that guide research activity. No scientist ever chooses to pursue a line of inquiry that has been proven to produce poor results or fail. Yet in teaching poor practices may often persist in the absence of a rationale or impetus for change. Thus, the demonstration through assessment of effective learning within a discipline plays a crucial role in encouraging changes in practice.

Undoubtedly, individual disciplines differ in their expectations for student learning, especially their comparative emphasis on memorizing facts, comprehending concepts and acquiring skills, which may determine the format and structure of classroom activities, the character of assignments, and the extent to which they are interactive. In geological sciences the focus of teaching still tends to reside in course contents and curricula rather than in student outcomes even in classes taught for non-science majors who may never take another class in the discipline. Thus, a key challenge is to demonstrate that a shift in focus from content to learning objectives can enhance student achievement.

### 2. Course objectives:

#### Teaching Geological Sciences

Geological sciences is arguably the most interdisciplinary of the sciences. It encompasses all aspects of the physics, chemistry and biology of the Earth, augmented by the perspective of deep time. It can therefore be regarded as a cornerstone of science education within liberal learning because it offers the basis for understanding the physical world around us. However, its breadth presents particular challenges in teaching and learning. Specifically, student's experiences in high school tend to reinforce disciplinary divisions rather than help to build integrative perspectives. Few students are well prepared in all the different aspects of science involved in geological sciences, which therefore poses significant

challenges in teaching such an inherently interdisciplinary subject. Thus, one of the main objectives of this course is to develop the fundamental skills in science needed to think across disciplines.

#### Explicit and covert objectives

In almost every class there are two separate levels of objectives; those that are explicitly documented as course aims and those that constitute the unstated goals of the instructor, which may include broader skills relevant to a liberal education. The syllabus for G131 "Oceans and Our Global Environment" (<.../synopsis.html>), which has changed little over the years, presents the stated objectives for the class in terms of general aims, course contents, its emphasis, and directives, as follows:

- To provide an integrated introduction to ocean science.
- To explain the principles of chemical, physical and biological oceanography.
- To emphasize the role of oceans in regulation of global climate.
- To illustrate the environmental importance of the oceans.
- To explore the observational basis of the science of oceanography on the web.
- To enhance awareness and understanding of oceanic phenomena.
- To stimulate an interest in the scientific study of the oceans.

This list does not overtly state the series of course objectives that are related to the development or reinforcement of fundamental skills in interpretation of scientific data. In any introductory class for non-science majors that earns students distribution credits in 'Natural and Mathematical Sciences,' which may represent the last formal coursework in science for some students, it is imperative that teaching efforts focus on the acquisition of fundamental skills. These skills include the ability to understand how data can be represented in the form of graphs, histograms, and maps, and the capacity to construct, describe, evaluate and interpret such information. Consequently, underlying the stated course objectives are several more covert objectives including:

- An exposure to diagrams, especially practice in recognition of key elements and assessment of graphical data that leads to familiarity with standard forms of data representation (tables, histograms, graphs, maps, cross sections). For example, the class materials for G131, my introductory class in oceanography, include instruction using various maps where colors are variously used to illustrate ocean temperatures or ocean salinity at the surface or at defined depths, ocean bathymetry, ocean currents, ocean productivity, or tidal strength. One objective is therefore to teach students how to read and digest the information in such maps, and develop their abilities to recognize the keys that indicate what any individual color scheme represents. Ideally, the aim is to instruct the students in this interpretation process and then test their ability to perform similar assessments independently.
- Successful execution of tasks in data assessment that build skills in recognition of data presented in various formats and ideally mastery in comprehension of the information that they present.

- c. An experience in science that affords practical skills and ideally a thirst for further courses to build and develop them.
- d. The acquisition of core knowledge and factual information about science and the oceans that could be regarded as relevant general knowledge for anyone with a baccalaureate degree.

For students, success in attaining the skills associated with this latter series of objectives will provide a more lasting and valuable personal accomplishment than any level of learning related to the specified course objectives. I am eager to develop strategies for learning that both build and assess interpretive skills in examination and evaluation of scientific data and endeavor to design assignments focused on these elements. My contention is that lessons structured around these goals can provide useful templates for such activities in other fields of science.

#### *Student Engagement*

Teaching introductory oceanography in the mid-continent presents unique challenges. Many students have little familiarity with the oceans and marine processes, which may be compounded by limited training in science. In many traditional science classes they are bombarded with knowledge, information and jargon without commensurate training in the skills of scientific inquiry. Too often the requirement to acquire or evaluate data is perceived by them as ‘busy work,’ and perhaps the greatest concern is that for some students these introductory classes for non-science majors represent their last formal coursework in science. Moreover, the traditional structure of lectures and laboratory classes often fails to engender any interest in science, especially when tests concentrate on memorization of facts rather than comprehension of concepts. Thus, there is a critical need to provide vehicles for learning that engage, entertain and educate the class.

### **3. Sequence of Themes & Topics:**

The broad themes of the course and the specific aspects of oceanography considered within these topics ([../synopsis.html](#)) are covered in the following sequence:

- a. *Geographical and Geological Framework of the Oceans*: Shape, size, history and exploration.
- b. *Constituents of the Oceans*: Sea floor sediments, seawater and salts.
- c. *Atmosphere-Ocean Interactions*: Atmospheric gases, winds, and controls on Earth's heat budget.
- d. *Climate and Weather Phenomena*: Hurricanes, El Niño events, and global warming.
- e. *Dynamic Processes in the Oceans*: Ocean circulation, currents, waves, tsunami and tides.
- f. *Fringes of the Ocean*: Coastal waters, estuaries, shorelines, beaches and erosion.
- g. *Biological Oceanography*: Ocean productivity, habitats and lifestyle of marine biota, shallow and deep-water ecosystems.
- h. *Oceans and Environmental Issues*: Pollution, toxins, and marine resources.

This sequence of themes is covered within the lectures, generally following the order of their presentation within the course text, prefaced by an introduction to the class and to the history of oceanography. Some topics (e.g. hurricanes) are addressed in greater detail within specific course assignments,

especially those that are the central focus of web-based exercises.

### **4. Instructional Design:**

Several factors influenced many of the instructional decisions during the initial design and subsequent, successive development of the course. Specifically, there are student-centered issues that need to be considered in addition to scheduling constraints, seating arrangements, and the availability of instructional technology aids. These concerns include an awareness of the wide range of student backgrounds and abilities in science, the need for class activities and interactions that engage students, the importance of assignments that address key learning objectives, and the goal of encouraging good study habits, notably recognition of the benefits of class attendance.

#### *Targeting a range of student preparedness.*

A critical objective in all classes is the creation of an environment for learning in which all students can be successful sustained by activities linked to appropriate use of pedagogy. One perennial challenge is how to devise assignments that are within the compass of the entire class and yet extend the most capable students. This objective is part of the broader goal of building a classroom atmosphere that encourages achievement and caters to different student learning styles. It includes recognition that there may be substantial differences between specific aspects of a course that serve to interest and motivate individual students and that different levels of scaffolding may be required. Consequently, knowledge of the study habits and learning attitudes of students is critical to optimizing the possibilities for their success through efforts to make class materials and topics interesting and relevant. Persuasion is also important. There is the need to convince students of the benefits of investing time and energy in their learning experience, a challenge facilitated by use of effective and varied pedagogy while handicapped by the dominance of concerns over grades for many members of the class.

#### *Incorporating interaction in class.*

Large introductory classes arguably present the greatest challenges in College teaching, because simple management issues can dominate any aspirations to accomplish pedagogical goals. Fortunately, a large class with only about 100 students, like G131 “Oceans and Our Global Environment,” still permits direct interactions with students and the opportunity to recognize and acknowledge many members of the class as individuals. I have also found room design to be important, preferring a central aisle that provides the opportunity to wander among the students when posing questions to the entire class, or during intervals of student discussion with their neighbors. Such interactions within lectures include open discussion of specific questions and answers in an effort to involve and engage students in the class and focus their attention on critical issues and concepts that may be the subject of written exam questions.

#### *Reinforcing key skills.*

My most recent course changes promote efforts that endeavor to develop key skills through web-based exercises and discussion sessions, to hone and establish them through on-line quizzes, and then assess them in written examinations. Development of assignments that sequentially involve preparative, exploratory, analytical, and interpretative elements to reinforce targeted skills prior to assessment is intellectually

demanding and time consuming, yet it best couples class activities to critical course objectives. Undoubtedly help or discussion sessions that introduce, discuss, and review these assignments provide valuable support for these endeavors.

