**Problem D ICM Teaming Strategies**

As societies become more interconnected, the set of challenges they face have become increasingly complex. We rely on interdisciplinary teams of people with diverse expertise and varied perspectives to address many of the most challenging problems. Our conceptual understanding of team success has advanced significantly over the past 50+ years allowing for better scientific, creative, or physical teams to address these complex issues. Researchers have reported on best strategies for assembling teams, optimal interactions among teammates, and ideal leadership styles. Strong teams across all sectors and domains are able to perform complex tasks unattainable through either individual efforts or a sequence of additive contributions of teammates.

One of the most informative settings to explore team processes is in competitive team sports. Team sports must conform to strict rules that may include, but are not limited to, the number of players, their roles, allowable contact between players, their location and movement, points earned, and consequences of violations. Team success is much more than the sum of the abilities of individual players. Rather, it is based on many other factors that involve how well the teammates play together. Such factors may include whether the team has a diversity of skills (one person may be fast, while another is precise), how well the team balances between individual versus collective performance (star players may help leverage the skills of all their teammates), and the team’s ability to effectively coordinate over time (as one player steals the ball from an opponent, another player is poised for offense).

In light of your modeling skills, the coach of the Huskies, your home soccer (known in Europe and other places as football) team, has asked your company, **I**ntrepid **C**hampion **M**odeling (ICM), to help understand the team’s dynamics. In particular, the coach has asked you to explore how the complex interactions among the players on the field impacts their success. The goal is not only to examine the interactions that lead directly to a score, but to explore team dynamics throughout the game and over the entire season, to help identify specific strategies that can improve teamwork next season. The coach has asked ICM to quantify and formalize the structural and dynamical features that have been successful (and unsuccessful) for the team. The Huskies have provided data**[1]** detailing information from last season, including all 38 games they played against their 19 opponents (they played each opposing team twice). Overall, the data covers 23,429 passes between 366 players (30 Huskies players, and 336 players from opposing teams), and 59,271 game events.

To respond to the Huskie coach’s requests, your team from ICM should use the provided data to address the following:

• Create a network for the ball passing between players, where each player is a node and each pass constitutes a link between players. Use your passing network to identify network patterns, such as **dyadic** and **triadic configurations** and team formations. Also consider other structural indicators and network properties across the games. You should explore multiple scales such as, but not limited to, micro (pairwise) to macro (all players) when looking at interactions, and time such as short (minute-to-minute) to long (entire game or entire season).

• Identify performance indicators that reflect successful teamwork (in addition to points or wins) such as diversity in the types of plays, coordination among players or distribution of contributions. You also may consider other team level processes, such as adaptability, flexibility, tempo, or flow. It may be important to clarify whether strategies are universally effective or dependent on opponents’ counter-strategies. Use the performance indicators and team level processes that you have identified to create a model that captures structural, configurational, and dynamical aspects of teamwork.

• Use the insights gained from your teamwork model to inform the coach about what kinds of structural strategies have been effective for the Huskies. Advise the coach on what changes the network analysis indicates that they should make next season to improve team success.

• Your analysis of the Huskies has allowed you to consider group dynamics in a controlled setting of a team sport. Understanding the complex set of factors that make some groups perform better than others is critical for how societies develop and innovate. As our societies increasingly solve problems involving teams, can you generalize your findings to say something about how to design more effective teams? What other aspects of teamwork would need to be captured to develop generalized models of team performance?

**Problem E ICM Drowning in Plastic**

Since the 1950s, the manufacturing of plastics has grown exponentially because of its variety of uses, such as food packaging, consumer products, medical devices, and construction. While there are significant benefits, the negative implications associated with increased production of plastics are concerning. Plastic products do not readily break down, are difficult to dispose of, and only about 9% of plastics are recycled**[1]**. Effects can be seen by the approximately 4-12 million tons of **plastic waste** that enter the oceans each year**[1,2]**. Plastic waste has severe environmental consequences and it is predicted that if our current trends continue, the oceans will be filled with more plastic than fish by 2050**[2]**.

The effect on marine life has been studied**[3]**, but the effects on human health are not yet completely understood**[4]**. The rise of **single-use** and **disposable plastic products** results in entire industries dedicated to creating plastic waste. It also suggests that the amount of time the product is useful is significantly shorter than the time it takes to properly **mitigate** the plastic waste. Consequently, to solve the plastic waste problem, we need to slow down the flow of plastic production and improve how we manage plastic waste.

