Bahan Ajar:

1. Pencemaran Suhu (*thermal pollution*)

Hamdhani, S.P., M.Sc., Ph.D

Pencemaran Perairan (SKS: 3)

Definition

- Thermal pollution is any deviation from the natural temperature in a habitat and can range from elevated temperatures associated with industrial cooling activities to discharges of cold water into streams.

- Kata kunci: *penyimpangan dari suhu normal, lebih tinggi dan lebih rendah dari suhu normal*

Dodds, W. K., & Whiles, M. R. (2010). Chapter 16—Responses to Stress, Toxic Chemicals, and Other Pollutants in Aquatic Ecosystems. *Dodds, WK, Whiles, MR, Eds*, 399-436.

Polusi suhu pada perairan (thermal pollution)

- Degradasi kualitas air akibat proses atau kegiatan yang merubah suhu alamiah air

Apakah ini termasuk pencemaran suhu?

Yes!!

- Sebelum dibendung, sungai Colorado memiliki rentang suhu 0,5-27 °C
- Setelah dibendung (1963), air yang dilepaskan dari bendungan menjadi konstan 8 °C.
- Perubahan ini mengeliminasi spesies asli yang dilindungi pada sisi bawah bendungan

water release at Glen Canyon Dam

Razorback Sucker

Colorado Pikeminnow

Humpback Chub

Sumber-sumber polusi suhu

- **Effluent**: dari buangan air limbah olahan IPAL, ini merupakan hal yang paling banyak terjadi
- **Runoff**: air limpasan dari jalanan dan lahan parkir meningkatkan suhu runoff yang masuk ke badan air (masalah yang serius pada sungai-sungai kecil)
- **Penebangan hutan**: hilangnya naungan/teduhan vegetasi meningkatkan paparan sinar, di saat yang sama kenaikan kekeruhan akan meningkatkan ***heat absorption***, dan berdampak pada spesies yang sensitif

Effects of Clear-Cutting on Stream Temperature

Brown and Krygier, 1970. *Water Resources Research*, 6(4):1133-1139

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Effects of Clear-Cutting on Stream Temperature

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Abstract. The principal source of energy for warming streams is the sun. The amount of sunlight reaching the stream may be increased after clear-cut logging. Average monthly maximum temperatures increased by 14°F and annual maximum temperatures increased from 57° to 85°F one year after clear-cut logging on a small watershed in Oregon's coast range. In a nearby watershed where strips of brush and trees separated logging units from the stream, no changes in temperature were observed that could be attributed to clear-cutting.

INTRODUCTION

Timber, water, and sport and commercial fish are the principal resources in the Oregon coast range. The need for delineating the areas of conflict between logging and utilization of the other resources led to the establishment of the Alsea Logging-Aquatic Resources Study in 1958. The purpose of this broadly interdisciplinary study was to determine the effect of logging on the physical, chemical, and biological characteristics of small coastal streams.

The purpose of this paper is to describe the long-term effects of two clear-cuttings on the temperature regime of two small streams in Oregon's coast range. One watershed contained three small clear-cuts; the edges of the clear-cuts were at least 100 feet from the stream. The second watershed was completely clear-cut. An earlier report [*Brown and Krygier*, 1967] described the first-year effect of clear-cutting only during the logging operation on the completely clear-cut watershed. This report reviews results from a network of 18 thermograph stations distributed through the watersheds. The observation period extends from two years before logging through the fourth summer after logging.

Temperature is a significant water quality parameter. It strongly influences levels of oxygen and solids dissolved in streams. Temperature changes can induce algal blooms with subsequent changes in taste, odor, and color of a stream. Warm water is conducive to the growth and development of many species of aquatic bacteria, such as the parasitic columnaris disease. Increased populations of these bacteria may cause fish mortality [*Brett*, 1956]. The growth of fish may be directly affected by water temperature as demonstrated on juvenile coho salmon [*Brett*, 1956]. In short, water temperature is a major determinant of the suitability of water for many uses.

Research has been limited on temperature changes in small streams from land use, although fishery biologists have long been concerned with the effects of deforestation on water temperature. *Meehan et al.* [1969] studied the effects of clear-cutting on the salmon habitat of two southeastern Alaska streams. They noted a statistically significant increase in mean monthly temperatures after logging. The maximum increase in average monthly temperature was about 4°F. The increase in maximum temperature was about 9°F during July and August.

During a study of logging and southeastern trout streams, *Greene* [1950] reported that maximum weekly temperatures recorded during May on a nonforested stream were 13°F higher than those recorded on a nearby forested stream. He noticed also that the maximum temperature dropped from 80° to 68°F after the nonforested stream meandered through 400 feet of forest and brush cover.

