Engineering Practices for Maintainable Software

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Overview

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- Summary
What is Software Engineering?
What is Software Engineering?

- The application of a systematic, disciplined, quantifiable approach to the development and maintenance of software.
What is Software Engineering?

• The application of a **systematic**, disciplined, quantifiable approach to the development and maintenance of software.
What is Software Engineering?

- The application of a **systematic**, disciplined, quantifiable approach to the development and **maintenance** of software.
Analysis: break down a larger problem into smaller understandable pieces (modules).

Synthesis: construct software from the smaller understood pieces.
Analysis And Synthesis

Problem

Subproblem 1
Subproblem 2
Subproblem 3
Subproblem 4
Analysis And Synthesis

Generalized Stock Assessment Framework

- Mortality
- Spawning Biomass
- Recruitment
- Selectivity
- ...
Phases of A Software Engineering Project:

- Communication
- Planning
- Modeling
- Development
- Testing
- Deployment

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Communication:

• Meet with stakeholders.
• Gather requirements.
• Identify what exactly we are trying to solve.
• Document decisions.
Planning:

• Planning is iterative.

• Gauge the project scope.

• Identify what resources are needed to solve the problem.

• Engage stakeholders in planning activity.

• Communicate the development plan.
Modeling and Design:

- The **information domain** of the problem needs to be understood (information flows in and out of the system and subsystems).
- The **function** of the software should be defined.
- The **behavior** of the software should be represented.
Development:

- Use structured or object-oriented programming (both emphasize modularity).
- Use appropriate data structures.
- Write self-describing code.
- Conduct regular code reviews.
- Unit test code.
- Refactor as necessary.
Software Engineering in Practice

Testing:

• Identify areas that need improvement.
• All test should be traceable to software requirements.
• Tests should be planned before testing begins.
Software Engineering in Practice

**Deployment:**

- A complete package should be created.
- A support system should be established prior to release.
- Documentation should be provided to the end user.
- A maintenance plan should be established (extensions and updates).
Core Principles of SE

Starting High Level

- *Think about the problem before you start to develop the solution*

- *Divide and Conquer*
  - Break down the problem into smaller understandable modules.
  - This makes a large problem manageable.

- *KISS (Keep It Simple, Stupid!)*
  - Don’t add unnecessary complexity.

- *Keep Learning*
  - Stay up to date on new technology.
  - Acknowledge your mistakes and learn from them.

- *Remember the purpose of the software*
  - Keep the big picture in mind.
  - Don’t add unnecessary functionality.

- *Remember you aren’t necessarily the end user*
  - Keep in mind the end user won’t necessarily be as familiar with the system as you.
Core Principles of SE

The Process

• **Have a Vision.**
  - If you don’t know exactly what to build, you won’t build the right thing.
  - Ask questions and get clarity.

• **Be Systematic**
  - Take a logical and thoughtful approach to the design.
  - Analyze and Synthesize.

• **Develop Iteratively**
  - Supports modularity.
  - Compliments extensibility.

• **Make it work first, then optimize**
  - Write it first, profile and optimize after.
Core Principles of SE

Put thought into the Code

- **YAGNI (You Ain't Gonna Need It!)**
  - Don’t add features that aren’t required.
  - Don’t add features that aren’t required.
  - Don’t add features that aren’t required

- **DRY (Don't Repeat Yourself)**
  - Reuse code whenever possible.

- **Don’t re-invent the wheel**
  - Use existing solutions if the code isn’t related to the fundamentals of your application.
  - Just be aware of deep dependency and the issues that may arise.

- **Debugging is harder than writing code**
  - Write readable code rather than compact code.
  - It’s likely that someone else will have to work on your code later.
Programming Paradigms
Programming Paradigms: Structured Programming

What is structured programming?
What is structured programming?

In structured programming, the program is divided into small modules so it’s easier to understand.
Programming Paradigms: *Structured Programming*

- A logical programming method that is considered a precursor to object-oriented programming (OOP).
- Facilitates program understanding and modification
- Has a top-down design approach
- A system is divided into compositional subsystems
Programming Paradigms: *Structured Programming*

While not done

- **Spawn_Recruit**
  - Compute $S_0$
  - Compute # recruits

- **Mortality**
  - Compute $F$
  - Compute $Z$

- **NumbersAtAge**
  - So on...