Your team has been hired by the **I**nternational **C**ouncil of Plastic Waste **M**anagement (ICM) to address this escalating environmental crisis. You must develop a plan to significantly reduce, if not eliminate, single-use and disposable plastic product waste.

• **Develop a model to estimate the maximum levels of single-use or disposable plastic product waste that can safely be mitigated without further environmental damage**. You may need to consider, among many factors, the source of this waste, the extent of the current waste problem, and the availability of resources to process the waste.

• **Discuss to what extent plastic waste can be reduced to reach an environmentally safe level**. This may involve considering factors impacting the levels of plastic waste to include, but not limited to, sources and uses of single-use or disposable plastics, the availability of alternatives to plastics, the impact on the lives of citizens, or policies of cities, regions, countries, and continents to decrease single-use or disposable plastic and the effectiveness of such policies. These can vary between regions, so considering regional-specific constraints may make some policies more effective than others.

• Using your model and discussion, **set a target** for the minimal achievable level of global waste of single-use or disposable plastic products and discuss the impacts for achieving such levels. You may consider ways in which human life is altered, the environmental impacts, or the effects on the multi-trillion-dollar plastic industry.

• While this is a global problem, the causes and effects are not equally distributed across nations or regions. Discuss the equity issues that arise from the global crisis and your intended solutions. How do you suggest ICM address these issues?

• Write a two-page memo to the ICM describing a realistic global target minimum achievable level of global single-use or disposable plastic product waste, a timeline to reach this level, and any circumstances that may accelerate or hinder the achievement of your target and timeline.

**Problem A MCM Moving North**

Global ocean temperatures affect the quality of **habitats** for certain ocean-dwelling species. When temperature changes are too great for their continued thriving, these species move to seek other habitats better suited to their present and future living and reproductive success. One example of this is seen in the lobster population of Maine, USA that is slowly migrating north to Canada where the lower ocean temperatures provide a more suitable habitat. This geographic population shift can significantly disrupt the livelihood of companies who depend on the stability of ocean-dwelling species. Your team has been hired as consultants by a Scottish North Atlantic **fishery** management consortium.

The consortium wants to gain a better understanding of issues related to the potential migration of **Scottish herring** and **mackerel** from their current habitats near Scotland if and when global ocean temperatures increase. These two fish species represent a significant economic contribution to the Scottish fishing industry. Changes in population locations of herring and mackerel could make it economically impractical for smaller Scotland-based fishing companies, who use fishing vessels without on-board refrigeration, to harvest and deliver fresh fish to markets in Scotland fishing ports.

**Requirements**

1. Build a mathematical model to identify the most likely **locations** for these two fish species over the next 50 years, assuming that water temperatures are going to change enough to cause the populations to move.

鱼在哪儿

2. Based upon how rapidly the ocean water temperature change occurs, use your model to **predict** best case, worst case, and most likely **elapsed time(s)** until these populations will be too far away for **small fishing companies** to harvest if the small fishing companies continue to operate out of their current locations.

预测鱼会逗留多长时间

3. In light of your predictive analysis, should these small fishing companies **make changes** to their operations?

根据预测数据，看看捕鱼公司是否需要行动

a. If yes, use your model to identify and assess practical and economically attractive **strategies** for small fishing companies. Your strategies should consider, but not be limited to, realistic options that include:

- Relocating some or all of a fishing company’s assets from a current location in a Scottish port to closer to where both fish populations are moving;

- Using some proportion of small fishing vessels capable of operating without landbased support for a period of time while still ensuring the freshness and high quality of the catch.

- Other options that your team may identify and model.

b. If your team rejects the need for any changes, justify reasons for your rejection based on your modeling results as they relate to the assumptions your team has made. *Hook Line and Sinker*

4. Use your model to address how your proposal is affected if some proportion of the fishery moves into the **territorial waters (sea)** of another country.

鱼群移动出国对模型的影响

5. In addition to your technical report, prepare a one- to two-page article for magazine to help fishermen understand the **seriousness of the problem** and how your proposed solution(s) will improve their future business prospects.

文学建模：阐述问题严重性&方法有效性