*Rewarding Class Attendance.*

It seems appropriate that course grades should focus on rewarding and encouraging participation rather than on directly penalizing student absences. Moreover, the mere presence of students in the classroom does not ensure that they are attentive, especially in science classes for non-majors at the 100-level. Undoubtedly the optimum incentive for class attendance is recognition by the students themselves that active participation in the learning process will help them be successful. Inevitably it requires that they perceive some tangible benefit from the class, whether it is simply a higher grade, or a better appreciation of the world around us. College students are adults and should bear personal responsibility for their attitude toward academic study. I am therefore fundamentally opposed to the principle of taking attendance and the use of attendance counting toward class grades. The goal is to convince students that attendance is beneficial to their learning because it encourages good study habits. It therefore behooves an instructor to demonstrate tangible benefits from attentive participation in class. My philosophy is that students should be encouraged and cajoled into active participation, not punished if

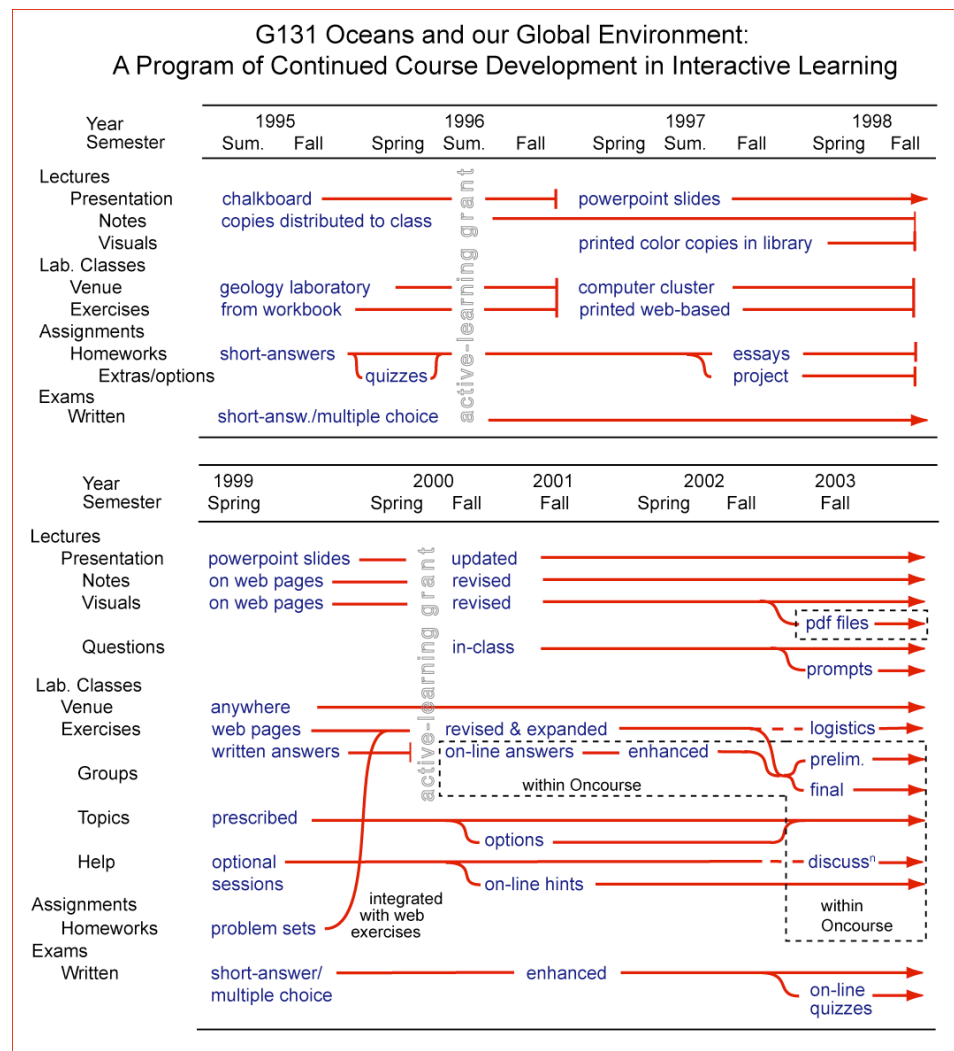
they are disengaged, because their disengagement is likely to reflect a failure of the classroom activities to engage the student. Routinely I report on the discrepancy between the exam grades of students whose attendance may be regarded as casual rather than committed, which I can explicitly demonstrate (Section D.3) although some students seem immune to this logic.

**5. Course Components**

The components of the class have evolved over time (Fig. 1). Perhaps the major changes are in terms of the format, number and contents of assignments, specifically exercises and problem sets, and the proportion of final grade assigned to these required components. Adjustments in scheduling and class times (i.e. whether taught as three 50-minute lectures/week, or as two 80-minute lectures/week, or as a combination of lectures and discussion sessions) also influence the number of written examinations, especially when the class is taught during an 8-week session rather than over the full semester. In recent semesters the class has comprised four main components:

- a. *Lecture Presentations:* A sequential discussion of topics is presented as a series of powerpoint slides that document major points using text summaries, supplemented and illustrated by numerous pictures, diagrams, graphs, maps, and video images. This series of slides was initially developed in 1996, and has been

Fig. 1: A summary of the sequence of progressive developments in course components for G131 Oceans and Our Global Environment.



subsequently updated, amended, augmented and enhanced for every successive iteration of the course. All of the individual slides are accessible to students from the class web pages ([../resources.html](#)).

- b. *In-Class Discussion Questions:* To facilitate active student participation in class sessions, selected issues are formulated as questions ([../resources.html](#)) on slides presented as the basis for open class discussion. The aim, often developed by follow-up comments to responses, is to prompt recognition of underpinning concepts and those factors that represent critical elements of each topic when coupled with the key answers provided. These same points are regularly used as a source for exam questions, and they also provide a helpful guide in assessing the familiarity of the class with specific topics. Typically, only about 30% of students in the class actually volunteer to answer questions, or otherwise actively contribute through the semester. Thus, the discussions are not as widely effective in engendering participation as I would wish, although this proportion of the class may perhaps be the maximum attainable without mandating or explicating rewarding contributions.
- c. *Web-based Exercises:* In the mid 1990's the oceanographic community began its broad adoption of the internet as a means for dissemination of information about the oceans, in part because of the visual nature of most oceanographic data. At this time I recognized the potential of employing the burgeoning accessibility of oceanographic data sets and resources found on the internet in the development of interactive exercises within an introductory undergraduate class in oceanography. This approach arose from my wish to address the dynamics of ocean processes in a manner that is wholly impossible using laboratory workbooks. When I first inherited G131 from a colleague I continued his practice of using selected exercises from a workbook (Pipkin et al., "Laboratory Exercises in Oceanography") as the basis for laboratory activities in the class. My initial development and use of internet resources was facilitated by an active learning grant from Indiana University, recognizing the prospect that use of the internet could provide higher learning experiences for students. Specifically, they could themselves retrieve data sets, and be guided toward their examination and evaluation to discover concepts embedded in these materials. The exercises themselves involve visiting these external websites that provide oceanographic data and assessing aspects of the information to address specific questions related to class themes. The selection of topics has included:
  - i. *Geological Themes:* Earthquakes and plate tectonics, Spreading rates and plate motion, Volcanoes, and volcanic activity, Californian earthquakes, Sea floor topography.
  - ii. *Ocean and Atmospheric Characteristics:* Ocean temperatures, Ocean salinities, Ocean water masses, Atmospheric carbon dioxide, The Antarctic ozone hole,
  - iii. *Ocean and Atmospheric Dynamics:* Hurricanes in the Atlantic and east Pacific, Ocean currents,

Rings in the Gulf Stream, Ocean waves and their heights, Ocean tides.

- iv. *Integrated Topics:* El Niño events, Primary productivity in the oceans.

The specific range of topics used for exercises tended to vary among semesters primarily because aspects of the target information and data was updated and renewed. However, the choice in any particular semester was determined by several factors including:

- i. *Availability of Suitable Websites:* Changes have frequently been necessitated by the disappearance of specific sites, sometimes immediately prior to the launching of the exercise that used them. Similarly, new exercises have been created to take advantage of the discovery of further opportunities – typically new data sets or resources – to extend the range of activities with additional topics. Thus, a limited number of the exercise topics, rather than the entire range, has been employed in any individual semester. However, the stability of the sites has improved over time; this reliability has helped to smooth the process of selecting exercise topics and data sources in recent semesters.
- ii. *Other Course Revisions:* The exercises are intended to mesh with topics covered within the lectures. The timing and sequence of exercises has therefore changed to keep pace with the coverage of topics within the lectures.
- iii. *Time Management:* The full range of options intended for the course exercises has often not been attainable because of time constraints. In practice the development or revision of individual exercises, especially wholesale modifications to their overall format, is phenomenally time-consuming. Thus, introduction of new assignments, additional options in exercise choices, or changes in the structure of the websites have not always been accomplished as planned.

These changes in the exercises meant that students would typically explore and interpret sets of data different from those examined in the previous semester. Indeed, the continued developments, revisions and expansions of the web-based exercises using an increasingly diverse range of web-based data meant that no two successive semesters were identical (compare versions from Spring 1999, Spring 2000, and Fall 2002 accessible at [../simon/G131exercises.html](#), <http://php.indiana.edu/~simon/G131exercisesS2000.html> and [../exercises2002.html](#), respectively\*). In several semesters they were arranged in sets containing exercises that were obligatory combined with the choice of additional selections from a range of other topics. Each individual exercise typically comprised a series of pages explaining:

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\*References to web pages on the <http://php.indiana.edu/~simon/> website are abbreviated so that [../simon/G131home.html](#) represents <http://php.indiana.edu/~simon/G131/home.html>.