- **CatchAtAge**
  - So on...
Programming Paradigms: *Structured Programming*

```
Main
|
↓
Spawn_Recruit
  ↓
  Compute S0
  ↓
  Compute # recruits

Mortality
  ↓
  Compute F

NumbersAtAge
  ↓
  Compute Z

CatchAtAge
```
Programming Paradigms:

Object-oriented Programming

What is object oriented programming?
What is object oriented programming?

Object-oriented programming (OOP) is a software programming model constructed around objects. This model compartmentalizes data into objects (data fields) and describes object contents and behavior through the declaration of classes (methods).
Programming Paradigms:  
Object-oriented Programming

What is an Object?

• Software representation of a real-world object

• Just as with real-world objects, software objects have state and behavior
  • For example, Dogs have state (name, color, breed) and behavior (barking, fetching, drooling)
Programming Paradigms:  
*Object-oriented Programming*

Key concepts of OOP

- **Encapsulation**: This makes the program structure easier to manage because each object’s implementation and state are hidden behind well-defined boundaries.

- **Polymorphism**: This means abstract entities are implemented in multiple ways.

- **Inheritance**: This refers to the hierarchical arrangement of implementation fragments (reusability).
Programming Paradigms:  
Object-oriented Programming

Encapsulation:

Refers to an object's ability to hide data and behavior that are not necessary to its user. Encapsulation allows a group of members and methods to be represented as a single unit.

Benefits:

- Protection of data from accidental corruption
- Flexibility and extensibility of the code
- Reduction in complexity
- Lower coupling between code fragments and hence improvement in code maintainability
Programming Paradigms: 
Object-oriented Programming

Polymorphism:

The dictionary definition of *polymorphism* refers to a principle in biology in which an organism or species can have many different forms or stages. This principle can also be applied to object-oriented programming.
Object-oriented Programming

Polymorphism:

class SelectivityBase {
public:
    virtual double Evaluate(double age) = 0;
};

class Logistic : public SelectivityBase {
    double a50;
    double s;
public:
    virtual double Evaluate(double age) {
        return 1.0 / (1.0 + exp(-1.0 * (age - a50) / s));
    }
};

class DoubleLogistic : public SelectivityBase {
    double alpha_asc;
    double beta_asc;
    double alpha_desc;
    double beta_desc;
public:
    virtual double Evaluate(double age) {
        return (1.0 / (1.0 + exp(-beta_asc * (age - alpha_asc) / (1.0 - (1.0 / (1.0 + exp(-beta_desc * (age - a))))));
    }
};
Programming Paradigms:  
Object-oriented Programming

Polymorphism:

class SelectivityBase {
    public:
        virtual double Evaluate(double age) = 0;
};

class Logistic : public SelectivityBase {
    double a50;
    double s;
    public:
        virtual double Evaluate(double age) {
            return 1.0 / (1.0 + exp(-1.0 * (age - a50) / s));
        }
};

class DoubleLogistic : public SelectivityBase {
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    double beta_asc;
    double alpha_desc;
    double beta_desc;
    public:
        virtual double Evaluate(double age) {
            return (1.0 / (1.0 + exp(-beta_asc * (age - alpha_asc) 
                  (1.0 - (1.0 / (1.0 + exp(-beta_desc * (age - a
                  )

            );


\text{Same Signature, Different Logic}
Polymorphism:

```cpp
class SelectivityBase {
public:
    virtual double Evaluate(double age) = 0;
};

class Logistic : public SelectivityBase {
    double a50;
    double s;
public:
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class DoubleLogistic : public SelectivityBase {
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            (1.0 - (1.0 / (1.0 + exp(-beta_desc * (age - a
```
Programming Paradigms: Object-oriented Programming

Inheritance:

Inheritance allows the user to define a class in terms of another class, which makes it easier to create and maintain an application. This also provides an opportunity to reuse the code functionality and fast implementation time.
Inheritance:

A class can be derived from more than one classes, which means it can inherit data and functions from multiple base classes. To define a derived class, we use a class derivation list to specify the base class(es)
Programming Paradigms:

Object-oriented Programming

Inheritance:

class Shape {
public:

    void SetHeight(int height) {
        this->height = height;
    }

    void SetWidth(int width) {
        this->width = width;
    }

protected:
    int height;
    int width;
};

class Rectangle : public Shape{
public:
    int area(){
        return this->height*this->width;
    }
};

int main(int argc, char** argv) {

    Rectangle r;
    r.SetHeight(10);
    r.SetWidth(2);
    std::cout<<r.area()<<"\n";

    return 0;
}

Output

20
Programming Paradigms: 
**Object-oriented Programming**

Inheritance:

```cpp
class Shape {
public:

    void SetHeight(int height) {
        this->height = height;
    }

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    }

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```

Output

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Programming Paradigms:
Object-oriented Programming
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class Rectangle : public Shape{
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    Rectangle r;
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    return 0;
}

Output
20
Key Concepts
Key Concepts

• **Modularity**
• **Reusability**
• **Extensibility**
• **Extensible Design**
• **Iterative Development**
• **Scalability**
• **Maintainability**
Key Concepts: Modularity

- Well defined, independent components (functions or objects)
- Perform logically discrete functions
- Building blocks for a larger component(s)
- Can be implemented and tested in isolation before integration
- Accommodates division of work
- Improves maintenance
Key Concepts: **Modularity**

Generalized Stock Assessment Framework

- Mortality
- Spawning Biomass
- Recruitment
- Selectivity

...
Key Concepts: *Modularity*

Generalized Stock Assessment Framework

- Mortality
- Spawning Biomass
- Recruitment
- Selectivity
Reusability, a product of modularity, is the use of existing elements within the software development process. These elements are products and by-products of the software development life cycle and include code, test suites, designs and documentation.
Key Concepts: Extensibility

Extensibility is the measure of a software components capacity to be appended with additional members or features. An application is considered extensible when its operations may be augmented with add-ons and plugins without the need for reengineering.
Key Concepts: Extensible Design

- Extensible design is to accept that not all features can be designed in advance

- The system starts as basic framework that allows for changes (extensions)

- Extensible design allows small changes to be implemented upon request (Agile development)

- Extensibility imposes fewer dependencies during development
Iterative development is a methodology that divides the project into smaller pieces (modules). The main concept of iterative development is to create small projects with well defined scope within a project. Iterative development naturally complements extensible design.
What is scalability?
What is scalability?

*Software scalability refers to a system's ability to handle an increase in workload.*
Key Concepts: Scalability

- A system is said to be scalable when it does not require reengineering to handle an increase in workload.

- “Workload” may refer to required data storage, number of users, or anything that pushes the software past its original capacity.

- Designing software with scalability in mind saves time and money in the future.
Key Concepts: Scalability

What’s the problem with scaling failures?
Key Concepts: Scalability

What’s the problem with scaling failures?

- Increased workload becomes a barrier to productivity.
What’s the problem with scaling failures?

• Increased workload becomes a barrier to productivity.

• “Fixes” add complexity.
Key Concepts: Scalability

What’s the problem with scaling failures?

- Increased workload becomes a barrier to productivity.
- “Fixes” add complexity.
- Complexity increases cost and decreases effectiveness.
Key Concepts: Scalability

What’s the problem with scaling failures?

- Increased workload becomes a barrier to productivity.
- “Fixes” add complexity.
- Complexity increases cost and decreases effectiveness.
- Users abandon the product.
Scaling Up

- Refers to the idea of adding more advanced hardware to handle the increase in workload. For example, a faster CPU or more memory.

- *Best performance solution, most costly.*
Key Concepts: Scaling Failure Solutions

Scaling Out

• Refers to the idea of adding more hardware, not more advanced hardware.

• Much more widely used solution.

• Cost is lower because there isn’t a need for more advanced hardware.
Key Concepts: **Maintainability**

**Maintenance** is the action of modifying a software product after initial release.

**Maintainability** is the ease with which a software product can be modified.
Key Concepts: Maintainability

Categories:

- **Corrective Maintenance** is a task performed to identify and fix failures (bugs) in the system.

- **Adaptive Maintenance** is the implementation of a changes as result to a change in the environment. (hardware or operating system).

- **Perfective Maintenance** is the extension and improvement of the software quality.
Key Concepts: Maintainability

Software Quality Characteristics for Enhanced Maintainability:

- **Flexibility**: The ease at which the software can be amended.
- **Reliability**: Performance should be reliable with minimal faults.
- **Portability**: The application should run on different platforms, Linux, Windows, Mac OS, etc.
- **Efficiency**: Practical and efficient use of system resources.
- **Testability**: Software should be tested easily and as a result users can easily check that the results are correct.
- **Understandability**: Software should be easy for users to understand.
- **Usability**: Usage is easy and comfortable.
Tips For Better Code
Why Have a Coding Convention?
Tips For Better Code: Coding Convention

Why Have a Coding Convention?

• 80% of a product’s lifetime cost goes to maintenance.

• Software is usually maintained by someone other than the original author.

• Code conventions improve readability.
Tips For Better Code: Coding Convention

Common Coding Conventions

- **C**
  - SEI CERT
  - Bar Group
- **C++**
  - Google
  - SEI CERT C++
- **Java**
  - Java Code Convention
  - Software Monkey
- **R**
  - R-core
Write Useful Comments

You won’t appreciate them until you’ve stopped working on a project for a while. Useful Comments make it easier for you and those after you who have to maintain your code.

- Write meaningful, single line comments for easily understood components.
- Write full paragraphs for components that are not easily understood.
- For complex blocks of logic, describe what’s going on in words before the logic appears.
Tips For Better Code: Self-Describing Code

Write Self-Describing Code

Give Symbols Human readable names.
• It makes source code easier to understand.
• It makes code easier to maintain and extend.
Tips For Better Code: Self-Describing Code

Write Self-Describing Code

Give Symbols Human readable names.
  • It makes source code easier to understand.
  • It makes code easier to maintain and extend.

Example

