

Judges' Commentary: The Outstanding Marine Pollution Papers

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Introduction

The Interdisciplinary Contest in Modeling (ICM)[®] is an opportunity for teams of students to tackle challenging real-world problems that require a wide breadth of understanding in multiple academic subjects. This year's problem focused on the recently much publicized "Great Pacific Ocean Garbage Patch." Scientific expeditions into the North Pacific Central Gyre (a convergence zone where debris is accumulating) have led to a number of interesting scientific and technical problems. (Hereafter we refer to it simply as "the Gyre.")

Eight judges gathered to select the most successful entries of this challenging competition out of an impressive set of submissions.

The Problem

The primary goal of this year's ICM was to model and analyze one issue associated with the debris problem. Specifically, teams were asked to address several elements with their model:

1. Determine the problem's potential effect on marine ecology.
2. Address government policies and practices that should be implemented to ameliorate the negative effects.
3. Consider needs for future scientific research.
4. Consider the economic aspects of the problem.

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Several examples of issues that the teams might consider were also provided. For the first time, the ICM problem submissions were limited to a maximum length of 10 pages.

Overall, the judges were impressed both by the strength of many of the submissions and by the variety of issues they chose to model. In many cases, very different modeling approaches were used to address the same issue; as a result, this year's problem led to the greatest variety in submissions to the ICM in memory.

Judges' Criteria

The framework used to evaluate submissions is described below, and it remained very similar to the criteria used in 2009. However, the 10-page limit for the submissions had an impact on the importance of the final criterion concerning communication. Teams that dramatically exceeded the limit were not considered for the Outstanding paper category.

Executive Summary

It was important that a team succinctly and clearly explain the highlights of its submission. The executive summary needed to include the issue that the team chose to address and the modeling approach(es) used for analysis. Further, the summary needed to answer the most pressing questions posed in the problem statement, namely, the effect on the marine ecology, economic aspects of the issue, and how to ameliorate the problem. Truly outstanding papers were those that communicated their approach and recommendations in well-connected and concise prose.

Domain Knowledge and Science

The problem this year was particularly challenging for students in terms of the science. To address the requirements effectively, teams needed first to establish an ecological frame of reference. Many teams were able to do this reasonably well; teams that excelled clearly did a great deal of research. Often, what distinguished the top teams was the ability not just to describe the garbage patch in a single section of the paper, but also to integrate this domain knowledge throughout the modeling process.

A second important facet of the problem was the ability to understand economic issues associated with the chosen problem. Many teams created reasonable models but unfortunately never tied them to the economic discussion.

Modeling and Assumptions

For teams that chose to focus on describing and understanding the distribution of plastic in the Gyre, simulation was a popular approach to the problem. Differential equations were probably the most prevalent models used (in a wide variety of ways). Often, the models appeared appropriate but lacked any discussion of important assumptions. Additionally, some papers lacked a reasonable discussion of model development. Finally, the very best papers not only formulated the models well but also were able to use the models to produce meaningful results to address the problem and to make recommendations.

Solution/Recommendation

Perhaps the most distinct difference between the best papers and others was the ability to utilize the team's models to develop or propose an actual solution to the problem. For example, a team might effectively model the distribution of plastic in the Gyre in one section of the paper. A completely independent section would then provide recommendations for remediating the plastic problem but without ever making use of the model or the model results.

Analysis/Reflection

Successful papers utilized the models developed in early sections of the paper to draw conclusions about the important issues in addressing problems with the garbage patch and addressed how assumptions made in the model could impact the solution and recommendation. In the best papers, trade-offs were discussed and—in truly exceptional cases—some sensitivity analysis was conducted to identify potential issues with the solutions presented.

Communication

The challenges of the modeling in this problem and the page limit may have contributed to the difficulty that many teams had in clearly explaining their solutions. Papers that were clearly expositing distinguished themselves significantly, emphasizing that *it is not only good science that is important, but also the presentation of the ideas*. In some cases, teams spent all their space describing the modeling and never presented important results, conclusions, or recommendations. On the other hand, some teams never really explained their models, making it difficult to judge the validity of their results. Balancing the need to present enough work to fully answer the question, while keeping to the 10-page limit, was clearly a challenge in this year's contest.

Discussion of the Outstanding Papers

The judges were most impressed by papers that offered unique and innovative ideas. Three of the four Outstanding papers this year took very novel approaches to the problem and issues. The fourth paper was representative of what many teams opted to do but was more clearly articulated and the modeling more complete than others attempting the same approach.