- i. *Background*: Offered information on the specific topic in the form of a statement of the exercise goals, and a brief explanatory description of the target data sources, coupled with links to external references that explained features of the data, or their collection and use.
- ii. *Links*: Provided links to the websites containing the data sets, or maps to complete the questions, or links to programs and other to select to generate the required data.
- iii. *Questions*: Documented the series of questions for the exercise, and the web-based resources often with pop-up hints.
- iv. *Oncourse Submission*: Included links to Oncourse for on-line submission of answers, although students were recommended to keep a separate back-up record of their answers in the event that their submission to Oncourse failed in some way.

Most of the pages for the final iteration of the web-based exercises in this format, namely those from Fall 2002, remain accessible ([../exercises2002.html](#)). However, these have become redundant in the wake of revisions made in Fall semester 2003. The exercise pages and links ([../exercises.html](#)) now simply provide summaries of the objectives of the individual exercises, access to background information, and guides and hints to individual questions. The questions themselves, and the links to the websites that provide the data and information to complete the exercise are now fully administered within the Indiana University *Oncourse* environment.

The data sets that are the focus of the exercises are variously presented as tables, maps, graphs or others images. Some involve the selection of options from a menu, or the entry of numbers (e.g. values for latitude and longitude) into programs that generate specific data sets for evaluation. The questions involve:

- i. Description of the features or characteristics of the data, such as an explanation of what a graph or map represents.
- ii. Retrieval of information for a particular region, time or presented in a particular format (e.g. a cross-sectional view) that is generated by use of a web-based program through specifying coordinates or other modifiers.
- iii. Assessment of temporal changes (daily, weekly, seasonal, annual) in oceanographic data (e.g. ozone, productivity, tides) usually by comparison of separate data sets.
- iv. Evaluation of spatial variability in the data, typically by examination of different maps, or distinct regions of a global map, and appraisal of the differences.
- v. Comparison of data sets from different sources generally derived from different approaches to the measurement of a specific characteristic (e.g. plate motions from GPS data or the NUVEL-1 calculator).
- vi. Determination of correspondences between data sets or of their rank order based on an established criterion.

- vii. Interpretation of tabulated, visual, or graphical data in the context of oceanographic concepts and principles.
- viii. Numerical problems using data to calculate parameters of specific phenomena. For example, use of spreading rates to determine the timing of opening of the Atlantic Ocean.
- d. *Help Sessions*: Optional help sessions were offered until recently to provide advice on the web-based exercises. These meetings, scheduled in the early evening, provided a description and explanation of the questions for individual exercises and afforded the opportunity for students to have any questions answered. Initially, two sessions per exercise were offered and their timing was based on student preferences in an effort to optimize attendance and thereby maximize their availability and benefit to the class. Ultimately, these sessions were reduced to one per week at an established time. Attendance at these class meetings varied greatly - undoubtedly other classes or commitments precluded some students' participation - but it never exceeded 30% of enrolled students. Strongly positive comments on evaluation forms about the help sessions imply that the students who attended indeed found them useful. Also, circumstantial evidence indicates that their scores for the exercises benefited from their participation. However, no attendance records were ever taken and this unsubstantiated assertion cannot be verified. A similar beneficial effect can be inferred for those students who attended formal office hours (Instructor or Associate Instructor), or were actively engaged at some time in communication about learning materials. In Fall semester 2003 the help sessions were replaced by introduction of formal discussion sessions involving group interactions in an attempt to provide the benefit of collective examination of the exercise questions for all students (Section E.2.a).
- e. *Additional Web Resources*: The precise hierarchical arrangement of the webpages has changed as the various elements of the course have evolved, but the general structure and layout of the pages has remained consistent (compare home pages and links for Spring 1999, Spring 2000 and Fall 2003 semesters at [../~simon/home.html](#), [../~simon/G131\\_home.html](#) and [../home.html](#), respectively). In most cases the older pages are no longer accessible and I have long ago lost count of the total number of original pages, revised pages, and associated images that have been created or imported, but they number in the thousands. The current home page provides links to the four major elements of the course webpages that, in turn, provide links that enable access to the full range of web resources for the class. The four principal links are:
  - i. *Information*: A series of interlinked pages that describe the syllabus, course objectives, grading policies, format of assignments and examinations, and provide contact details.
  - ii. *Schedule*: The planned sequence for coverage of lecture topics, the due dates of all class assignments, and the time set for all examinations and review sessions.

- iii. *Resources*: Access to a listing of class materials, with links to web pages that display in-class questions (e.g. water and ocean structure, [.../waterq.html](#)), notes on lecture topics (e.g. ocean and atmosphere, [.../atmosN.html](#)), and Powerpoint slides for every lecture topic and review session (e.g. continental margins and ocean basins, [.../margins.html](#)). For Fall 2003 links to learning prompts for each topic were added. In addition, the visuals accessible from the resources web page are also available as pdf files from a folder within the 'in touch' area of the Oncourse class pages (e.g. the mid-term review; [.../MTReview.pdf](#)) The materials available from the resources links have the advantage of enabling students who miss class to review these materials. In addition, they allow easy and accurate review of these materials at a later time, and provide for uniformity in the materials available for study. On the negative side, ready access to these materials probably reduces the quality of note taking by students, which may also engender class inactivity. They may reduce the perceived need for attendance by less active students. Moreover they require significant resources in terms of server space and instructor time to implement. Despite these concerns I think that the benefits outweigh the disadvantages.
- iv. *Exercises*: Until Fall semester 2003 the 'Exercises' link provided access to all of the pages that served to co-ordinate the web-based exercises. It now primarily serves as a source of links to background information on the exercise topics and provides details of the different requirements of each group (A, B, C and D in Fall semester 2003).

## 6. Course Assessments

### Written Examinations:

Central to my teaching philosophy is the principle that learning within a course should be assessed in terms of the student's abilities to demonstrate the use of acquired knowledge or understanding of critical concepts. Thus, I have resisted the convenience of resorting entirely to laborsaving, multiple-choice questions that may simply test powers of recall or memorization of facts. For oceanography, I regard the ability to identify locations where specific features (e.g. tectonic plate boundaries) or phenomena (e.g. upwelling) occur on a world map, or the capability to describe and interpret a graph (e.g. of temporal changes in atmospheric CO<sub>2</sub> levels) as fundamental skills. I am therefore committed to the use of short-answer questions focused on assessing student learning in these critical areas. Thus, the format of written examinations within G131 has remained consistent - a combination of multiple choice and short answer questions - although the number and timing of the

Fig. 2: Representative examples of multiple choice questions and answers for written exams in G131.

exams has varied over the years.

- a. *Multiple Choice Questions*: Answers (selected from five options) require knowledge of topics that may be reinforced by in-class discussion or web-based exercises. 3 points are awarded for correct answers and 1 point for partially correct answers. Examples of multiple-choice questions are accessible among the class web pages ([.../spring2002/exams3.html](#)) and are presented here as examples of questions and answers (Fig. 2).
- b. *Short-Answer Questions*: Answers require description or explanation of specific oceanographic phenomena, often by annotation of maps or diagrams. Questions typically have multiple parts and several choices are offered. Examples of short-answer questions are accessible among the class web pages ([.../spring2002/exams4.html](#)) and are presented here as questions and commentary on possible answers (Fig. 3).

### Problem Sets:

Separate web-based problems were introduced in Spring semester 1999 (see [.../~simon/G131problems.html](#)), which were subsequently incorporated into the web-based exercises. The goal was to provide students with the experience of deriving new insights from considering simple quantitative aspects of the data. Several problems used the same web sites and data sets as those of the web-based exercises, which made it both appropriate and practical to integrate the problems within the exercises.

### Essays:

In three semesters (Fall 1997, Spring and Fall 1998) students were required to write a short (1000 words) essay and/or a longer mini-project (3000 words) on an instructor-approved topic of their choice. The aim was to enable students to explore aspects of the oceans that were of interest to them, compensating for the fact that many oceanographic topics

### Multiple Choice Questions: Examples

G131 Oceans: Final Exam      Name \_\_\_\_\_

<p>6. The ultimate source of energy for most life in the oceans is:</p> <p>A. wind and waves B. the Sun C. salt D. warm ocean waters E. radioactivity</p>	<p><b>B</b> 94% of students answer this question correctly.</p>
<p>7. Eastern boundary currents at low latitudes tend to be:</p> <p>A. wide B. fast moving C. cold D. meandering E. A and C</p>	<p><b>E</b> B and D describe features of western boundary currents.</p> <p><b>3 points for answer E, 1 point awarded for answers A and C.</b></p>
<p>8. The concentrations of nutrients (i.e. nitrate and phosphate) in surface ocean waters are:</p> <p>A. depleted by upwelling B. lower than the concentrations in deep ocean waters C. highest in the center of ocean gyres D. replenished by primary production E. A and C</p>	<p><b>B</b> A, C and D all describe behavior opposite to that observed.</p>
<p>9. Muddy benthic environments most favor which of the following:</p> <p>A. filter feeders B. predators C. sediment ingestors D. epifauna E. all of the above</p>	<p><b>C</b> Relationships between organisms and their habitats are a point of emphasis.</p>
<p>10. The term S-waves is used to describe:</p> <p>A. salinity changes related to wave movements B. standing waves in lakes C. secondary or shear seismic waves D. seiches E. none of the above</p>	<p><b>C</b> Various types of waves are considered within the course.</p>
<p>11. In the ocean carbonate oozes are most likely to be found:</p> <p>A. on mid-ocean ridges B. beneath productive waters in the equatorial Pacific C. in shallow waters D. around Antarctica E. B and D</p>	<p><b>C</b> Answers B and D are typical of siliceous rather than carbonate oozes.</p>

**Short Answer Question: Example**

G131 Ocean: Exam #3 Name \_\_\_\_\_

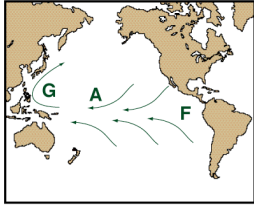
2. Answer BOTH parts, (i) and (ii). Select any THREE of the following features of the atmosphere or ocean. For each give ONE example of their location on the map and indicate their direction or spatial extent (2 PT EACH).

