2020 年美国大学生数学建模竞赛（MCM/ICM）A 题中英版

全球海洋温度影响某些海洋生物的栖息地质量。当温度变化太大以至于无法继续生长时，这些物种便开始寻找其他更适合其现在和将来的生活和生殖成功的栖息地。其中一个明显的例子就是美国缅因州的龙虾种群，该种群正缓慢地向北迁徙到加拿大，那里较低的海洋温度提供了更合适的栖息地。这种地理上的种群迁移会严重破坏依赖海洋生物物种稳定性的公司的生计。

您的团队已被苏格兰北大西洋渔业管理协会聘为顾问。如果全球海洋温度升高，该财团希望更好地了解与苏格兰鲱鱼和鲭鱼从其目前在苏格兰附近的栖息地迁徙有关的问题。这两种鱼类是苏格兰渔业的重要经济来源。鲱鱼和鲭鱼种群位置的变化可能使以苏格兰为基地的小型捕捞公司在经济上造成不确定风险，后者使用没有船上制冷的渔船来捕捞鲜鱼并将其运送到苏格兰渔港的市场。

要求

1. 建立一个数学模型，以识别未来50年内这两种鱼类最可能的位置，假设水温将发生足够的变化以导致种群移动。
2. 根据海水温度变化的速度，使用您的模型预测最佳情况、最坏情况和最有可能经过的时间，直到这些种群距离小渔业公司太远以至于如果小渔业公司继续在其当前位置外作业将一无所获。
3. 根据您的预测分析，这些小型捕捞公司是否应该改变其经营方式？
- a. 如果是，请使用您的模型为小型捕捞公司识别和评估实用且经济上有吸引力的策略。您的策略应考虑但不限于现实的选择，包括：
    - 将部分或全部捕捞公司的资产从苏格兰港口的当前位置迁移到两个鱼类种群都迁徙的附近；
    - 使用一定比例的小型渔船，这些渔船可以在没有陆上支持的情况下运行一段时间，同时仍确保渔获物的新鲜度和高质量。
    - 您的团队可以识别和模拟的其他可能的选项。
- b. 如果您的团队拒绝进行任何更改，请根据建模结果来说明拒绝的原因，因为建模结果与您的团队所做的假设有关。
4. 使用您的模型来解决: 如果有一部分渔业移至另一个国家的领海时您的建议受到的影响。
5. 除了技术报告外，还要为 Hook Line and Sinker 杂志准备一份长达两页的文章，以帮助渔民了解问题的严重性以及您提出的解决方案将如何改善他们的未来的业务前景。

您的提交应包括：

- 一页摘要表
- 目录
- 一页至两页的杂志文章
- 您的解决方案不超过20页，最多包含摘要，目录和文章的24页。

注意：参考列表和任何附录均不计入页数限制，应在完成解决方案后显示。您不应使用受版权法限制使用的未经授权的图像和材料。要确保您引用的想法的来源和报告中使用的材料。

专业词汇

- **渔业**：特定种类的鱼类及其栖息区域的集合。
- **栖息地**：生物或团体正常生活或发生的环境类型。
- **小型捕捞公司****：从事商业捕捞的公司，其资金来源非常有限或者用于购买新设备/船只的财务资源非常有限
- **领海（海洋）**：“根据1982年《联合国海洋法公约》的定义，是一条沿基线延伸最多 12 海里（22.2公里；13.8 英里）的沿海水带（通常是指低水位线）。领海被视为国家的主权领土，尽管允许外国船只（军用和民用）无害通过该海，或过境海峡；这种主权也延伸到上方的空域和下方的海底。” [领土水域，于 2020 年 1 月 28 日从维基百科 从 https://en.wikipedia.org/wiki/Territorial_waters 检索。]

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.

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.

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

- 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 land-based 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.

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.

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

Your submission should consist of:

- One-page Summary Sheet
- Table of Contents
- One- to Two-page Article
- Your solution of no more than 20 pages, for a maximum of 24 pages with your summary, table of contents, and article.

Note: Reference List and any appendices do not count toward the page limit and should appear after your completed solution. You should not make use of unauthorized images and materials whose use is restricted by copyright laws. Ensure you cite the sources for your ideas and the materials used in your report.

Glossary

- **Fishery**: The collection of fish of a given species and the area that they inhabit.

- **Habitat**: The type of environment in which an organism or group normally lives or occurs.

- **Small Fishing Company**: A company engaged in commercial fishing with limited or very limited financial resources to invest in new equipment/vessels.

- **Territorial Waters (sea)**: "as defined by the 1982 United Nations Convention on the Law of the Sea, is a belt of coastal waters extending at most 12 nautical miles (22.2 km; 13.8 mi) from the baseline (usually the mean low-water mark) of a coastal state. The territorial sea is regarded as the sovereign territory of the state, although foreign ships (military and civilian) are allowed innocent passage through it, or transit passage for straits; this sovereignty also extends to the airspace over and seabed below." [Territorial Waters. (n. In Wikipedia. Retrieved January 28, 2020, from https://en.wikipedia.org/wiki/Territorial_waters.]