Levno and Rothacher [1967] reported large temperature increases in two experimental watersheds in Oregon after logging. The shade provided by riparian vegetation in a patch-cut watershed was eliminated by scouring after large floods in 1964. Subsequently, mean monthly temperatures increased 7°–12°F from April to August. Average monthly maximums increased by 4°F after complete clear-cutting in a second

Effects of Clear-Cutting on Stream Temperature

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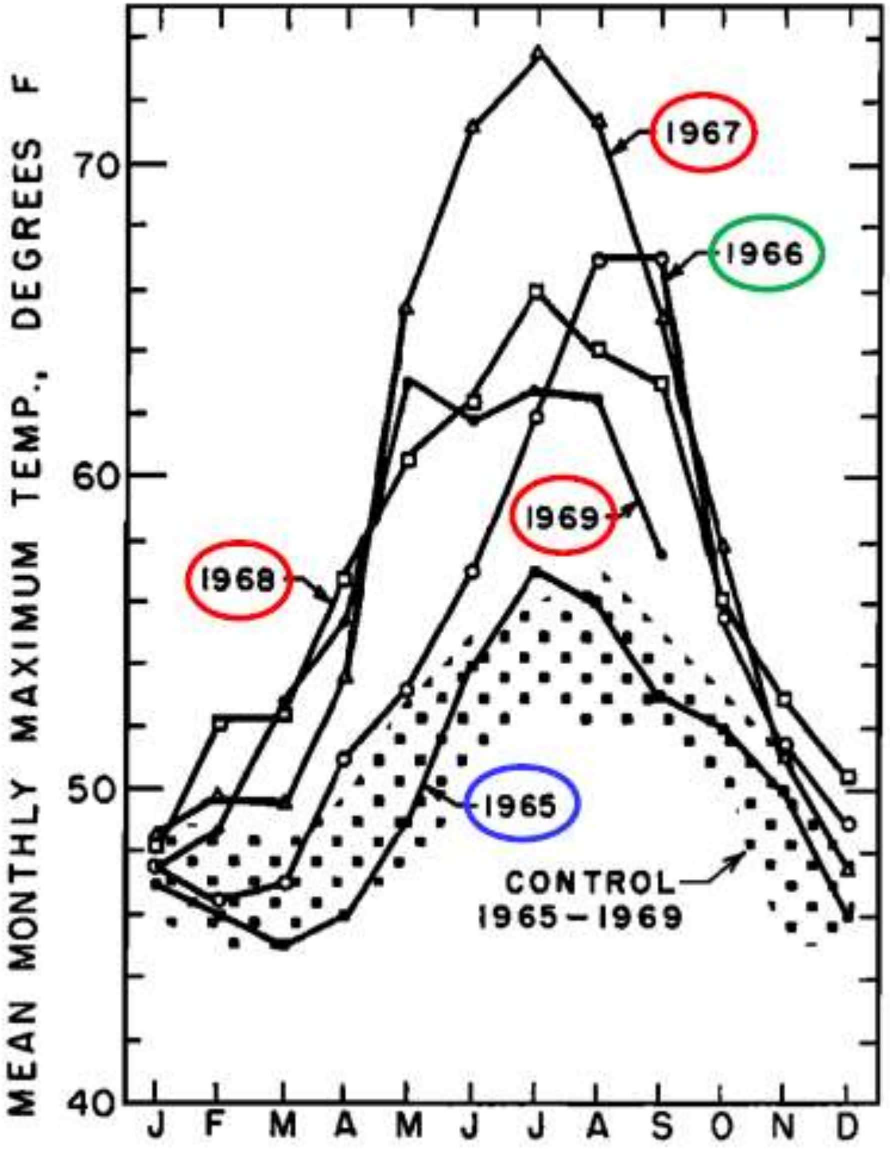