A. trade winds  
B. an ocean gyre  
C. a cold ocean current  
D. a location prone to tsunamis  
E. westerly winds  
F. region of equatorial divergence  
G. a warm ocean current  
H. principal area of hurricane formation in the East Pacific.

(Use the letter code to designate the position and shading or lines to show the extent of each feature. The equator passes through the mouth of the Amazon River and across the island of Papua New Guinea, north of Australia).

(ii) Briefly summarize the major controls, influences or characteristics that govern any one of the following topics. Use diagrams when appropriate or helpful (6 POINTS)

(a) layered structure of the atmosphere, and its characteristics  
(b) wave dynamics and their formation, plus controls on their height  
(c) the characteristics of different water masses in the Atlantic Ocean



**Students are required to sketch both the location and area or direction of each feature. They have several choices.**

**Idealized answers are shown in green.**

**There are maps in the classroom, but reference points are also given.**

**Students can choose between these three topics.**

**Students are encouraged to use diagrams to enhance and expand their answers. Full points are awarded for answers that explain the phenomena, not simply reproduce and accurately label the relevant figures.**

**Bonus** What are rip currents? (2 POINTS)

**Bonus questions tend to be specific, but often address topics that were the subject of in-class discussions.**

Fig. 3: An example of a short answer question with guides to answers typical of those used in written exams for G131.

some students expressed or demonstrated some reluctance to invest significant time for essays or projects that represented only a minor component (5-15%) of their total grade. Thoughtful and thorough reading and critiquing of 60 to 80 2-page essays ranging across the entire field of oceanography constituted 15-30 hours of grading per assignment. The benefit to student learning versus the time investment for these essays and projects was deemed significantly less than that for the web-based exercises, which again made this course component dispensable.

- d. *Scientific Interpretations and Writing Skills*: Many of the students' essays demonstrated a lack of cogent arguments and assessment of scientific information. Students' abilities to write objectively with clarity varied greatly. It was apparent that real benefit to student learning would only emerge from development of the essays as part of an iterative process. However, concerns related to the interpretive aspects of the essay suggested that additional experience in examining oceanographic data sets might be more useful learning exercise.
- e. *Student Responses*: Student comments indicated that many considered that the grading of the essays was the most arbitrary of the course components. Moreover, the diversity of topics made the development of rubrics effectively impossible.

My conclusion was that the use of essays in a 100-level class for non-science majors is impractical without providing appropriate scaffolding to enhance their writing through workshops or detailed feedback. It would be more appropriate in writing-intensive courses where students have the opportunity to improve their writing skills in an iterative manner coupled to development of knowledge and understanding of their chosen topic. However, G131 would require complete restructuring to accomplish this goal and the value of the web-based exercises in achieving key learning objectives seemed much greater, in part because of the scaffolding provided to enhance their effectiveness.

#### Quizzes:

Short (5 question, 10 minute) tests introduced within class in Spring semester 1996 comprised of a combination of multiple-choice and short-answer questions, mirroring the format of the written examinations. They were discontinued because their comparability to other examinations meant that they played no distinct role in the assessment of student learning. A different style of on-line quiz was introduced in Fall semester 2003 that was designed to assess student's comprehension of concepts developed in the web-based exercises. Many of these assessments required interpretation of data sets comparable to those evaluated in the individual exercises, thereby building on prior course components.

#### Web-Based Exercises:

Section C.5.c above presents details of the web-based exercises and their evolution over time. The fundamental aim of the exercises is to train students to evaluate visual data sets and

received sparse attention during formal class sessions. This component in assessment of student learning was later eliminated for several reasons:

- Topic Selection*: A significant proportion of the students struggled to choose a topic for their essays and projects, which led to a surfeit of meetings with students to explain and discuss possibilities, and a deluge of requests for extra time to complete the assignment.
- Resources*: Undoubtedly, most students derived their information solely from the text, or from limited searches for other sources, which at times led to some rather superficial essay contents. Overall, there was a need for students to have some familiarity with relevant oceanographic data and reference materials, and an ability to use search engines (library and internet) to achieve an effective outcome. The absence of these vital skills among a significant proportion of the class meant that training in them was needed to make such assignments effective vehicles for student learning. Without appropriate preparation the projects were of limited value to the students, and were most unlikely to attain their goal of introducing the class to research-based questions and problems. The decision not to restructure this component of the course to provide the necessary skills was rooted in the intention to focus class assignments around the web-based exercises.
- Challenges in Grading*: Students expected significant feedback on their essays, especially a detailed justification of the grade awarded. Yet the value of the essays is significantly limited if students are simply given a grade; it is more important to give students feedback on their work and the opportunity to learn from that experience. In addition, the feedback on an individual essay has little benefit or purpose if no revisions or resubmission are required. Moreover,

Fig. 4: Changes in student scores for specific questions related to visual concepts in written exams for G131.

assess their ability to relate observational data to oceanographic phenomena. Individual questions within the exercises have defined point scores, which vary dependent on the complexity of the response required. The simplest questions require information presented in the images to be reported without comment or interpretation. The most challenging questions are labeled as bonus questions, enabling students to receive scores greater than 100%.

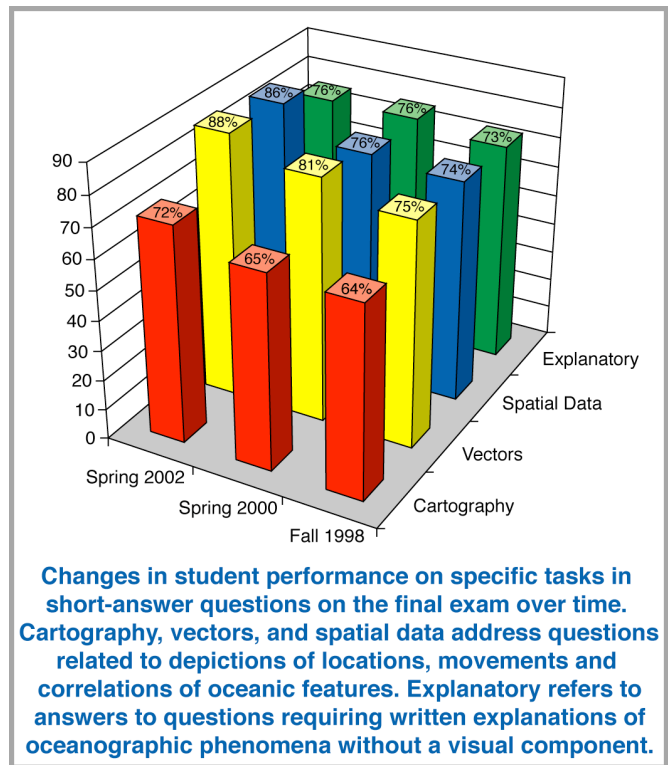
**D. EVIDENCE OF STUDENT LEARNING:**

**1. Student Accomplishments Related to Explicit Course Goals**

The various assignments and examinations within G131 relate directly to the stated course objectives (Section C.2). For example, short-answer questions in the written examinations require students to explain aspects of oceanography linked to its physics, chemistry and biology, and role in global climate. Similarly, the web-based exercises directly involve description, explanation and interpretation based on observational data. Consequently, competence in these areas of learning, commensurate with expectations of general knowledge for a baccalaureate degree, is clearly demonstrated by students who earned a grade of B or higher (about 54% of the students who completed the course; Table 1).

**2. Student Accomplishments Related to Covert Course Goals**

The web-based exercises exposed students to numerous diagrams and maps, and required them to read and digest information contained in these pictures. Students who were successful in these endeavors undoubtedly demonstrated skills in interpretation of information presented in this visual format. Comparison of responses to individual parts of questions in the final written examinations also showed an improvement in students' ability to successfully answer specific questions requiring explanation of spatial data, vectors and cartographic information. The average scores for answers to common questions addressing these elements of student learning



improved from Fall 1998 to Spring 2002 (74 % to 86%, 75% to 88%, and 64% to 72%, respectively; Fig. 4), whereas there was little change (73% to 76%) in answers to simple explanatory questions in the same examinations.

**3. Inquiries Related to Student Learning**

Within the context of this portfolio I have examined several aspects of. Four of these are considered here as brief evaluations of the effects of course assessments, innovations, class attendance and size on student performance.