```java
double sel(double a) {
    return 1.0 / (1.0 + exp(-1.0 * (a - a50) / s));
}

double calculate_logistic_selectivity(double age) {
    return 1.0 / (1.0 + exp(-1.0 * (age - a50) / s));
}
```
Tips For Better Code: Use An IDE

Use an Integrated Development Environment

Benefits:
• Expands Coders Capabilities.
• Increased Functionality.
• Navigate to members by treating them as hyperlinks.
• Autocompletion when you can't remember the names of all members.
• Automatic code generation.
• Refactoring.
Tips For Better Code: Use An IDE (Continued)

**Use an Integrated Development Environment**

**Benefits:**
- Warning-as-you-type.
- Automated Testing.
- Integrated Debugger.
- Profiling.
- Integrated Source Control.
- Auto Code Formatting.
- Auto Code Completion.
- Call Graph Generation.
What is Refactoring?

Definition:

Refactoring consists of improving the internal structure of an existing program’s source code, while preserving its external behavior.

Benefits:

• Refactoring improves objective attributes of code (length, duplication, coupling and cohesion, cyclomatic complexity) that correlate with ease of maintenance.

• Refactoring helps code understanding.

• Refactoring encourages each developer to think about and understand design decisions, in particular in the context of collective ownership / collective code ownership.

• Refactoring favors the emergence of reusable design elements (such as design patterns) and code modules.
Avoid global variables whenever possible!

- A global variable is a variable defined in the 'main' program. Such variables are said to have 'global' scope.

- A local variable is a variable defined within a function. Such variables are said to have ‘local’ scope.

- They can be modified anywhere in the program, making it difficult to find the source of change.

- Functions can access global variables and modify them.

- They violate the concept of modular programming.

- It’s better practice to send a variable as a parameter to a function.
Tips For Better Code: Use Meaningful Names

Use Meaningful Names:

- Good code should be meaningful in terms of variable names, function/method names, and class names.

- Don’t use names like “fyr” or “lyr” for your variables. It is not informative. “first_year” and “last_year” would be more meaningful.

For example:

```csharp
double calculate_logistic_selectivity(double age) {
    return 1.0 / (1.0 + exp(-1.0 * (age - a50) / s));
}
```
Tips For Better Code: *Use Meaningful Names*

**Use Meaningful Names:**

- Good code should be meaningful in terms of variable, function/method names, and class names.

- Don't use names like “fyr” or “lyr” for your variables. It is not informative. “first_year” and “last_year” would be more meaningful.

**For example:**

```java
double calculate_logistic_selectivity(double age) {
    return 1.0 / (1.0 + exp(-1.0 * (age - a50) / s));
}
```

It's obvious what this function does and what it's parameter is!
Tips For Better Code: *Use Meaningful Names*

Use Meaningful Names:

- Good code should be meaningful in terms of variable/function/method names, and class names.
- Don’t use names like “fyr” or “lyr” for your variables. It is not informative. “first_year” and “last_year” would be more meaningful.

For example:

```java
double calculate_logistic_selectivity(double age) {
    return 1.0 / (1.0 + exp(-1.0 * (age - a50) / s));
}
```

The verb “calculate” makes it clear that the function is doing a calculation rather than a lookup. The “logistic_selectivity” makes it clear what the return value is.
Use Meaningful Structures:

• Use a naming convention when naming directories and files.

• Use simple directory structures.

• Keep the directory hierarchy as shallow as possible.

• Try to split up code by it’s business logic (modules).
Tips For Better Code: Use Version Control System

Version Control:

- There are many varieties to choose from.
- Managing changes should be easy.
- Choose whatever version control software works best for the workflow of you and your team.

Popular Choices:
- Git
- Mercurial
- Apache Subversions
Tips For Better Code: Use Documentation Generators

Code Documenters

• For large projects with many classes and functions, it’s convenient to automatically generate API documentation.

• Document generators are useful for keeping track of what’s going on in the code.

Useful Documentation Generators:

• Doxygen
• JavaDocs
• roxygen
Tips For Better Code: **Code For Efficiency**

**Code Efficiency:**

- Code efficiency plays a vital role in applications in a high-execution-speed environment where performance and scalability are foremost.

- The goal of code efficiency is to reduce resource consumption and completion time as much as possible.

- Simply put, the more efficient the code, the lower the computational overhead!
Example of Inefficient Code:

```cpp
tips For Better Code: Code For Efficiency

enum RecruitmentFunction {
    BEVERTONHOLT = 0,
    RICKER,
    DERISO,
    SHEPARD
};

double calculate_recruitment(double spawning_biomass, RecruitmentFunction recruitment_function) {
    if (recruitment_function == BEVERTONHOLT) {
        return beverton_holt(spawning_biomass);
    } else if (recruitment_function == RICKER) {
        return ricker(spawning_biomass);
    } else if (recruitment_function == DERISO) {
        return deriso(spawning_biomass);
    } else if (recruitment_function == SHEPARD) {
        return shepard(spawning_biomass);
    } else {
        std::cout << "Error: unknown recruitment function" << std::endl;
        return 0.0;
    }
}
```
Example of Inefficient Code:

```cpp
enum RecruitmentFunction {
    BEVERTONHOLT = 0,
    RICKER,
    DERISO,
    SHEPARD
};

double calculate_recruitment(double spawning_biomass, RecruitmentFunction recruitment_function) {
    if (recruitment_function == BEVERTONHOLT) {
        return beverton_holt(spawning_biomass);
    } else if (recruitment_function == RICKER) {
        return ricker(spawning_biomass);
    } else if (recruitment_function == DERISO) {
        return deriso(spawning_biomass);
    } else if (recruitment_function == SHEPARD) {
        return shepard(spawning_biomass);
    } else {
        std::cout << "Error: unknown recruitment function" << std::endl;
        return 0.0;
    }
}
```

Case statements are expensive operations.
**Tips For Better Code: Code For Efficiency**

**Example of Efficient Code Using the Structured Programming Paradigm:**

```cpp
enum RecruitmentFunction {
    BEVERTONHOLT = 0,  
    RICKER,           
    DERISO,           
    SHEPARD
};

typedef double(*recruitment_function_ptr)(double);

std::vector<recruitment_function_ptr> recruitment_functions
    = { &beverton_holt, &ricker, &deriso, &shepard };

double calculate_recruitment(double spawning_biomass, RecruitmentFunction recruitment_function) {
    return recruitment_functions[recruitment_function](spawning_biomass);
}
```
Example of Efficient Code Using the Structured Programming Paradigm:

```cpp
enum RecruitmentFunction {
    BEVERTONHOLT = 0,
    RICKER,
    DERISO,
    SHEPARD
};

typedef double(*recruitment_function_ptr)(double);

std::vector<recruitment_function_ptr> recruitment_functions
    = {&beverton_holt, &ricker, &deriso, &shepard};

double calculate_recruitment(double spawning_biomass, RecruitmentFunction recruitment_function) {
    return recruitment_functions[recruitment_function](spawning_biomass);
}
```

The correct function is called directly without the use of case statements.
Tips For Better Code: *Code For Efficiency*

*Example of Efficient Code Using the Object-Oriented Programming Paradigm:*

