Name: _____

IB DP ESS HL · Unit HL.b.2 · Weekly Homework

Coastal watershed runoff, hypoxia and natural capital valuation

____ / 19 marks

Investigation: How does distance downstream through a terraced coastal watershed affect nitrate concentration, dissolved oxygen, and seagrass cover?

Method: 1. Collect replicate water samples at 09:00 across four estuarine zones. 2. Measure nitrate concentration with a calibrated colorimeter. 3. Record dissolved oxygen using an optical probe at 0.4 m depth. 4. Estimate seagrass cover using five 0.5 m quadrats per zone.

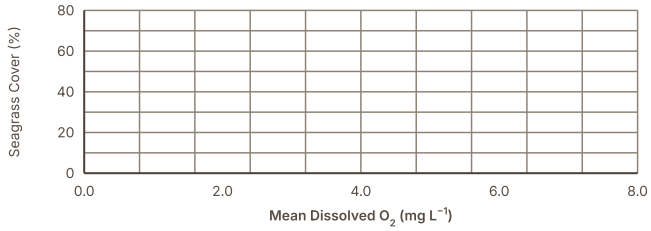
Variables: IV = Sampling zone | DV = Nitrate (mg L^{-1}), dissolved oxygen (mg L^{-1}), seagrass (%) | Controlled = Time (09:00), probe depth (0.4 m)

Key Words & Units: eutrophication = nutrient enrichment driving algal blooms · hypoxia = dissolved oxygen below 2.0 mg L^{-1} · indirect use value = non-market regulating service · externality = uncompensated third-party cost

Method tip: For percentage reduction, subtract Mangrove Cove nitrate from Terrace Drain nitrate, divide by Terrace Drain nitrate, then multiply by 100.

EAL sentence frame: Mean nitrate falls by [X]% across the mangrove buffer because ..., whereas Deep Basin hypoxia develops when ...

Sampling Zone	Mean Nitrate (mg L^{-1})	Mean Dissolved O_2 (mg L^{-1})	Seagrass Cover (%)
Terrace Drain	18.4	5.8	12
Upper Estuary	14.2	3.1	4
Deep Basin	9.6	1.4	0
Mangrove Cove	2.1	7.9	78



Grid for plotting Seagrass Cover (%) against Mean Dissolved O_2 (mg L^{-1})

Part A · Read & Process Data

Q1. Analyse nitrate decrease downstream toward the mangrove buffer. **[5]**

(a) Calculate the decrease in mean nitrate concentration from Terrace Drain to Mangrove Cove with units. [2]

(b) Calculate percentage reduction in mean nitrate from Terrace Drain to Mangrove Cove to 1 d.p. [3]

Q2. Plot and interpret the dissolved oxygen and seagrass dataset on the grid above. **[4]**

(a) Plot all four zones accurately and join with a smooth trend curve [2] · (b) Describe the pattern below. [2]

Part B · Interpret & Explain Systems

Q3. Explain how upstream nitrate runoff triggers estuarine hypoxia and natural capital loss. **[5]**

(a) Explain how dense surface phytoplankton blooms lower dissolved oxygen in the Deep Basin. [3]

(b) Explain one indirect use value of Mangrove Cove and one negative externality shown in this catchment. [2]

Part C · Evaluate & Redesign Policy

Q4. Evaluate water sampling and catchment management in this investigation. **[5]**

(a) State one limitation of sampling dissolved oxygen at 09:00 only, and suggest one method improvement. [3]

(b) Evaluate paying upstream farms to establish a riparian mangrove and willow buffer strip. [2]

Optional Challenge (+3 marks · Extension)

Compare contingent valuation with avoided harbour dredging cost when valuing the Mangrove Cove buffer. [3]

IB DP ESS HL · Unit HL.b.2 · Mark Scheme & Teacher Notes

Matched 1:1 to Student Worksheet pp. 1–2 · British Academic English

19 + 3 marks

Part A · Q1 & Q2 Mark Scheme (Data Processing & Plotting) [9 marks]

Q1(a) [2]

- Subtracts Mangrove Cove value from Terrace Drain: 18.4 − 2.1 **[1]**
- Decrease = **16.3 mg L^{-1}** with unit **[1]**

Q1(b) [3]

- Divides decrease by Terrace Drain baseline: 16.3 ÷ 18.4 **[1]**
- Multiplies by 100 (= 88.587%) **[1]**
- Rounds correctly to 1 d.p.: **88.6% [1]**

Q2(a–b) [4]

- All four data points plotted within half a small grid square **[1]**
- Smooth best-fit curve drawn cleanly through the points **[1]**
- Describes a positive, non-linear relationship **[1]**
- Quotes two paired values, e.g. 0% cover at 1.4 mg L^{-1} vs. 78% at 7.9 mg L^{-1} **[1]**

Accept: Equivalent fraction method (1 − 2.1 / 18.4) × 100 = 88.6%, or error carried forward (ECF) on Q1(b).
Do not accept: Dividing by 2.1 mg L^{-1}, or extrapolating the curve past 7.9 mg L^{-1}.

Part B · Q3 Mark Scheme (Systems & Ecological Economics) [5 marks]

(a) [3]

- Dense surface algae block sunlight reaching submerged seagrass **[1]**
- Dead phytoplankton and plant matter are broken down by aerobic bacteria **[1]**
- Bacterial respiration uses up dissolved oxygen, leading to Deep Basin hypoxia (1.4 mg L^{-1}) **[1]**

(b) [2]

- Indirect use value: mangrove prop roots trap silt or take up nitrates, lowering downstream dredging cost **[1]**
- Negative externality: upstream nitrate runoff damages estuarine fisheries without appearing in farm prices **[1]**

Accept: Raised biochemical oxygen demand (BOD) during decay, or storm-surge protection as an indirect use value.
Do not accept: General claims that algae consume all oxygen in daylight without linking shading and decay.

Part C · Q4 Mark Scheme (Evaluation & Catchment Policy) [5 marks]

(a) [3]

- Limitation: one 09:00 reading misses overnight respiration dips, daytime photosynthesis peaks, and tidal flushing **[1]**
- Improvement: log readings continuously over 24 hours with optical probes, or sample pre-dawn and midday **[1]**
- Justification: catches the minimum night-time dissolved oxygen concentration **[1]**

(b) [2]

- Advantage: Payment for Ecosystem Services (PES) brings externality costs into farm budgets and lowers dredging costs **[1]**
- Limitation: Buffer schemes require ongoing compliance checks, or may exclude tenant farmers who lack formal land titles **[1]**

Accept: Sampling across dry and wet fertiliser seasons in (a), or fairness concerns over smallholders in (b).
Do not accept: Repeating measurements without naming diurnal oxygen swings or timing.

Optional Challenge Mark Scheme (Extension) [+3 marks]

(+3)

- Avoided dredging prices silt retention from real engineering bills **[1]**
- Contingent valuation surveys public willingness to pay for non-use existence and bequest values **[1]**
- Clear contrast: contingent valuation covers cultural worth, whereas survey answers can suffer from hypothetical bias **[1]**

Accept: Replacement-cost method in place of avoided dredging, or stated vs. revealed preference contrast.
Do not accept: Calling contingent valuation direct market timber or shellfish income.

Teacher Pacing & EAL Check: Allow roughly 45 minutes in total. Check that students subtract Terrace Drain to Mangrove Cove nitrate with mg L^{-1} units in Q1(a), quote paired mg L^{-1} oxygen values in Q2(b), and use Slide 6 during Friday Q3 peer marking. Keep extension marks separate.