The effects of acute gamma irradiation on the survival of Chinese black sleeper (Bostrichthys sinensis)

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1. Introduction
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1. Introduction
Main sources of radioactivity in Ocean

- **Global nuclear weapons testing, 1950s-'60s**: 400 peta-Bequerels (PBq)
- **Chernobyl**: 85 PBq
  - 10-30 PBq
  - 3-30 PBq
- **Fukushima**: 0.00004 PBq
- **Three Mile Island**: 0.00004 PBq
- **Potassium-40**: 15,000,000 PBq

Fukushima released 3 to 30 petaBequerels of radioactive cesium-137 directly into the sea and 10 to 30 PBq into the atmosphere, of which about 50% eventually ended up in the ocean.

Three Mile Island released 0.00004 PBq entirely into the air.

Chernobyl released 85 PBq, mostly into the air.

Nuclear weapons tests released 400 PBq over several years. The majority has eventually landed in the sea.

Though serious, these totals pale compared to the abundance of radioactive substances naturally present in seawater such as uranium-238 and potassium-40.

From Jack Cook, WHOI
Nuclear Energy Growth

Additional stressor to marine ecosystem?

What if another Fukushima accident happens??
## Existing studies

### From UNSCEAR (2008)

<table>
<thead>
<tr>
<th>Ecosystem (number of references)</th>
<th>Total number of data (%)</th>
<th>Number of data for each exposure duration</th>
<th>Number of data for each exposure irradiation pathway</th>
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<tr>
<td></td>
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<td><strong>Type</strong></td>
<td><strong>Total number</strong></td>
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<tr>
<td>Terrestrial (579)</td>
<td>19 883 (72.6)</td>
<td>Acute</td>
<td>12 273</td>
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<tr>
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<td></td>
<td>Chronic</td>
<td>6 795</td>
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<td>Acute</td>
<td>4 526</td>
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<td></td>
<td></td>
<td>Chronic</td>
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<tr>
<td>Marine (45)</td>
<td>1 470 (5.4)</td>
<td>Acute</td>
<td>1 116</td>
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</table>

**Few data for tropical ecosystem! No data from China!!**

From Gamier-Laplace (2006)
Objectives

- **To examine the effect of acute gamma radiation on the survival and biochemical indicators of a typical fish species in the coastal environment of China**
- **To provide essential information for radiological risk assessment and relevant stakeholders, including policymakers, nuclear regulators, environmental agencies, nuclear power plant, fisheries departments, marine aquaculture organizations and companies.**
Facts about Chinese black sleeper

- An intertidal species
  - More presumable pollution from both land and water
- A facultative air-breathing fish
  - Perfect for irradiation study
- High economic value
2. Methods
Sampling
Irradiation

- 5 irradiated groups + 1 control group
- ~60 individuals in each group
- Co-60 point source
- Single exposure of 3, 6, 12, 24 and 48 Gy (determined by Alanine dosimeter (Aerial, France), respectively
- Dose rate: 1.5 Gy/min
Culturing

- 25 ~ 26 °C
- Sterilized local seawater
- Fed with shrimp twice a week
3. Results and Discussion
**LD$_{50,30}$ Calculation Formulas**

- **Karber’s Method:**
  \[
  \lg LD_{50}^* = x_k - d \left[ \left( \sum_{i=1}^{k} p_i - (3 - p_1 - p_k) \right)/4 \right]
  \]
  - Where: $x_k$ – the log value of maximum dose
  - $d$ – the log value of dose difference
  - $p_i$ – mortality in group $i$

- **95 % confidence Interval:**
  \[
  \lg^{-1} \left( \lg LD_{50}^* \pm 1.96 S_{\lg LD_{50}} \right)
  \]
  \[
  S_{\lg LD_{50}} = d \sqrt{\frac{\sum p_i(1-p_i)}{n_i}}
  \]
**Estimated LD$_{50}$**

- $LD_{50} = 7.1 \text{ Gy (6.3 ~ 7.9 Gy)}$

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**LD$_{50}$ for acute irradiation:**

- 10-25 Gy

**Most sensitive aquatic organism:**

- Fish

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*From UNSCEAR (2008)*

**Diagram:**

- Viruses
- Molluscs
- Protozoa
- Bacteria
- Moss, lichen, algae
- Insects
- Crustaceans
- Reptiles
- Amphibians
- Fish
- Higher plants
- Birds
- Mammals

**ACUTE LETHAL DOSE (Gy):**

- $10^0$
- $10^1$
- $10^2$
- $10^3$
- $10^4$
4. Conclusion and prospects
Conclusion

- \( \text{LD}_{50, 30} \) for the acute irradiation on Chinese black sleeper was estimated to be 7.1 Gy, with a 95% confidence interval of 6.3 Gy to 7.9 Gy, which is lower than the previous value summarized by UNSCEAR. More experiments are needed to confirm the above result.
The way forward...

- DNA deficiency tests
- Chronic radiation experiment
- Other local species
Thank You!
谢谢(Xiè xiè)!