- The Beijing Jiaotong University submission “A New Method for Pollution Abatement: Different Solutions to Different Types” was unique in looking at the pollution problem from a risk-analysis perspective. Using multi-attribute decision theory, this team developed a model to rank the types of debris in the Gyre by their level of “risk.” The modeling was complete and well explained. The team also then used the results of the model to propose a strategy for reducing the debris problem. The judges were a bit troubled by the conclusions of the paper—considering types of debris as significantly different may not be realistic—but the results followed from the assumptions in the Moore et al. [2001] paper provided with the problem statement.
- The paper from Lawrence University, “Size-Classified Plastic Concentration in the Ocean,” was perhaps the most clearly written and thorough among the Outstanding papers. The team developed a model to classify the plastics in the Gyre. Their models looked at many factors, physical and chemical, to determine size and concentration of the debris. In addition to the very thoroughly explained modeling efforts, the paper ends with sections discussing some of the limitations of the model and then some very specific conclusions and recommendations that stem directly from the model itself.
- The Hangzhou Dianzi University submission, “Quantitative Marine Debris Impacts and Evaluation of Ocean System,” became known among the judges as the “monk seal” paper. This team took a unique approach to the problem by studying the impacts of ocean debris on a single species, the Hawaiian monk seal. A “grey model” and time-series approach was utilized to consider trends for the monk seal, and then an analytical hierarchy process (AHP) used to try to quantify impacts of debris. The paper was not the strongest in terms of how well the team explained and presented their results, but the clever approach to the problem appealed to the judges.
- The final Outstanding paper, “Shedding Light on Marine Pollution” by the team from Carroll College, considered the specific issue of photodegradation of polyethylene floating in seawater. The team developed models for this process and very clearly articulated their approach and assumptions. This paper was among the best at presenting the modeling efforts and also noteworthy for the science (namely, chemistry) utilized in the process. The judges would have liked to see a bit more in the conclusions to explain the importance of the modeling results and ties to policy, but they were very impressed by the focus and clarity of this paper.

Conclusion and Recommendations for Future Participants

The judges really enjoyed reading the submissions for this year's ICM contest. All teams deserve congratulations for the tremendous work done in a very short period of time and on a very difficult problem. The judging was, as a result, both pleasurable and challenging.

One issue worthy of mention that arises each year is that of proper scholarship in utilizing other sources in writing a paper. In researching the science for these complicated problems, teams naturally use information and ideas taken from a variety of resources. This is acceptable as long as those ideas are clearly documented in the paper. Copying the exact words from other papers should be minimized; but, if done, the words need to be placed in quotation marks, so that it is clear that it is not original to the authors.

Several key points from this year's contest judging emerged in determining the very best submissions. These are thoughts that may be useful to future ICM competitors.

- Many teams failed to select a single issue to model and analyze, instead trying to address all of the ideas for issues proposed in the problem statement. In some cases, these teams appeared to have done a remarkable amount of excellent modeling. However, it was simply impossible for them to present all this work in such a short report or to do justice to such a wide array of problems in such a short time period. The teams that were most successful clearly shaped the problem that they would address. When presented with a problem with a very large scope, narrowing the focus is critical.
- Judges were impressed with those who took a unique perspective on the problem. That could be either a different modeling approach (perhaps using a particular science, such as chemistry) or considering a different aspect of the problem (one example was a team that looked at how the plastic gets into the ocean). Original thought, as long as it was grounded in solid research, was cherished.
- Finally, a well-written and integrated report that reads well from start to finish is critical. The sections of the report should follow naturally and not appear as completely separate sections or ideas. The conclusions and recommendations, in particular, should be clearly tied to the modeling work presented.

Reference

Moore, C.J., S.L. Moore, M.K. Leecaster, and S.B. Weisberg. 2001. A comparison of plastic and plankton in the North Pacific central gyre. *Marine Pollution Bulletin* 42: 1297–1300.

About the Author

Rod Sturdivant is an Associate Professor at the U.S. Military Academy in West Point, NY. He earned a Ph.D. in biostatistics at the University of Massachusetts–Amherst and is currently program director for the probability and statistics course at West Point. He is also founder and director of the Center for Data Analysis and Statistics within the Dept. of Mathematical Sciences. His research interests are largely in applied statistics with an emphasis on hierarchical logistic regression models.