*Question Format in Written Examinations*

Written examinations in G131 comprise both short-answer and multiple-choice questions (Sections C.6.a and C.6.b) prompting evaluation of evidence for systematic differences in student performance in their answers to these different types of question. Student performance in short-answer and multiple-choice questions can be directly compared by consideration of the difference in their scores for the two types of question. In addition, the performance of students can be evaluated in terms of their earned letter grades (A through F) for the course. This comparison can be presented as a plot of the difference in student scores for short-answer and multiple-choice questions versus their letter grades, using data for individual semesters and as a cumulative average (Fig. 5). The resulting graphs show that high-achieving students demonstrate better understanding of the complex concepts assessed by short-answer questions, and suggests that these questions offer better differentiation between student abilities than multiple-choice questions.

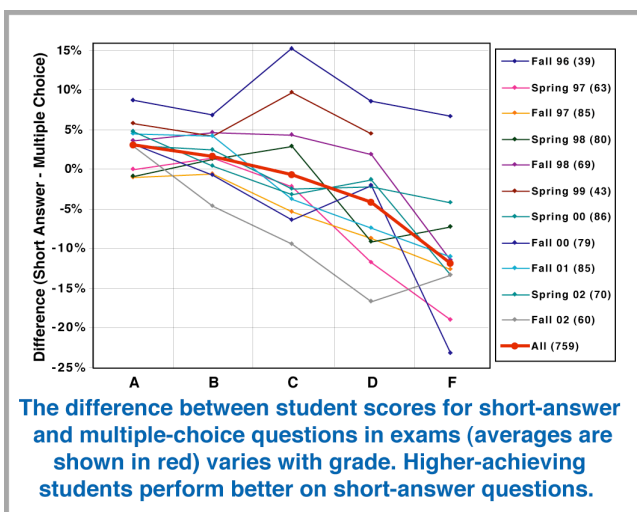


Fig. 5: Comparison of differences in student scores for short-answer and multiple-choice questions in written exams according to their final grade in G131.

Fig. 6: Comparison of benefits to students according to their final grades of offering partial credit for multiple-choice questions in written exams for G131.

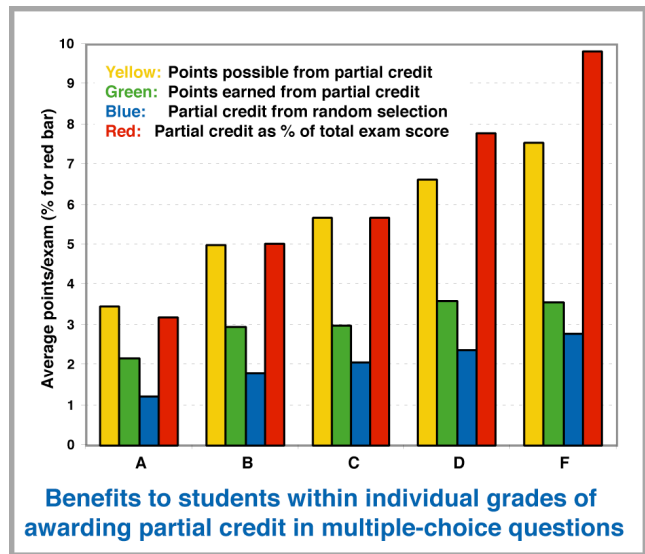
*Partial Credit for Multiple-Choice Questions*

In the written examinations some partially or broadly correct answers to multiple-choice questions can earn students partial credit for their answer (one point versus three points for correct answers; Section C.6.b). The use of this approach in scoring multiple-choice questions warrants assessment to examine the effect of this practice. It can be expected that higher achieving students are likely to achieve a higher success rate in receiving partial credit. However, the opportunities for them to earn this credit will be fewer because they are most likely to select the correct answer (Fig. 6).

There are two predominant outcomes from this practice, namely the impact on student grades and the effect on student perceptions of the course. The first aspect was examined by calculation of partial credit points earned versus those possible, and relative to random selection for all sections of the class from 1995 through 2002. The contribution of the points for partial credit relative to exam scores was also determined. These data were also divided according to student final grades. The results show that awarding partial credit for multiple-choice questions generally increases exam scores and provides marginally greater benefit to students receiving lower grades (Fig. 6). However, the discrepancy between these students' responses and random selection appears to increase with grade. The effect of awarding partial credit is wholly anecdotal. No student has ever made a negative comment on the practice of offering partial credit, whereas many have made positive comments.

*Class Attendance and Exam Performance*

One approach to assess the effectiveness of student learning in lectures is to evaluate evidence for any correspondence between exam scores and student attendance. For a class in which attendance is never taken these data need to be obtained by other methods. It is my practice to return exam scripts to students when grading is complete but without announcing when such distribution will specifically occur. Consequently,



the scores for students who are in class to collect their exam scripts can be compared with those of students who are not present. The results averaged over multiple semesters with 866 students show significant differences (Fig. 7). The average score of students who are present in class to collect their scripts ('regular attendees') is 13% higher than those who are absent ('casual attendees'). It is impossible to determine whether the regular attendees are benefiting from the lectures, or whether the data simply reflect students with better study habits, but the data document the different.

*Exam Performance and Class Size*

The size of the class for G131 has varied significantly over the semesters creating different environments for student learning that prompting consideration of the effectiveness of chosen pedagogy. A key question is whether the size of a class potentially affects the opportunity for the students to learn effectively. This issue can be addressed by comparison of the average scores on written exams for different semesters. The results show a steadfast decrease in scores with increasing class size (Fig. 8). Many factors may contribute to this trend, especially differences in student demographics, such as the proportion of students simply seeking distribution credit. It illustrates a need to identify any systematic factors in the student population that affect learning in larger classes.

**E. REFLECTIONS:**

**1. General Conclusions**

There is no substitute for experience in teaching. Consequently, teaching oceanography for eight years has improved my understanding of class dynamics and student expectations, progressively developing my ability to meet the collective and individual expectations of the students and thereby enhancing the learning process. However, tangible evidence to demonstrate this perception requires analysis of student achievements in assignments and assessment of learning outcomes, which also serves to identify targets for

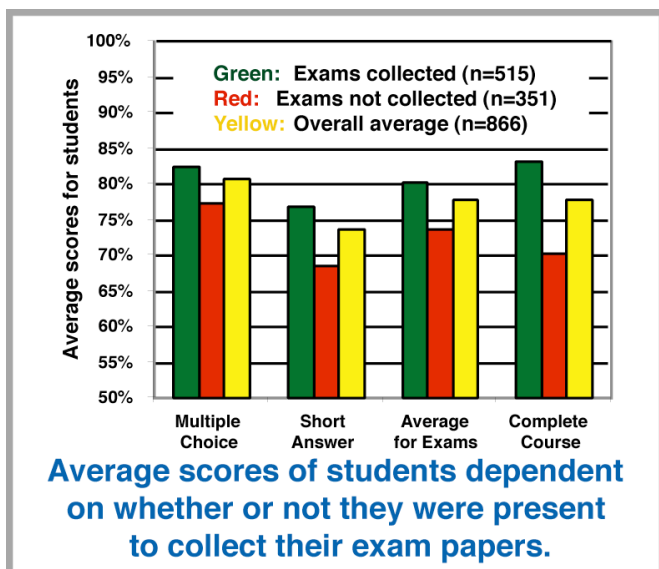


Fig. 7: Evidence from collection of written exam scripts of the effect of class attendance on student performance and final grades for G131.

Fig. 8: Correlation between student scores in written exams and class size for G131.

class development and possibilities for further innovative changes in pedagogy. Any evaluation, self-assessment, or reflection therefore represents a reference point along the continuum of teaching experience.

It is incumbent on an instructor to employ established practices proven to succeed, but also to explore new approaches, and to test the value of such enhancements through experimentation in the classroom. Thus, there is a constant need to reflect on experiences that help establish an understanding of teaching effectiveness. An integral part of this process is assessment of the value of particular class components, especially assignments, to major course goals and the extent to which stated learning goals are being met by the approaches and methodologies that are chosen. My activities in teaching G131 have followed these principles. The class components have been regularly changed (Fig. 1) to explore new, and hopefully more effective, approaches to student learning.

## 2. Changes for Fall 2003

For the Fall semester of 2003, as in 2001, G131 was taught as a second eight-week class. Substantial changes were made in

## EARTHQUAKES and PLATE TECTONICS

### Preliminary Questions

These preliminary questions should be answered using [oncourse](#) before the discussion sessions on this topic on Nov. 4 and 5. They are intended to provide the basis for developing an understanding of earthquakes in the discussion session and an aid to completion of the **Final Questions** on Earthquakes and Plate Tectonics due on Nov. 11.

Scores for these preliminary questions are awarded according to the principles outlined in the exercises web page for the course. The main purpose is for you to demonstrate that you have examined the earthquake data in preparation for the discussion session.

### Data Set A

Your group placement requires that you examine Data Set **A**, which focuses your examination of earthquakes on events in the region of Japan and in the South Pacific. The final questions will involve investigation of data sets for earthquakes on a global scale.

### Objectives

These questions involve examination of a listing of recent earthquakes on the internet and assessment of their characteristics, especially magnitude and depth, and their relationship to boundaries that divide the Earth's surface into a series of plates.