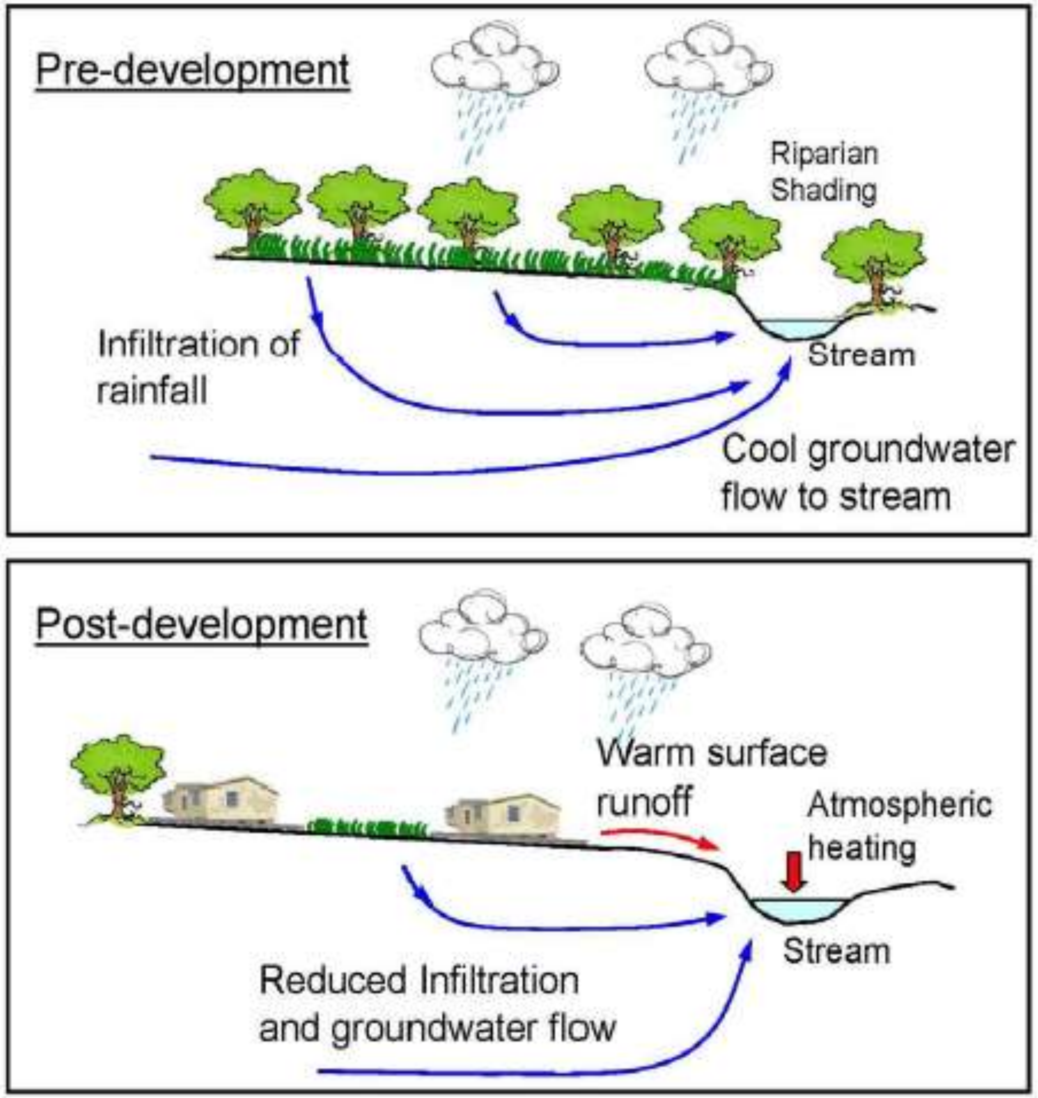
Fig. 4. Mean monthly maximum temperatures for the clear-cut and uncut control watersheds before (1965), during (1966), and after (1967–1969) logging.

First research that documented impact of clear-cut logging on stream temperature

Pembangunan urban dan efeknya pada suhu air sungai

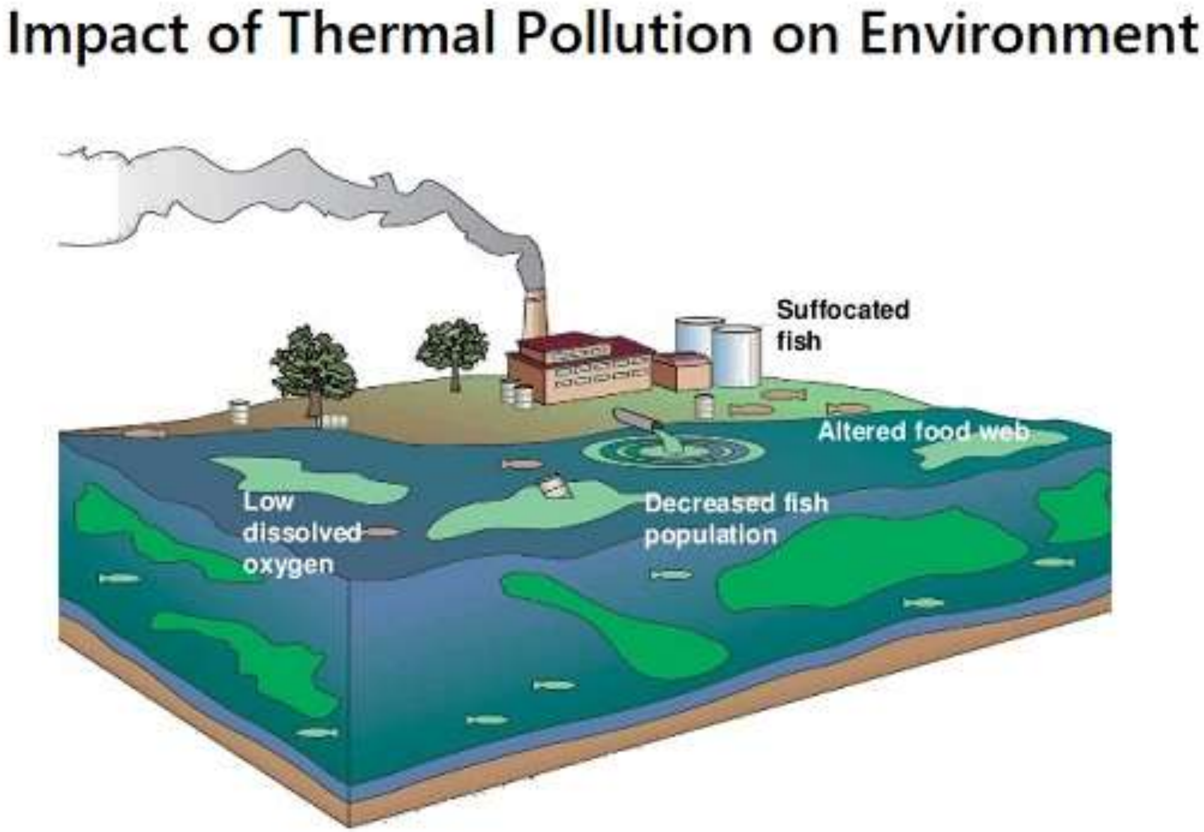
- Penggunaan dan pemanfaatan lahan mengubah cara air hujan berpindah dari daratan ke badan air (sungai dan danau)
- Kontributornya:

1. Peningkatan suhu aliran runoff
2. Mengurangi infiltrasi dan aliran air tanah
3. Berkurangnya vegetasi tepi sungai yang berdampak meningkatnya paparan sinar matahari



Lalu.. Apa konsekuansi dari polusi suhu pada perairan?

- Naiknya suhu air akan mengurangi kemampuan kelarutan gas-gas
- Naiknya suhu juga meningkatnya kelarutan garam di air
- Pada musim panas, suhu air akan mendekati suhu batas toleransi maksimal pada beberapa organisme akuatik
- Kenaikan suhu merupakan hal penting pada *algal blooms*
- Berperan penting pada pertumbuhan bakteri pathogen akuatik, seperti *Flexibacter columnare,* (columnaris disease) yang dapat menyebabkan kematian ikan



Algal bloom (eutrofikasi)

Nutrient:
Misalnya:
Nitrogen,
phosphorus

- Alga tumbuh subur lalu mati dan mengkonsumsi Oksigen →Low DO
- Blocking sunlight
- Meningkatkan suhu air → stratifikasi ↑ → lapisan alga semakin tebal
- Low DO → a big problem for aquatic organisms

- *F. columnare* infections may result in skin lesions, fin erosion and gill necrosis, with a high degree of mortality, leading to severe economic losses

- Necrosis is **the death of body tissue**

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Article

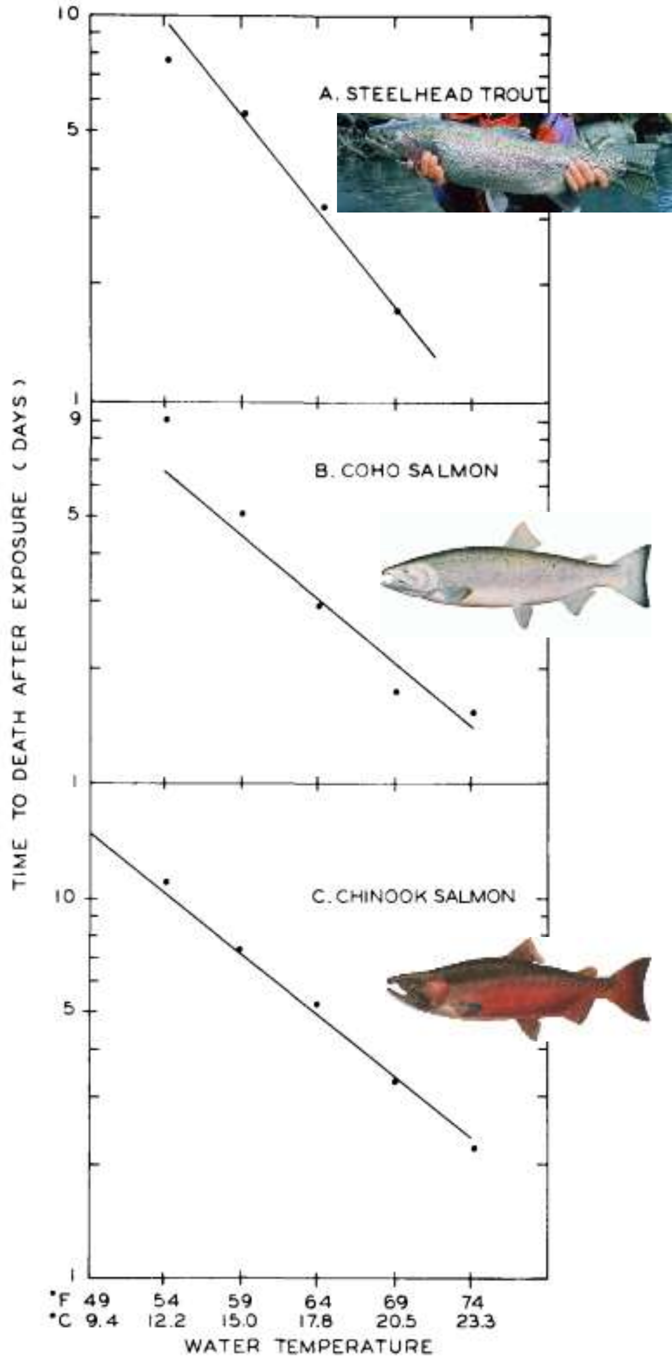
Relation of Water Temperature to *Flexibacter columnaris* Infection in Steelhead Trout (*Salmo gairdneri*), Coho (*Oncorhynchus kisutch*) and Chinook (*O. tshawytscha*) Salmon

