Conclusion for Fish Prediction Notebook

Results Analysis and Key Findings

1) Training Duration Impact (50, 100, 200 epochs)

- Model performance plateaus within the first 30-50 training cycles
- 50 epochs: Achieved test accuracy of ~94.73% with consistent learning curves
- 100 epochs: Marginal improvement to ~94.9%, with early stopping triggered around epoch 65
- 200 epochs: Performance degradation to ~94.36%, early stopping at epoch 54
- Extended training periods lead to **moderate overfitting**, evidenced by fluctuating per-class recall metrics

Key Insight: Additional training epochs beyond the saturation point provide minimal gains while introducing overfitting risks.

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2) Learning Rate Analysis (1e-4, 1e-3, 1e-2)

- **Conservative rate (1e-4)**: Gradual but steady progress, achieving final accuracy of ~92.89%
- **Optimal rate (1e-3)**: Superior performance balance, reaching peak accuracy of ~95.34% and final score of ~95.10%
- **Aggressive rate (1e-2)**: Rapid initial progress with training instability, final accuracy of ~94.98%

Key Insight: The moderate learning rate delivers optimal convergence speed and stability; conservative rates lead to underfitting while aggressive rates cause training instability.

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3) Network Architecture Comparison (layers/neurons)

- **Minimal architecture (1×32)**: Insufficient model complexity, resulting in underfitting (~93.75%)
- **Balanced architectures (2×64, 2×128)**: Consistent performance around 94.7-94.8%
- **Complex architecture (3×64)**: Early peak performance (~94.98%) but reduced training stability
- **Over-parameterized (3×128)**: Suboptimal results (~94.49%) despite increased capacity

Key Insight: Increased model complexity can achieve higher peak performance but at the cost of training stability; moderate architectures provide superior generalization.

4) Summary of Findings

- Performance peaks occur earlier with higher learning rates and increased model capacity, but may deteriorate with prolonged training
- Optimal strategy: **Early stopping near peak performance** combined with **moderate model complexity** and **balanced learning rate** to ensure both stability and generalization capability

Executive Summary

This comprehensive analysis of neural network hyperparameters for fish species classification reveals that model optimization requires careful balance rather than simply maximizing parameters. The study demonstrates that:

1. **Training efficiency**: Models reach optimal performance within 30-50 epochs, with extended training offering diminishing returns
2. **Learning rate optimization**: A moderate learning rate (1e-3) provides the best trade-off between convergence speed and stability
3. **Architecture design**: Moderate complexity architectures outperform both simple and overly complex designs in terms of generalization
4. **Performance strategy**: The combination of appropriate early stopping, balanced model capacity, and optimal learning rate yields the most reliable and generalizable results

The findings emphasize that effective deep learning model development prioritizes systematic hyperparameter tuning over brute-force parameter scaling.