They involve exploration, examination and evaluation of various examples of earthquake data presented as tables, diagrams and maps to answer a variety of questions. Each of the questions require description, assessment and interpretation of data accessed from the designated web pages.

A brief commentary on the contents of each of the websites is offered, and the links to the websites that present the various sets of oceanographic data appear in a second browser window.

The questions are divided into a series of individual topics. All questions should be answered.

### Earthquake Listings

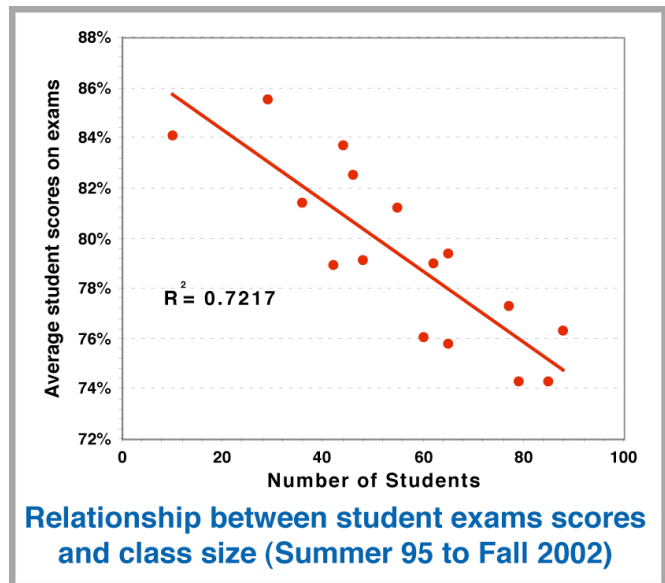
First, examine the interactive listing and map of all major earthquakes within the last 7 days (<http://qldss7.cr.usgs.gov/neis/bulletin/bulletin.htm>) to view the data provided for all earthquakes: magnitude, time, location, depth, and region. The format for the presentation of this information is provided separately ([information](#)).

In answering several of these questions you need to provide the date, time and location (place name) of the earthquake. Note also that data on this list are continually updated. Consequently, some of the data for the earliest earthquakes on this list will not be accessible from this site tomorrow, although a listing of earthquakes over the past 8-30 days is available (<http://qldss7.cr.usgs.gov/neis/qed/qed.html>).

### Earthquakes in the Japan Region

From the previous website (<http://qldss7.cr.usgs.gov/neis/bulletin/bulletin.htm>) scroll down to the map below the listing and click in the Japan region, avoiding the specific squares that denote recent earthquakes (alternatively, go [here](#)). Examine the listing of recent major earthquakes. Selecting individual listings or clicking on individual squares on the map provides open the link to detailed information about that earthquake.

- The map shows the positions of recent earthquakes plotted on a topographic map like that examined in the previous exercise on Oceanographic Concepts. What does the size and color of the circles depicting individual earthquakes represent?
- What are the magnitudes of the weakest and strongest earthquakes from the map and accompanying list? (Give details of their dates, times and locations.)
- Based on the listing of recent earthquakes does there appear to be any correspondence between an earthquake depth and its magnitude? [HINT](#)



the web-based exercises to accommodate this schedule and in direct response to the introduction of formal discussion sessions.

- Web-based exercises:* The exercises were reconfigured

### Earthquake and Plate Boundaries

The objectives of these questions is to explore the list of recent events in Japan ([Japan](#)), and in the South Pacific ([S. Pacific](#)) in the context of different types of plate boundaries. The characteristics of plate boundaries, whether divergent, convergent or transform ([boundary types](#)), and a map of their global positions are described separately ([plates](#)).

The aim is to identify earthquakes that are associated with specific types of plate boundaries.

Selecting individual earthquakes from the listing or on the map links to a web page for the specific earthquake, which provides a map that indicates the site of the event and shows the positions of plate boundaries as yellow lines. In addition there is a link below the maps entitled "historical seismicity" that provides a map of the depths and magnitude of all earthquakes in the region.

In all the following questions give details of the dates, times, depths, magnitudes and locations of the earthquakes you select.

- Find an event occurring on a divergent plate boundary. [HINT](#)
- Find an event occurring on a convergent plate boundary where both plates are oceanic. [HINT](#)
- Find another event occurring on a convergent plate boundary where both plates are oceanic.

### Deep Earthquakes

The aim now is to identify deep (>100km) earthquakes in the Japan and South Pacific regions ([Japan](#) and [S. Pacific](#)) and examine their association with specific types of plate boundaries.

- Select two events that record deep (>100km) earthquakes. (Give details of their dates, times, depths, magnitudes and locations.)
- Describe the tectonic setting (i.e. the type of plate boundary) of these earthquakes.
- Is there any correspondence between the locations of deep earthquakes (>100km) and their tectonic setting (i.e. type of plate boundary) based on evidence from your answer to Q. 8? [HINT](#)

### Regional Characteristics of Deep Earthquakes

Examine the individual pages of information for your two deep earthquakes selected from the Japan and South Pacific regions ([Japan](#) and [S. Pacific](#)). Follow the link below their maps entitled "historical seismicity." The map now shown provides information on all the depths and magnitude of all earthquakes in the region.

- Is there any directional trend in the depth of these earthquakes in this region? For example, do they become progressively deeper in a particular direction?

### Preparation for Final Questions

The final questions will require reference to the list of recent events (<http://qldss7.cr.usgs.gov/neis/bulletin/bulletin.htm>) or the longer list of events over the past 8-30 days (<http://qldss7.cr.usgs.gov/neis/qed/qed.html>) and maps that show relationships between earthquake magnitudes and depths, including <http://qldss7.cr.usgs.gov/neis/eolists/MAG7/maq7.html> and [http://qldss7.cr.usgs.gov/neis/weekly/weekly\\_locations.html](http://qldss7.cr.usgs.gov/neis/weekly/weekly_locations.html).

The final questions will include:

- Is there any correspondence between earthquake magnitude and either depth or tectonic setting?
- Why do individual plate boundaries exhibit pronounced differences in their range of earthquake depths?
- How does the spatial distribution of earthquake depths across oceanic convergent plate boundaries help to explain the fate of ocean crust?

Fig. 9: Example of the preliminary questions for the earthquakes and plate tectonics exercise in Fall 2003 ([.../CPPrelimEx.pdf](#)).

to provide a more structured approach to the questions, building incrementally on the data sets, and operating entirely within the Oncourse environment. The new format consisted of a series of four sets of preliminary questions (e.g. [.../CPPrelimEx.pdf](#); Fig. 9) that were taken by different assigned groups of students (A, B, C and D), and followed by a single set of final questions (e.g. [.../CPFfinalEx.pdf](#); Fig. 10) to be answered by everyone after the discussion sessions. All students were required to complete the preliminary questions as a preparation for the discussion session.

- b. *Discussion Sessions*: these gatherings, scheduled in the early evening (5:45 – 6:35 p.m.) on Tuesday and Wednesday, were introduced as an integral component of the class replacing the optional help sessions. Attendance at these sessions was varied, maximizing at perhaps 80%, but sometimes perhaps as low as 35%. Unfortunately, students who enrolled in the class after the drop/add for the semester were not required to

register for the discussion sessions - indeed they could not. Consequently, in the first class meeting there was an immediate need to co-ordinate placements in the discussion sessions that evening and the following evening, since both were to be held before the second class meeting. The original goal of the discussion sessions was to enable students to discuss their results with partners, in small groups and in large groups, sequentially. However:

- The arrangement of seating in the lecture room was not conducive to group work, consequently discussion tended to be in pairs.
- At times a significant portion of the class had not completed the preliminary questions as required. Initially few students brought copies of their answers for the preliminary questions. Consequently, they were ill prepared to answer questions or participate in the discussion. However, this situation improved as the

## EARTHQUAKES and PLATE TECTONICS

### Final Questions

These final questions should be answered using [oncourse](#) after the discussion sessions on this topic on Nov. 4 and 5. They are intended to address the understanding of earthquakes gained from the preliminary questions and subsequent information learnt in the discussion session. Answers to these **Final Questions** on Earthquakes and Plate Tectonics due on Nov. 11.

Scores for these final questions are awarded according to the points assigned to individual questions, as outlined in the exercises web page for the course.

The main purpose is for you to demonstrate your understanding of the characteristics of earthquakes and their relationship to plate tectonics

The hints for this exercise can be accessed directly from links at this site: [HINTS](#)

### Note on Grading

Your scores for this exercise like those for the preliminary questions cannot be determined automatically by oncourse, as stated on the class web pages.

Point scores for the responses to each question will be manually assessed by Erik, who will announce in class when the grading for individual exercises is complete.

Your answers to the preliminary questions are worth 20% of your grade for this exercise; answers to these final questions constitute the other 80% of the grade, although answers to the bonus questions among the Final Questions can lead to combined scores above 100%.

### Data Sets and Group Placement

Your group placement requires that you examine a limited data set to answer for the preliminary questions. Each of the four data sets explored earthquakes in different regions (given below). For the **Final Questions** you should examine the complete listing of earthquakes on a global scale, not just the specific regions.