Authors: R. A. Holt, J. E. Sanders, J. L. Zinn, J. L. Fryer, and K. S. Pilcher | AUTHORS INFO & AFFILIATIONS

Publication: Journal of the Fisheries Board of Canada • September 1975 • https://doi.org/10.1139/f75-182

Abstract

The effect of water temperature upon mortality from experimental infection by *Flexibacter columnaris* and on mean time to death was investigated in juvenile steelhead trout (*Salmo gairdneri*), coho salmon (*Oncorhynchus kisutch*), and spring chinook salmon (*Oncorhynchus tshawytscha*). Eight temperatures increasing from 3.9 to 23.3 C (39 to 74 F) by increments of 2.8 C (5 F) were studied. Fish were infected by the direct contact method whereby a suspension of the pathogen was added to the water. It was found that at temperatures of 9.4 C (49 F) and below, no deaths due to the experimental infection with *F. columnaris* occurred. At 12.2 C (54 F) mortality varied from 4 to 20% among the three species, and increased progressively with increasing temperature to 100% in steelhead trout and coho salmon at 20.5 C (69 F), and 70% in chinook salmon at that temperature. With all three salmonid species, an inverse linear relationship was



- Given that the metabolic rates of ectotherms are directly related to temperature and that the vast majority of freshwater organisms are ectothermic, thermal pollution can strongly affect freshwater communities.

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Organisme dan suhu tubuh

- Beberapa terminology:
- *Endotherm* – hewan yang menghasilkan suhu tubuhnya sendiri (berdarah panas)
- *Ectotherm* – hewan yang tidak dapat menghasilkan suhu tubuhnya sendiri (berdarah dingin)

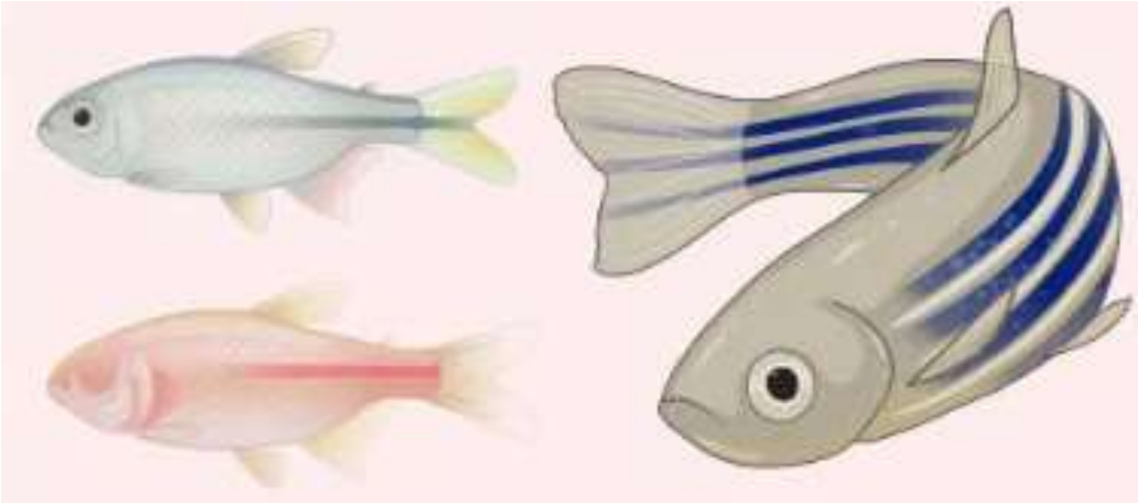
- *Homeotherm – hewan yang memiliki suhu tubuh konstan (homeostatis)*
- *Poikilotherm* – hewan yang suhu tubuhnya menyesuaikan dengan lingkungannnya