```cpp
enum RecruitmentFunction {
    BEVERTONHOLT = 0,
    RICKER,
    DERISO,
    SHEPARD
};

class recruitment_model_base {
    public:
        virtual double calculate_recruits(double spawning_biomass) = 0;
};

class beverton_holt : public recruitment_model_base {
    public:

        double calculate_recruits(double spawning_biomass) {
            ...
        }
};
```
Tips For Better Code: \textit{Code For Efficiency}

\textbf{Example of Efficient Code Using the Object-Oriented Programming Paradigm (Continued):}

class ricker : public recruitment_model_base {
    public:

        double calculate_recruits(double spawning_biomass) {
            ...
        }
};

class deriso : public recruitment_model_base {
    public:

        double calculate_recruits(double spawning_biomass) {
            ...
        }
};

class shepard : public recruitment_model_base {
    public:

        double calculate_recruits(double spawning_biomass) {
            ...
        }
};
Example of Efficient Code Using the Object-Oriented Programming Paradigm (Continued):

```cpp
recruitment_model_base* recruitment_model;

void initialize_recruitment_model(RecruitmentFunction recruitment_function) {
    switch (recruitment_function) {
        case BEVERTONHOLT:
            recruitment_model = new beverton_holt();
            break;
        case RICKER:
            recruitment_model = new ricker();
            break;
        case DERISO:
            recruitment_model = new deriso();
            break;
        case SHEPARD:
            recruitment_model = new shepard();
            break;
        default:
            std::cout << "Error: unknown recruitment function, using beverton_holt" << std::endl;
            recruitment_model = new beverton_holt();
    }
}
```
Tips For Better Code: **Code For Efficiency**

**Example of Efficient Code Using the Object-Oriented Programming Paradigm (Continued):**

```c++
recruitment_model_base* recruitment_model;

void initialize_recruitment_model(RecruitmentFunction recruitment_function) {
    switch (recruitment_function) {
        case BEVERTONHOLT:
            recruitment_model = new beverton_holt();
            break;
        case RICKER:
            recruitment_model = new ricker();
            break;
        case DERISO:
            recruitment_model = new deriso();
            break;
        case SHEPARD:
            recruitment_model = new shepard();
            break;
        default:
            std::cout << "Error: unknown recruitment function, using beverton_holt" << std::endl;
            recruitment_model = new beverton_holt();
    }
}
```

**Recruitment model pointer**
Example of Efficient Code Using the Object-Oriented Programming Paradigm (Continued):

```cpp
recruitment_model_base* recruitment_model;

void initialize_recruitment_model(RecruitmentFunction recruitment_function) {
    switch (recruitment_function) {
    case BEVERTONHOLT:
        recruitment_model = new beverton_holt();
        break;
    case RICKER:
        recruitment_model = new ricker();
        break;
    case DERISO:
        recruitment_model = new deriso();
        break;
    case SHEPARD:
        recruitment_model = new shepard();
        break;
    default:
        std::cout << "Error: unknown recruitment function, using beverton_holt" << std::endl;
        recruitment_model = new beverton_holt();
    }
}
```
Example of Efficient Code Using the Object-Oriented Programming Paradigm (Continued):

```cpp
inline double calculate_recruitment(double spawning_biomass) {
    return recruitment_model->calculate_recruits(spawning_biomass);
}
```

The correct method is called without the use of case statements.
What is a Profiler?

A profiler is an instrument used to perform dynamic analysis in a running application in order to obtain information on performance in regards to memory and CPU usage.
Tips For Better Code: Use A Profiler

Why Use A Profiler?

- Profilers allow you to find bottlenecks quickly.
- Find memory leaks.
- Collect statistics, such as memory usage, number of function calls, amount of time spent in a function, etc.
Tips For Better Code: Use A Profiler
Tips For Better Code: Use A Profiler

Vital runtime information
Summary

- Use a disciplined/systematic approach to development.
- Use a modular design pattern.
- Keep the design simple.
- Use a structured or object-oriented programming paradigm.
- Remember the key concepts.
  - Modularity
  - Extensibility
  - Scalability
  - Incremental Development
  - Maintainability
- Use efficient, but readable code.
- Profile often.
Questions?