Group	A	B	C	D
Region(s) and Links	<a href="#">Japan &amp; S. Pacific</a>	<a href="#">Australia</a>	<a href="#">S. America &amp; S. Pacific</a>	<a href="#">Alaska &amp; N. Pacific</a>

### Objectives of Final Questions

These questions, like the preliminary ones, involve examination of a listing of recent earthquakes on the internet and assessment of their characteristics, especially magnitude and depth, and their relationship to boundaries that divide the Earth's surface into a series of plates.

They involve exploration, examination and evaluation of various examples of global earthquake data presented as tables, and maps to answer a variety of questions. Each of the questions require description, assessment and interpretation of data accessed from the designated web pages.

The questions are divided into a series of individual topics. All questions should be answered.

### Earthquake Listings

Use the interactive listing and map of all major earthquakes within the last 7 days (<http://gldss7.cr.usgs.gov/neis/bulletin/bulletin.html>). As before, in answering several of these questions you need to provide the date, time and location (place name) of the earthquake. Note also that data on this list are continually updated.

Consequently, some of the data for the earliest earthquakes on this list will not be accessible from this site tomorrow, although a listing of earthquakes over the past 8-30 days is available (<http://gldss7.cr.usgs.gov/neis/eqd/eqd.html>). It may be necessary for you to access the longer list to identify the earthquakes selected in answers to the preliminary questions.

### Global Earthquakes and Plate Boundaries

From the previous website (<http://gldss7.cr.usgs.gov/neis/bulletin/bulletin.html>) examine the listing of recent major earthquakes. Selecting individual listings or clicking on individual squares on the map provides open the link to detailed information about that earthquake. Consider the positions of the earthquakes in the context of plate boundaries, whether divergent, convergent or transform ([boundary types](#)). A global map of plate boundaries ([plates](#)) is available to help identify earthquakes that are associated with specific types of plate boundaries.

The aim is to select individual earthquakes from the listing, or on the map links, to reach a web page for the specific earthquake, which provides a map that indicates the site of the event and shows the positions of plate boundaries as yellow lines. In addition there is a link below the maps entitled "historical seismicity" that provides a map of the depths and magnitude of all earthquakes in the region.

In all the following questions **give details of the dates, times, depths, magnitudes and locations of the earthquakes you select.**

- What is the magnitude of the weakest earthquake from the list of recent earthquakes?
- What is the magnitude of the strongest earthquake from the list of recent earthquakes?
- Find two events that occurred on different divergent plate boundaries. [HINT](#)
- Find two events that occurred on different convergent plate boundaries where both plates are oceanic. [HINT](#)
- Find an event that occurred on a convergent plate boundary where one plate is oceanic and the other is continental. [HINT](#)
- Find an event that occurred at a transform plate boundary. [HINT](#)
- Is there any correspondence between earthquake magnitude and tectonic setting? (BONUS)

### Global Characteristics of Deep Earthquakes

The aim of the second series of questions is to identify deep (>100km) earthquakes and examine their association with specific types of plate boundaries. The earthquakes can be identified in the list of recent earthquakes (<http://gldss7.cr.usgs.gov/neis/bulletin/bulletin.html>) from the column that gives their depth, or the color of their identifier in the map below the list.

Follow the link below individual earthquake maps entitled "historical seismicity." The map now shown provides information on all the depths and magnitude of all earthquakes in the region. Again, when appropriate consider the positions of the earthquakes in the context of plate boundaries, whether divergent, convergent or transform ([boundary types](#)). A global map of plate boundaries ([plates](#)) is available to help identify earthquakes that are associated with specific types of plate boundaries.

- What is the depth of the shallowest earthquake from the list of recent earthquakes?
- What is the depth of the deepest earthquake from the list of recent earthquakes?
- Select four events that record deep (>100km) earthquakes. (Give details of their dates, times, depths, magnitudes and locations.)
- Describe the tectonic setting (i.e. the type of plate boundary: divergent, convergent, transform, and oceanic or continental) for each of the four earthquakes.
- Do all types of plate boundaries produce deep earthquakes?
- Why do some, but not all, plate boundaries exhibit pronounced differences in their range of earthquake depths? (BONUS)
- Is there any relationship between the locations of deep earthquakes (>100km) and their tectonic setting (i.e. type of plate boundary) based on evidence from your answer to the preceding questions? [HINT](#)
- Is there any directional trend in the depth of earthquakes in regions where deep earthquakes occur? For example, do they become progressively deeper in a particular direction?
- How does the spatial distribution of earthquake depths across oceanic convergent plate boundaries help to explain the fate of ocean crust? (BONUS)

### Earthquake Magnitude and Depth

For questions 17 again examine the list of recent earthquakes (<http://gldss7.cr.usgs.gov/neis/bulletin/bulletin.html>) comparing the values in the columns that give their depth and magnitude. For questions 18 and 19 examine the world map depicting the magnitude and depth of recent earthquakes: [http://gldss7.cr.usgs.gov/neis/weekly/weekly\\_locations.html](http://gldss7.cr.usgs.gov/neis/weekly/weekly_locations.html). In addition, to answer question 20 examine the world map of earthquakes with magnitudes >7: <http://gldss7.cr.usgs.gov/neis/eqlists/MAG7/mag7.html>

- Based on the list of recent earthquakes in the first link above does there appear to be any correspondence between an earthquake depth and its magnitude? [HINT](#)
- In the world map from the second link immediately above how are the magnitudes and depths of earthquakes represented on the map.
- How does the information from this map help to demonstrate whether the depth and magnitude of earthquakes are related or not? [HINT](#)
- Is there any correspondence between the locations of intense earthquakes (magnitude >7) and their tectonic setting based on the positions of their occurrence on the world map? [HINT](#)

Fig. 10: Final questions for the exercise on earthquakes and plate tectonics used for G131 in Fall 2003 ([.../CPFfinalEx.pdf](#)).

semester progressed, although very few students brought laptops to give them direct access to the data considered in the questions, or an opportunity to practice use immediate approaches to answering them.

- iii. Time spent answering explicit questions on parts of the exercise during the discussion sessions detracted significantly from the time available for group activities focused on the exercise. Thus the original plan for three separate sequences of discussion: in pairs, in groups of four, and in complete groups of eight, was found not to be feasible.

Elements of the discussion appeared successful, following the pattern of the help sessions, but the fact that there were only six sessions within the 8-week class meant that the class only became familiar with the format toward the end of the semester.

- c. *Exercises within Oncourse:* The web-based exercises are fully integrated into the Oncourse environment. In addition the in-touch facility within Oncourse was used to host a folder entitled lecture materials that provided access to pdf files of all of the powerpoint

lectures as handouts (2/page). I anticipate that this option will completely replace the visuals pages on the class web site as it is lower maintenance, and provides direct access to the materials for entire lecture topics.

- d. *Preliminary Concepts:* This initial exercise had previously focus on the interpretation of graphs and maps. For Fall 2003 it was rewritten to provide a better introduction to the types of questions encountered in both the exercises and the on-line quizzes, focusing on accessing web sites relevant to course topics and goals ([.../CPPreCon.pdf](#); Fig. 11).
- e. *On-line Quizzes:* These quizzes involved multiple-choice and short-answer questions (e.g. [.../CPOLQ.pdf](#); Fig. 12). They focused on concepts and interpretations developed in the web-based exercises, often requiring students to tackle short-answer questions covering a different time period or area of the ocean from those addressed in the exercises. Thus the class material within the exercises is introduced in the preliminary questions, developed in the final questions and then examined in the on-line quizzes.

## PRELIMINARY CONCEPTS

### Objectives

These questions involve exploration, examination and evaluation of various examples of oceanographic data presented as graphs, maps and data tables. Each of the questions require description, assessment and interpretation of data sets within each topic. A brief commentary on the contents of each of the websites is offered, and the links to the websites that present the various sets of oceanographic data appear in a second browser window. The questions are divided into a series of individual topics. All questions within each topic should be answered.

### Topographic Maps

An interactive map of the topography of the surface of the Earth is provided by a website operated by the [National Geophysical Data Center \(NGDC\)](#). The color scale is given to the left of the map.

1. What do the colors on the map represent?

Select the region of the Pacific Ocean that includes the island of Hawai'i to view an expanded map of this region ([Hawai'i](#)).

2. What variations in color appear to the West of Hawai'i?
3. What does the variation in color represent?
4. What other features of the ocean floor near Hawai'i can be observed in this colored map of the sea floor? (BONUS)

### Carbon Dioxide

A global network of monitoring stations have been recording atmospheric concentrations of CO<sub>2</sub> for many years. Graphs of the changes in CO<sub>2</sub> concentrations over time can be viewed at a University of Chicago website [Atmospheric CO<sub>2</sub> from NOAA Observatories](#). Scroll down this page to the diagram that has a caption above it that reads "Mauna Loa, Hawaii," or examine this link ([Mauna Loa](#)).

5. What range of years is represented by these data?
6. How has the concentration of CO<sub>2</sub> changed over the time shown in the graph?
7. Has the rate of change in the CO<sub>2</sub> concentration been uniform throughout this time? If not how has it changed?