- *Heterotherm* – hewan yang dapat menyesuaikan suhu tubuh antara Poikilothermic dan Homeothermic

	Endothermic	Ectothermic
Homeothermic (Constant T)	Mostly birds and mammals, although the tuna and some other large fish come close.	Some tropical reptiles and possibly dinosaurs come close; of course, this box should include organisms occurring deep in the ocean or even in deep lakes.
Poikilothermic (Adjust T)	Some birds and mammals (those that allow their body temperature to vary during certain time periods) as well as many insects and some other invertebrates.	Most fish, amphibians, and reptiles as well as most invertebrates.

Ikan dan suhu air

- Temperature is the "***ecological master factor***" for fish (Brett, 1971)
- Ikan termasuk ***ectotherms*** (berdarah dingin) → ikan tergantung pada sumber panas dari luar untuk meregulasi suhu tubuhnya



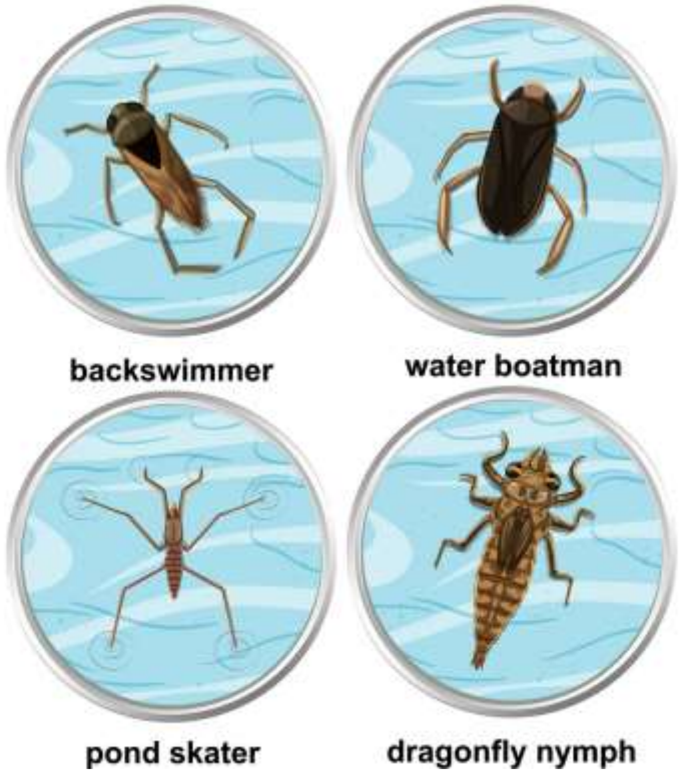
Brett, J. R. (1971). Energetic responses of salmon to temperature. A study of some thermal relations in the physiology and freshwater ecology of sockeye salmon (*Oncorhynchus nerka*). *Am. Zool. 11, 99-113.*

Ikan dan suhu air

Menurut laporan USGS tentang Suhu Air, dampak negatif dari perubahan suhu air pada ikan dapat meliputi:

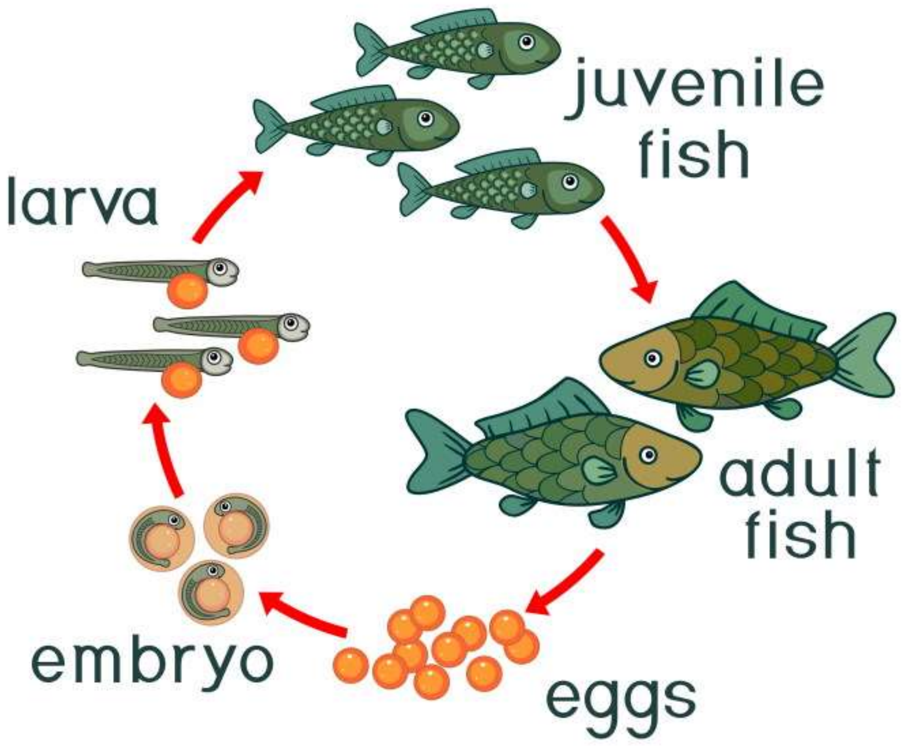
- Kematian dari dampak langsung (lethal temp, chill death)
- Kematian dari dampak tidak langsung (DO, gangguan pasokan makanan, reistensi terhadap penyakit menurun dll.)
- Gangguang aktivitas siklus hidup
- Kalah berkompetisi dengan spesies yang toleran
- Semua efek sekunder suhu air terhadap berbagai atribut kualitas air

- Raising water temperatures just 2 to 3°C above the optimal for some aquatic insects can greatly reduce the number of eggs produced by females because more energy is used to support higher metabolic rates and less is available for egg production (Vannote and Sweeney, 1980; Firth and Fisher, 1992)



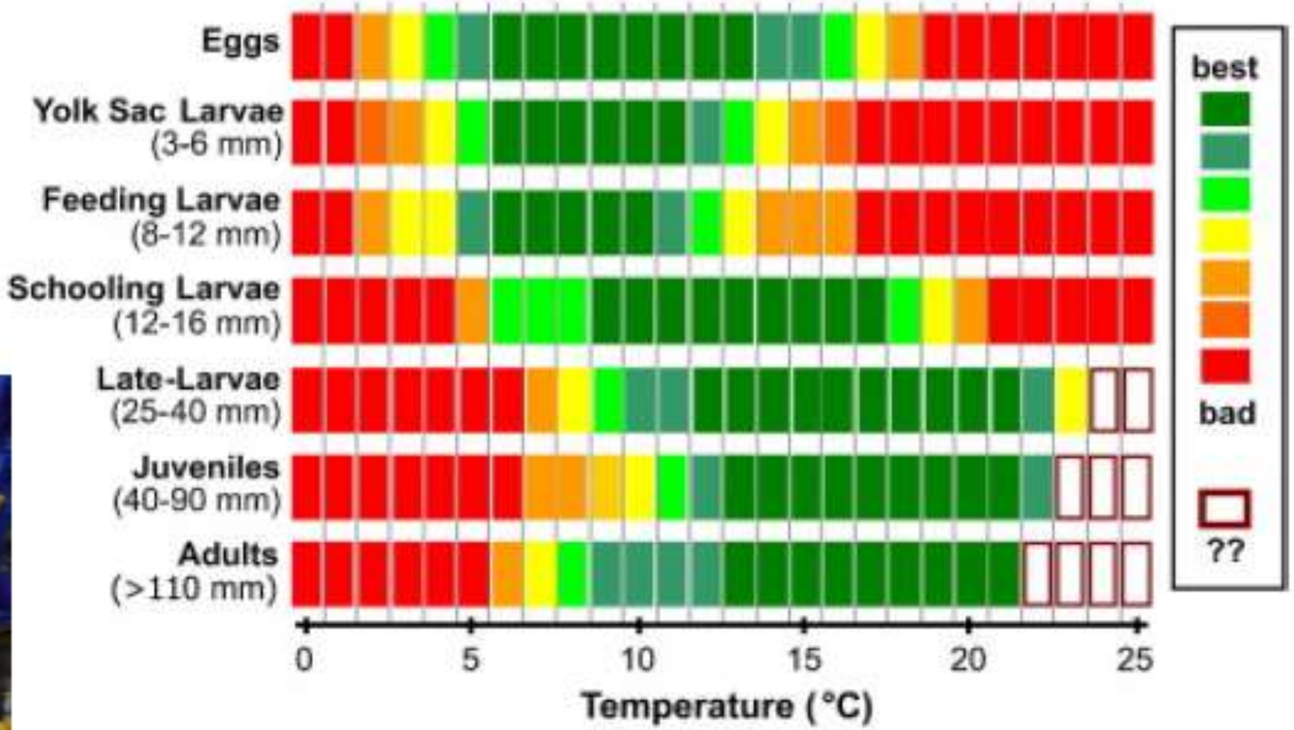
Ikan dan suhu air

- Ikan besar Vs Ikan kecil – Ikan berukuran besar relatif dapat dengan mudah menyesuaikan diri dengan perubahan suhu air pada periode waktu yang singkat (lebih banyak thermal inertia /buffering capacity)
- Siklus hidup ikan: (tiap fase mungkin memerlukan suhu spesifik)
    1. Egg -- Inkubasi
    2. Fry-larvae
    3. Juvenile
    4. Adult
    5. Spawning



Temperature-specific growth potential of European sprat (*Sprattus sprattus*) in the Baltic Sea

The European sprat, Sprattus sprattus, also known as bristling, brisling or skipper, is a herring-like marine fish



Peck et al. 2012. The ecophysiology of *Sprattus sprattus* in the Baltic and North Seas. *Progress in Oceanography*. 103, 42-57.

Dampak ekologi penting dari suhu air

- Effek dari suhu yang terlalu rendah atau terlalu tinggi
    - Metabolisme jadi semakin lambat
    - Kecepatan fotosintesis berkurang
    - Perubahan waktu reproduksi dan migrasi
    - Sebaran geografis spesies dapat berubah

- Suhu air terlalu tinggi juga akan:
    - Menurunnya kadar DO
    - Menyebabkan beberapa material menjadi lebih beracun terhadap biota akuatik (missal: ammonia)

Penanggulangan Pencemaran Suhu

- Mengenali sumber pencemar

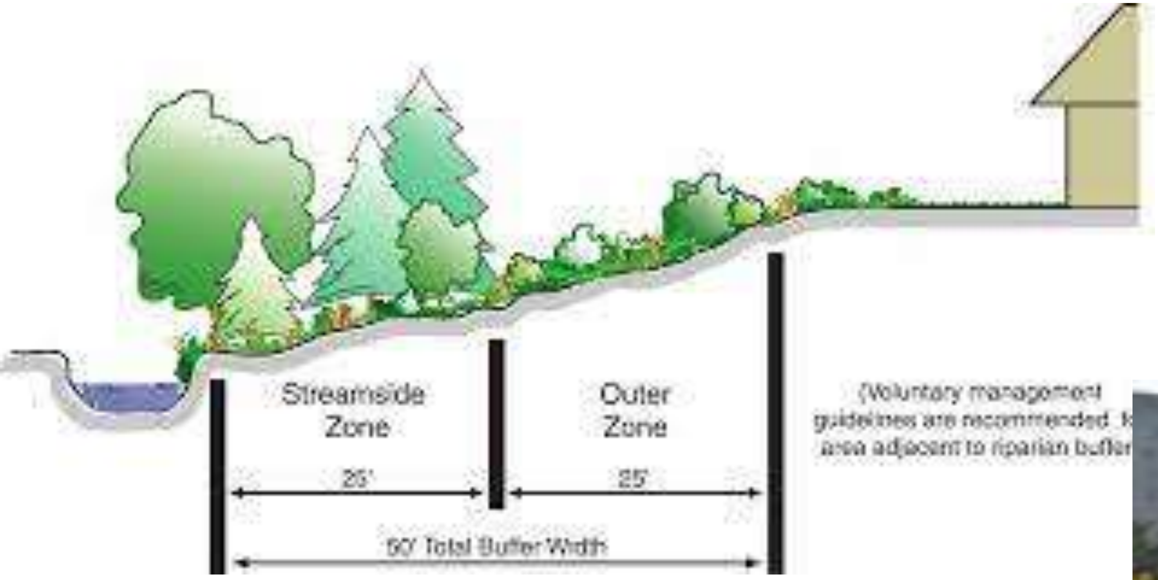
Sumber-sumber polusi suhu

- **Effluent**: dari buangan air limbah olahan IPAL, ini merupakan hal yang paling banyak terjadi
- **Runoff**: air limpasan dari jalanan dan lahan parkir meningkatkan suhu runoff yang masuk ke badan air (masalah yang serius pada sungai-sungai kecil)
- **Penebangan hutan**: hilangnya naungan/teduhan vegetasi meningkatkan paparan sinar, di saat yang sama kenaikan kekeruhan akan meningkatkan ***heat absorption***, dan berdampak pada spesies yang sensitif

- Pengelolaan untuk mengurangi dampak:

constructed wetland, riparian buffer zone, reforestration


91st Ave WWTP
S 91st Ave
S 99th Ave
ancho Osornio Lc
Tres Rios Wetlands
Tres Rios Wetlands Hayfield Site
Tres Rios Trailhead
Salt River
Salt River
Salt River
Google


Streamside
Zone
Outer
Zone
(Voluntary management
guidelines are recommended
area adjacent to riparian buffer
25'
25'
50' Total Buffer Width