### Antarctic Ozone Hole

The Climate Monitoring and Dynamics Laboratory maintains a website that enables graphs showing changes in ozone levels over Antarctica to be examined ([CMDL](#)). Enter this site and select the link in the column on the right hand side entitled 2001 South Pole Ozone Profiles (or go [here](#)). You now have the option to choose to view an ozone profile for a specific day. Select 28 October 2001 and click on the button entitled "Request Ozone Profile" below the dates. A graph will appear with three colored lines corresponding to [Pre-Ozone Hole](#) (blue), [Total Ozone](#) (red) and [Temperature](#) (green).

8. What is the vertical axis of this graph?
9. How does the amount (partial pressure) of ozone for 28 October 2001 (shown in red) vary with altitude?
10. At what range of altitude is the ozone partial pressure at a minimum?
11. How does the ozone profile for 28 October 2001 (in red) differ from that for 8 July 2001 (in blue)?
12. Does there appear to be any relationship between the ozone partial pressure for 28 October 2001 (in red) and temperature (in green)?

Return to the Climate Monitoring and Dynamics Laboratory website ([CMDL](#)) and select the link in the column on the right hand side entitled 2002 South Pole Ozone Profiles (or go [here](#)). Now select 27 October 2002 and click on the button entitled "Request Ozone Profile" below the dates. A new graph will appear with the same three colored lines corresponding to [Pre-Ozone Hole](#) (blue), [Total Ozone](#) (red) and [Temperature](#) (green).

13. At what altitude is the minimum partial pressure for ozone on this date, 27 October 2002?
14. Is there less ozone in the Antarctic atmosphere on 28 October 2001 (previous data) or on 27 October 2002 (these data)?

Again return to the Climate Monitoring and Dynamics Laboratory website ([CMDL](#)) and select the link in the central column entitled 2003 South Pole Ozone Profiles (or go [here](#)). Now select 22 October 2003 and click on the button entitled "Request Ozone Profile" below the dates. A new graph will appear with the same three colored lines corresponding to [Pre-Ozone Hole](#) (blue), [Total Ozone](#) (red) and [Temperature](#) (green).

15. What range of altitude shows a minimum value for ozone partial pressure?
16. Do these data for 22 October 2003 more closely resemble the profile for 28 October 2001 or that for 27 October 2002?

### Ocean Color

Satellites that monitor ocean color provide measurements of chlorophyll (the green pigment in plants that is critical for photosynthesis) concentration, which reflects the abundance of phytoplankton (plants) and therefore records the ocean productivity. Images that show ocean color are available at the SeaWiFS Project pages ([World Map](#)). The scale for this map (relating color to phytoplankton pigment concentration) can be seen using the link ([here](#)) immediately above the map. A target(1) version of the map can be viewed by clicking on the image. Ocean areas that are shown as black represent regions for which there is no data.

17. Which color correspond to the highest levels of ocean productivity and which color corresponds to the lower levels?
18. Give examples of areas of the ocean that are high productivity and low productivity. (Refer to the areas using the names of the oceans - Pacific, Atlantic, Indian - and regions according to the compass or other designations - northwest, southeast, central etc.)

The data sets from the SeaWiFS program also enable assessment of seasonal changes in ocean productivity. Examine and compare the two maps of ocean color for the Indian Ocean, one corresponding to the Spring season (April-June; [Indian Spring](#)) and the second corresponding to the Summer (July-September; [Indian Summer](#)). The images will open in separate browser windows.

19. What are the major differences in ocean productivity between the Spring and Summer within the Indian Ocean? (BONUS)

### Ocean Waves

Satellites can also monitor ocean waves and thereby record seasonal changes in winds that generate the waves. Images that show the height of ocean waves are available at the Topex/Poseidon Project pages. Examine and compare global maps of significant wave height for Winter ([January](#)) and Summer ([July](#)). The images will open in separate browser windows. The scale for the colors on the map is given immediately below it.

20. What is the range of wave heights in the North Atlantic Ocean in January?
21. What is the range of wave heights in the North Atlantic Ocean in July?
22. Where are the largest waves in the oceans in July?
23. What connection can be made between the significant wave height in July and the previous image of ocean productivity in the Indian Ocean during the Summer? (BONUS)

Fig. 11: Questions for the preliminary concepts exercise used for G131 in Fall 2003 ([.../CPPreCon.pdf](#)).

f. *In-class Learning Prompts:* A series of additional in-class discussions was prepared and used to prompt discussions with neighbors in the class at the end of specific topics (e.g. [.../worldp.html](#)). The goal was to better identify the critical aspects of individual topics that were central to the themes of the class, and provide students with the opportunity to discuss these points. The hope is that this process reinforces student knowledge and better prepares them for exam questions on such topics.

### 3. Closing Remarks

The advent of technology has opened new opportunities to embrace interactive learning about the oceans in the mid-continent. This course portfolio combined with the various web sites it identifies is intended to demonstrate the practicality of using web-based materials in an oceanography class, and some of the educational benefits that emerge from this innovation. The effectiveness of this approach is only partly addressed here, but the wealth of longitudinal data on student performance collected during the development and evolution of this class provides an opportunity to examine many questions about the depth and breadth of student learning in this course.

Some challenges that will be faced in future iterations of this course will parallel issues already experienced, such as the proliferation of possibilities for web-based materials. Ultimately, the function of the instructor in interactive learning using external resources must change, and I perceive my role evolving to act foremost as a guide and counselor in the exploration and evaluation of information about the oceans, helping students to develop pertinent skills in the process of learning.

## ON-LINE QUIZ #1

### Scope of Quiz

This on-line quiz administered using oncourse comprises questions based on information, concepts and skills explored in the web-based exercises and developed through discussion sessions.

### Schedule and Format

This first quiz is scheduled for Nov. 7 - 10. It requires:

- Answers to questions related to interpretation of oceanographic data akin to those considered in the exercises.
- Answers may be submitted (via oncourse) anytime between Friday, Nov. 7 at 5 p.m., until 11:59 p.m. on Monday.
- There are 25 points available in each quiz.
  - 2 points for each of the five multiple choice questions.
  - 1-5 points for individual parts of the five short answer questions.
- You have a total time of thirty minutes to complete this quiz.
- The scoring for the multiple choice questions is automatic, whereas the grading of the short answer questions is performed manually.

### Multiple Choice Questions

In each question you have a choice of five possibilities. Select the correct answer.

1. Which of the following statements best describes the relationship between earthquake depths and magnitude?
  - A. Earthquake magnitude increases as earthquake depth increases.
  - B. Earthquake magnitude decreases as earthquake depth increases.
  - C. All deep earthquakes are high magnitude earthquakes.
  - D. There is no correspondence between earthquake depth and magnitude.
  - E. Weak earthquakes tend to occur at shallow depths.
2. The specific earthquake characteristics that help to define convergent plate boundaries include:
  - A. The depths of the earthquakes.
  - B. The magnitude of the earthquakes.
  - C. The spatial distribution of earthquake depths.
  - D. The frequency of earthquakes.
  - E. Both A and C.
3. Which of the following statements best describes the global distribution and occurrence of earthquakes?
  - A. Earthquakes can occur anywhere.
  - B. Earthquakes only occur in oceanic regions.
  - C. Earthquakes tend to occur along defined belts or zones.
  - D. The occurrence of earthquakes is wholly random.
  - E. The timing of earthquakes in specific locations can be predicted.
4. Where are earthquakes most prevalent within the conterminous U.S.
  - A. Florida and southeastern states.
  - B. Indiana and the mid-west.
  - C. California and the west coast.
  - D. New England.
  - E. Earthquakes are prevalent everywhere in the U.S.
5. Which of the following pairs of types of plate boundary show general similarities in the spatial distributions and depths of their earthquakes?
  - A. Convergent ocean-continent and convergent ocean-ocean.
  - B. Transform and convergent ocean-ocean.
  - C. Transform and convergent ocean-continent.
  - D. Divergent and convergent ocean-ocean.
  - E. Divergent and convergent ocean-continent.

### Short Answer Questions

These questions, like those in the on-line exercises, require answers based on examination and assessment of information and data in specific web links. The short answer questions have different point values assigned to individual parts.

Examine the map of historical seismicity accessed from the following link - [Map](#) - and answer the questions that follow.

6. What range of earthquake depths (in km) occur in this region?
7. What type of plate boundary is associated with the earthquakes shown on the map?
8. Why is the type of plate boundary characterised by shallow earthquakes?

The preliminary concepts exercise included exploration of data on the Antarctic ozone hole accessed via the website for the Climate Monitoring and Dynamics Laboratory. The data examined included graphs showing changes in ozone levels over Antarctica. A pair of graphs of ozone in late September/early October in 2000 and 2003 are accessible from the following link - [ozone](#) - and are the data source for questions 9 and 10. The three colored lines in the graph correspond to [Pre-Ozone Hole \(blue\)](#), [Total Ozone \(red\)](#) and [Temperature \(green\)](#).

9. What are the major differences in ozone levels and temperature between the two graphs? Describe these differences in terms of the variations with altitude, and the characteristics of the ozone minimum in the two sets of data.
10. Were ozone levels over Antarctica lower on these specific dates in 2000 or 2003?

Fig. 12: The first on-line quiz used for G131 in Fall 2003 consisting of multiple-choice questions and short-answer questions based on interpretation of data and images from webpages ([.../CPOLQ.pdf](#)).